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 TWENTIETH.

1864.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMAN, GREEN, LONGMAN, ROBERTS, AND GREEN.
PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; J. ROTHSCHILD, 14 RUE DE BUCI
LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLXIV.

List

OF THE

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OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February 19th, 1864.

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ERRATA.

Vol. XX. 1864.—*Anniversary Address*, p. xxxiii.—Professor Ramsay has since learnt from Professor Sedgwick that the gentleman who afforded him the information for the obituary notice of Mr. Lucas Barrett was mistaken on two points. Mr. Barrett did not " deliver most of the geological lectures " at Cambridge in the years 1856–58; and he never was appointed Curator of the Woodwardian Museum, though he was privately engaged there by Professor Sedgwick.

P. xli (*note*).—*For* " much closer to the Carboniferous than to the Devonian type " *read* " much closer to the Devonian than to the Carboniferous type." (See *Ann. Address*, 1863, p. xlvii.)

ERRATA.

Vol. XX, ... page xxiii. — [illegible] ... that the ... [illegible] ... surface of ... [illegible] ... the years 1868 ... [illegible] ... managed there ... [illegible]

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ERRATA ET CORRIGENDA.

Part I.—Proceedings.

Page 9, line 9, *for* Kunkar *read* Kunkur.
,, 49, line 13, *for* Rantaj *read* Rantja.
Plate XI., *for* 2 *a*, 2 *b* *read* 3 *a*, 3 *b*.
Page xli, line 10 from bottom, *after* specially with *insert* that of.
,, xlvii, footnote, line 2, *for* for *read* from.
,, lvii, line 26, *for* large *read* larger.
,, 107, line 15, *for* 21 feet 6 inches *read* 19 feet 9 inches.
,, 107 and 109, to list of fossils add *Mytilus minutus*, Goldf.
,, 145, line 28, *for* that *read* on the point.
,, 185, line 7 from bottom, for *V*. read *var*.
,, 186, line 6, for *Zua* read *Cochlicopa*.
,, 194, line 22, *for* were *read* was.
,, 198, line 10, *for* boces *read* bones.
,, 204, line 28, page 205, line 1, *for* chalk-beds *read* Cretaceous beds.
,, 205, line 24, *for* Tiberius *read* Tiberias.
,, 206, line 8 from bottom, *for* Austen *read* Godwin-Austen.
,, 411, lines 1 and 9, for *Hunteri* read *minor*.
,, 425, line 23, *after* Powrie *add* Pl. XX. figs. 2*a*–2*c*.
,, 448, line 14 from bottom, *for* south to north *read* north to south.
,, 448, line 13 from bottom, *for* Forrington *read* Torrington.
,, 451, lines 15, 21, 28 and 38, *for* Petroclistow *read* Petrockstow.
,, 461, line 17, *after* narrow *insert* one.
,, 496, line 5, *for* Bolt *read* Bott.
,, 502, line 13, *for* Davis *read* Davies.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 19, 1864.

REPORT OF THE COUNCIL.

In presenting their Annual Report to the Geological Society of London, the Council are again afforded an opportunity of congratulating the Fellows upon the general prosperity and the unusually large increase in the numbers of the Society during the past year.

The Fellows elected last year are no fewer than 68 in number, an addition to the list unparalleled in the history of the Society; of these 54 have paid their fees, making with four previously elected, who paid their fees in 1863, the large augmentation of 58 new Fellows. On the other hand, 17 Fellows have died during the past year, and the Society has sustained the loss of 6 more by resignation, thus giving a net increase of 35 ordinary Fellows.

One Foreign Member has been reported as deceased.

30 Foreign Correspondents were elected last year in conformity with the resolutions passed at a Special General Meeting held on January 8, 1863, and alluded to in the last Annual Report of the Council. One of these has since been elected to fill the vacancy among the Foreign Members.

The total number of the Society at the close of 1862 was 969; at the close of 1863, 1033.

The Income during 1863 has exceeded the Expenditure by £15 10*s.* 3*d.* Considering that in the Library-expenditure of the year is included the sum of £33 13*s.* 6*d.*, being the cost of the new Supplement-catalogue, and that in the House-expenditure is included about £30 for carpet and matting in the Meeting-room; and taking into account that this was the first year in which the Bye-law reducing the Annual subscription of resident Fellows from £3 3*s.* to £2 2*s.*, and raising the subscriptions of future Non-residents to the same amount, came into operation, and that it lessened for a time the amount of the annual subscriptions by the sum of 220 guineas,—this result must be considered extremely satisfactory; and it proves both the elasticity of the Society's resources, and the wisdom of the measure just referred to.

The funded property of the Society remains the same as at the last Anniversary, namely, £4350.

The Council have to announce the completion of Vol. XIX. of the Journal, and the publication of the First Part of Vol. XX.

For the purpose of hastening the renaming and rearranging of the specimens in the Foreign Collections, the Council appointed, in November last, Mr. Horace Woodward as a temporary Assistant in the Library and Museum.

The completion of the Greenough Geological Map has been delayed by unavoidable causes; but the Council have to announce that Sheet No. 6 is now ready for distribution and sale, and that the remaining sheets are expected to be shortly prepared.

It is more than probable that a large proportion of the Fellows of the Society are little aware of the many resources for the study of Geology which the collections of the Society afford in its different departments of Library, Maps, and Collections of specimens of Minerals, Rocks, and Fossils. The Council, therefore, think it advisable to bring before the general body of the Fellows on the present occasion a somewhat detailed account of the advantages they possess on their own premises for studying different branches of geological science. The apartments of the Society are open daily from ten in the morning to five in the evening, and the paid officers of the Society are in attendance daily, except on Sundays.

The facilities of study are these:—A large library of books and maps, with a copious catalogue of both, which may be consulted on the spot, or, with certain necessary exceptions, lent out. Illustrative specimens may be laid before any Fellow who may wish to examine them at his leisure with the assistance of books. For the lists of the extensive library of books and the collections of maps, the Council refer to the Catalogue recently published, copies of which are sold to the Fellows for 6*s*. 6*d*., and they will now give a brief account of the various collections of specimens we possess.

I. We have a good and useful series of the simple minerals, arranged after the fourth edition of Phillips's 'Mineralogy,' by Allan, a copy of which is in the Library, with marginal references to the specimens in our collection.

II. We have a valuable series of Recent Shells, named by Mr. Woodward, and arranged according to the system followed in his 'Manual of the Mollusca,' a copy of which is in the Library, with marginal references to our collections.

III. We have a large series of typical specimens of Rocks, British and Foreign, accompanied by a manuscript Catalogue made by Mr. Horner. It includes those rocks which have foreign names, as described in the systematic works of Senft, Cotta, and Coquand; copies of which are in the Library. This collection consists mainly of the unstratified rocks; but it includes a large number of the older stratified rocks, from the Laurentian Gneiss upwards. The Secondary and Tertiary rocks can be best seen, as to their lithological characters, in the specimens which include fossils, and they therefore can be studied in the general stratigraphical collection of the Society. But endeavours are being made to obtain specimens, for this typical collection, of Secondary and Tertiary rocks found in the Alps and elsewhere, so altered by metamorphic action as to be undistinguishable from the oldest strata.

IV. The Collection of British Rocks and Fossils is arranged stratigraphically, and includes an extensive series of Cambrian and Silurian rocks and fossils, the latter of which have been named by Mr. Salter; a large series of Devonian and Old Red Sandstone Fishes, named by Sir Philip Egerton; also a large and most valuable series of the Carboniferous Mollusca, which waits for revision by some Fellow of the Society of acknowledged authority, and the Council have reason to hope that this task will be undertaken by Mr. Davidson. But in this division we have a very extensive and valuable collection of Coal-plants, named by Sir Charles Bunbury. With the exception of the Silurian series named by Mr. Salter, the Cretaceous fossils gone carefully over by Mr. Wiltshire, and the Crag fossils by Mr. Searles Wood, the remaining parts of the British series are in the same state as when presented by their respective donors. It is to be hoped that Fellows of the Society who are particularly conversant with fossils of different formations will voluntarily lend their aid to the Council in order that these collections may be placed in a more useful state than they can be while so large a proportion of the fossils are unnamed. To purchase assistance of this kind of any real value would require a sum far exceeding the means at the disposal of the Council, and it is therefore to be hoped that, in so numerous a body, voluntary aid will not be wanting for the accomplishment of a work of so much importance to the usefulness of the Society.

V. The Collection of Specimens illustrative of the Geology of Foreign Countries, now amounting to many thousand specimens from all parts of the world, may be said to be in a very satisfactory state, *so far as ready accessibility is concerned.*

The arrangement adopted is, in the first instance, geographical, and, under each country, first, stratigraphical; and next, when the number of specimens admits of it, zoological.

There is a full geographical manuscript Catalogue of the five great divisions of Europe, Africa, Asia, America, and Australia, with the subordinate countries of each division, in which all the specimens are entered under their proper heads. We have another manuscript Catalogue in which a stratigraphical arrangement is adopted, and in which there is a heading for each formation from the oldest to the newest, and under these are entered the Specimens we possess from all parts of the world. A Catalogue has been recently completed, as far as Europe is concerned, of the memoirs and notices of the geology of foreign countries contained in the Transactions, the Proceedings, and the Quarterly Journal of the Society, arranged according to countries, with references to the specimens illustrative of them that exist in the Society's Collections.

VI. Of Special Collections, that of the rocks from the Vosges Mountains, which form a most prominent part in the geology of France, and supply a vast variety of unstratified rocks, is important. This is a series of 156 specimens, which were presented to the Society in 1860 by Mr. Horner, accompanied by a full and instructive catalogue, which may be referred to usefully by those who are studying the numerous memoirs on the structure of that remarkable region.

Several years ago the late Earl of Ellesmere made us the very handsome donation of the original drawings for the plates of Agassiz's 'Poissons Fossiles.' They are contained in a separate cabinet, and will always be regarded with interest as original documents of that great work, and as beautiful specimens of art.

The brother of our late lamented President, Mr. Daniel Sharpe, presented in 1856 to the Society a very large and valuable Collection of Fossil Mollusca which had belonged to the latter, and had been named by him, including the important information of localities. They are arranged zoologically, and may be consulted with great facility.

In recent Numbers of our Quarterly Journal the Fellows will have read the very remarkable papers by Dr. Duncan on the Fossil Corals of the West India Islands. The Council have thought it advisable to make a special collection of these Corals, in order to facilitate the careful study of these papers. An interleaved copy of the memoirs, in which Dr. Duncan will give additional illustrations, accompanies the collection. There is also a named Collection of Fossil Foraminifera in the Society's possession, and a similar set of specimens of Polyzoa is in course of being collected.

We have three special collections which have a peculiar value as connected with the lithology and nomenclature of the early days of our science. In 1808, Dr. Babington, one of the founders of the Society, presented a series of 119 specimens from the Hartz Mountains. In 1818, Mr. Henry Heuland, an early member of the Society, gave a series of 271 specimens from various parts of Germany—one of the typical collections formed under the eye of Werner, illustrative of the geological system and nomenclature of the then famous School at Freyberg. The Count de Bournon, an eminent mineralogist, and also one of the founders of this Society, on his return with the Bourbons to France in 1815, presented to the Society a series of 356 specimens from Hungary, which had been formed by the traveller Beudant.

These three last special collections are valuable, not only as illustrating the geology of the countries, but are curious as enabling us to compare the rock-nomenclature of past and present time, and how far it may have been changed with advantage or otherwise.

The Council have thus given a brief outline of the materials for study which the Fellows are possessed of, and for consulting which the Council give every facility which the means in their power enable them to supply.

The Council have to report that they have awarded the Wollaston Medal to Sir Roderick Murchison, K.C.B., for his many distinguished services to Palæozoic Geology: especially—

1st. For his great work entitled "The Silurian System," in which he first reduced to order the intricate region occupied by the Silurian rocks in Wales, the adjoining counties, and other parts of England.

2nd. For his important work on the Geology of Russia, the fruit of several years' labour in the field, in which, with his coadjutors M. de Verneuil and Count Keyserling, he discovered and mapped the true relations of the formations that lie in European Russia and the Ural Mountains, and correlated them with the strata of the other parts of Europe. And

3rd. For his remarkable discovery of the true relations of all the rocks beneath the Old Red Sandstone that form the Highlands of Scotland, by which he proved the existence of an older Gneiss (Laurentian or Lewisian) and of a younger set of flaggy, metamorphic, micaceous, and gneissic strata of true Lower Silurian age.

The balance of the proceeds of the Wollaston Fund has been awarded to M. Deshayes, to assist him in his work on the Mollusca of the Paris Basin, and in testimony of the high esteem in which the Geological Society hold those labours.

Report of the Library and Museum Committee, 1863-64.

The Museum.

Since the last Anniversary an unusually large number of important additions have been made to the Foreign Museum, including some extensive collections illustrating the geology of considerable tracts of country. Of these donations the following are more especially noteworthy. An extensive series of Rock-specimens illustrating the geology of the region near the 49th parallel of latitude in America, and particularly referred to in Mr. Bauerman's Report on the Geology of that district, shortly to be published, presented by H. Bauerman, Esq., F.G.S. A very large and valuable collection of Rocks and Fossils illustrating the Geology of Victoria, and labelled with reference to the Map-sheets of the Geological Survey of that colony, presented by R. A. C. Selwyn, Esq. A collection of Cretaceous Fossils from Ras Fartak, on the south-east coast of Arabia, one of fossils from the Somali Mountains collected by Messrs. Burton and Speke, another of Fossils from the north bank of the River Nerbudda, and one of Tertiary Fossils from Travancore, all presented by Dr. H. J. Carter, F.R.S. A collection of Fossils from the Valley of Kelat, presented by Dr. Cook, of H.M. Bombay Army; a series of Tertiary Fossils from Borneo and Java, sent to England by M. Corn. de Groot, presented by Sir R. I. Murchison, K.C.B., F.G.S; a suite of Rock-specimens from Finland, presented by M. Nils de Nordenskiöld, For. Mem. G.S.; and specimens of Rocks from, and of Fluviatile Shells found at high levels in, the Nile Valley, presented by Dr. Leith Adams.

Collections in illustration of papers read before the Society have been given by Sir R. I. Murchison, K.C.B., F.G.S., Dr. Macdonald, F.R.S., Captain Bullock, R.N., and others. Interesting and important specimens have also been received from F. Poole, Esq., J. de C. Sowerby, Esq., M. E. Lartêt, For. Mem. G.S., H. Christy, Esq., F.G.S., and other donors; and Dr. J. Milligan, F.G.S., has made a large addition to a collection of Fossils from Tasmania presented by him some time back.

The Committee especially draw the attention of the Society to a valuable collection of specimens illustrating the Alluvial Gold-deposits of New South Wales, which is estimated to contain more than seventy pounds' worth of gold, and which, with the cases containing it, is the gift of Sir Daniel Cooper, Bart., late Speaker of the Legislative Assembly of New South Wales. These two cases of specimens are placed in the Tea-room.

The additions to the British collection have not been very numerous, the principal being a number of Bones from the Peat of Walthamstow, presented by N. T. Wetherell, Esq., F.G.S.; and a collection of specimens from the Peat of Somersetshire, presented by G. S. Poole, Esq.

The want of a Microscope for the use of the Fellows and the Officers of the Society having long been felt, the Council purchased, in March last, a very useful instrument of Messrs. Smith, Beck, and Beck at a cost of £9 12*s*.

The working materials of the Society have been further augmented through the presentation, by Leonard Horner, Esq., V.P.G.S., of a Wollaston's Reflecting Goniometer.

Owing to a press of Library-work during the past year, and to there having been but one Library and Museum Assistant during the greater portion of that period, much progress has not been made since the last Anniversary in naming and arranging the Fossils in the Foreign Collections; still this very important branch of the Museum-work has not been entirely neglected. Dr. Duncan has rendered very great service by devoting much time to the naming and arrangement of both the British and Foreign Fossil Corals; many of the specimens determined by him have been placed upon tablets by Mr. Stair, while the remainder are in course of being tableted. The Nummulitic Fossils from Scinde, which were named by M. d'Archiac, as well as some others from the same district, altogether occupying nine drawers, have also been placed upon tablets; but there yet remain a number of specimens of this collection, occupying five drawers, still unnamed; most of them, however, appear to be duplicates.

In order to prevent injury to delicate specimens, twelve drawers, containing the collections of Paris Basin and Touraine Fossils, have been fitted with glass covers at a cost of £1 1*s*. As isolated delicate specimens frequently occur in collections, the Committee recommend the purchase of a number of glass-top boxes for their reception from time to time. It also appears desirable to obtain a sufficient number of small tablets to facilitate the formation of a collection of Polyzoa.

Mr. Horner having constructed a Stratigraphical Catalogue of the Specimens in the Foreign Museum, it has been copied into a suitable book by Mr. Stair. It forms a kind of appendix to the Geographical Catalogues made previously, and will, it is hoped, prove of material assistance to Fellows wishing to make use of the Society's collections for stratigraphical purposes.

As many of the collections of Foreign Specimens in the Museum illustrate papers in the Transactions, Proceedings, and Quarterly Journal of the Society, and as others are from localities described or alluded to in those memoirs, Mr. Horner compiled a classified list of the papers in the Society's Publications relating to Foreign Geology, giving references to specimens in the Foreign Collections from the same localities. This Catalogue has also been copied by Mr. Stair, so far as Europe is concerned, and it will be finished as soon as circumstances will permit.

The drawers containing the Sharpe Collection of Mollusca have been furnished with glazed lining, and a Catalogue of the Foreign specimens contained in the collection has been commenced.

The numerous additions lately made to the Foreign Collections necessitated, two years ago, the provision of some new cabinets, but these have long since been filled. This year the use of about 120 drawers in the recess in the Lower Museum was obtained by eliminating the useless rock-specimens from the British Collection. These drawers are now almost all occupied, and the question of providing more space for Foreign specimens will soon command the attention of the Council once more. Several of the drawers here alluded to have been filled with valuable collections of rock-specimens, which have been removed from the Upper Museum and arranged in the recess by Mr. Horner, in close proximity and with reference to the typical collection of rocks formed by that gentleman four years ago.

Most of the above-mentioned progress in tableting, naming, and arranging Foreign specimens has been made during the latter portion of the year, during which time the staff of the Society has been raised to its former strength by the appointment, last November, of Mr. Horace Woodward as a temporary Assistant in the Library and Museum. Mr. Stair, who has proved a very efficient Assistant since his engagement in March 1860, has recently resigned his post in consequence of having received a Civil Service appointment, and it therefore becomes extremely desirable to appoint as soon as possible a competent successor.

The Committee cannot conclude this Report without drawing the attention of the Council to the unremitting zeal and continuous labour bestowed upon the rearrangement of the Society's Collections by Mr. Horner, who has spent several hours almost daily in actual work in the Museum.

W. J. HAMILTON.
ROBERT W. MYLNE.
J. PRESTWICH.
T. WILTSHIRE.

The Library.

Besides the usual Donations of Books and Maps, the Library has been added to by the purchase, shortly after the last Anniversary, of some valuable works of reference, amongst which are Waterhouse's 'Mammalia,' Van der Hoeven's 'Zoology,' and Middendorf's 'Reise in den Siberiens.'

The Map-collection has received some important additions, including the sheets of the Geological Survey of Victoria, and the Ordnance Survey of Great Britain (1-inch and 6-inch scales). Amongst other maps lately received may be mentioned Erdmann's 'Sveriges Geologiska Undersökning,' Gumbel's 'Baierische Alpen,' and a number of French charts from the Dépôt de la Marine.

The third Supplement-Catalogue, containing the titles of works added to the Library between the end of 1859 and June 1862, and a complete classified list of the Periodical works in the possession of the Society at the latter date, the publication of which was begun previously to the last Anniversary, has been completed for some months, and is supplied to the Fellows at a charge of 2*s.* The cost of this Catalogue has been included in the Library expenses of the past year.

Since the publication of the above-mentioned supplement, a new reference-catalogue of the Library has been made, in which all the books and pamphlets are arranged in one alphabetical list, with references to the shelves on which they are kept. It is hoped that this single reference-catalogue will remove the inconvenience heretofore felt by the Fellows in being obliged to consult successively four or five different lists.

The baize-coverings of the book-shelves in the Meeting-room have been fitted with rollers, so as to render the books more easily accessible, and at the same time to protect them from dust.

The constantly increasing annual additions to the Library again render necessary the erection of new Book-shelves, and the Committee recommend therefore such additional shelves being made on the plan of those now in the Meeting-room.

The additions made during the last two years to the Society's Portfolios have been arranged by Mr. Horace Woodward, who has also been of service in making diagrams for the Evening-meetings.

W. J. HAMILTON.
ROBERT W. MYLNE.
J. PRESTWICH.
T. WILTSHIRE.

Comparative Statement of the Number of the Society at the close of the years 1862 *and* 1863.

	Dec. 31, 1862.	Dec. 31, 1863.
Compounders	135	144
Contributing Fellows	306	329
Non-contributing Fellows	476	479
	917	952
Honorary Members	3	3
Foreign Members	48	47
Foreign Correspondents	..	30
Personage of Royal Blood	1	1
	969	1033

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1862 *and* 1863.

Number of Compounders, Contributing and Non-contributing Fellows, December 31, 1862		917
Add Fellows elected during former year and paid in 1863	4	
Add Fellows elected and paid in 1863	54	
	—	58
		975
Deduct Compounders deceased	2	
Contributing Fellows deceased	7	
Non-contributing Fellows deceased	8	
Contributing Fellows resigned	5	
Non-contributing Fellow resigned	1	
	—	23
		952

Number of Personages of Royal Blood, Honorary Members, and Foreign Members, Dec. 31, 1862	52
Add Foreign Correspondents elected in 1863	30
	82
Deduct Foreign Member deceased	1
	81

Number of Fellows liable to Annual Contribution at the close of 1863.

Ordinary Contributors	278
Non-residents elected before March 1st, 1862......	51
	329

DECEASED FELLOWS.

Compounders (2).

Beriah Botfield, Esq.
Joseph Henry Green, Esq.

Residents (7).

Marquis of Lansdowne.
Walter Ewer, Esq.
Dr. Packman.
John Wiggins, Esq.
Viscount Templeton.
John Taylor, Esq.
William Cubitt, Esq.

Non-residents (8).

Lucas Barrett, Esq.
Ebenezer Rogers, Esq.
Robert Allan, Esq.
William Stark, Esq.
Philip Duncan, Esq.
Sign. Gennaro Placci.
Samuel Peace Pratt, Esq.
Edward Clark, Esq.

Foreign Member (1).

Dr. Mitscherlich.

The following Persons were elected Fellows during the year 1863.

January 7th.—Henry M. Jenkins, Esq., Assistant-Secretary of the Geological Society, 2 Grote's Place, Blackheath; Griffith Davies, Esq., 21 Cloudesley Square, Islington; John Walter Lea, Esq., The Grange, Shepperton Green, Chertsey; and John Daglish, Esq., Hetton, Durham.

—— 21st.—Thomas Wardle, Esq., Leek Brook, Leek, Staffordshire; John Brunton, Esq., C.E., Engineer of the Scinde Railway, the Punjaub; Alfred Hewlett, Esq., Haigh, Wigan; Edward Brook, Jun., Esq., Oakley House, Edjeston, Huddersfield; and George Worms, Esq., 17 Park Crescent, Portland Place.

February 4th.—Clement le Neve Foster, Esq., of the Geological Survey of Great Britain; and William Babington, Esq., Clifton.

—— 18th.—Thomas Hood Hood, Esq., Member of the Legislative Council of Queensland, Australia; Samuel Wright, Esq., Buttermere, Cockermouth; John Rand Capron, Esq., Guildford; Julius Haast, Esq., Government Geologist, Canterbury, New Zealand; and John Randall, Esq., Madeley, Salop.

March 4th.—Il Commendatore G. Devincenzi, Royal Commissioner for Italy in the International Exhibition, Minister of Agriculture and Commerce, Turin; Il Cavaliero C. Perazzi, of the Royal Corps of Mining Engineers, Engineer for the district of Turin; John Watson, Esq., Whitby; Francis Drake, Esq., Leicester; and O. C. Marsh, Esq., Yale College, U.S.

March 18th.—Robert Mushet, Esq., Royal Mint, Tower Hill; Hilary Bauerman, Esq., Geologist to the North American Boundary Survey; Frank M'Lean, Esq., B.A., C.E., 2 Park Street, Westminster; and Samuel Baines, Esq., Holroyd House, Lightcliffe, near Halifax.

April 1st.—William Edward Wood, Esq,, Tamworth Castle, Tamworth; and S. N. Carvalho, Jun., Esq., 6 Aberdeen Park, Highbury Grove.

—— 22nd.—Major F. Ignacio Rickard, Inspector-General of Mines in the Argentine Republic, 21*a* Hanover Square; Charles Easton Spooner, Esq., Bron-y-Garth, Port Madoc; and Nicholas Kendall, Esq., M.P., Pelyn, Cornwall.

May 6th.—John Martin, Esq., Cambridge House, Portsmouth; Charles Carter Blake, Esq., 1 Mabledon Place; and William Whitaker Collins, Esq., 15 Buckingham Street, Adelphi.

—— 20th.—The Rev. Prof. Kingsley, M.A., F.L.S., Eversley, Hants; James Dees, Esq., C.E., Whitehaven; Robert Francis Hodgson, Esq., 126 Marine Parade, Brighton; John Scott, Esq., 3 Chester Place, Hyde Park; Sir Charles Tilston Bright, C.E., 12 Upper Hyde Park Gardens; Edward C. Musson, Esq., Martyr Worthy, Winchester; Thomas Glazebrook Rylands, Esq., F.L.S., Heath House, Warrington; Edward C. Hartsincke Day, Esq., Charmouth; and W. Dickenson, Esq., Croydon.

June 3rd.—The Rev. Richard Wilson Greaves, M.A., Rector of Tooting.

—— 17th.—Frederick G. Finch, Esq., Tudor House, Blackheath.

November 4th.—James C. Richardson, Esq., Glenrafon, Swansea; William Bath Kemshead, Esq., Cambridge House School, Southsea; Brinsely de Courcy Nixon, Esq., 17 Bury Street, St. James's; John Bell Simpson, Esq., Ryton West House, Blaydon-on-Tyne; and the Hon. John Leycester Warren, 32 Lower Brook Street.

—— 18th.—William Brightmore Mitchell, Esq., 16 Broom Hill, Sheffield; and Charles Tylor, Esq., 24 Holloway Place, Holloway.

December 2nd.—Arthur Lennox, Esq., Assistant Geologist, West Indian Survey, Jamaica; Arnold Thomas, Esq., Winnald's Hill, Coleford, Gloucestershire; Edwin Brown, Esq., Burton-upon-Trent; Harrison Hayter, Esq., 33 Great George Street; William James Nevile, Esq., Hatton House, Cheshunt, Herts; Edward Ball Knobel, Esq., 138 High Street, Burton-upon-Trent; George Cheetham Churchill, Esq., 13 Craven Hill, Bayswater; The Hon. W. O. Stanley, M.P., Penrhos, Holyhead; George Lyall, Esq., 38 Great Winchester Street, South Shields; Rev. Norman Glass, 39 Richmond Terrace, Clapham Road; Arthur Bott, Esq., 5 Hanover Terrace, Peckham; James Fergusson, Esq., 20 Langham

Place; William Vicary, Esq., 7 Albert Terrace, St. Leonard's, Exeter; and Alexander Bryson, Esq., Hawk Hill, Edinburgh.

December 16th.—H. M. Hozier, Esq., Lieutenant 2nd Life Guards, Staff College, Sandhurst; J. F. Iselin, Esq., M.A., Inspector of Science-Schools, South Kensington Museum; and Andrew Leith Adams, M.D., Surgeon 22nd Regiment, Malta.

The following Persons were elected Foreign Correspondents during the year 1863.

April 1st.—The Rev. Dr. Oswald Heer, Professor of Botany in the University of Zurich; Sign. Paoli Savi, Professor of Geology in the University of Pisa; Sign. G. Ponzi, Professor of Comparative Anatomy and Physiology in the University of Rome; Dr. Joseph Leidy, Professor of Anatomy in the University of Pennsylvania; Il Marchese Pareto, of Genoa; and Professor A. Daubrée, of the Jardin des Plantes, Paris.

—— 22nd.—Professor Favre, of Geneva; Franz Ritter von Hauer, of the Imperial Geological Institute of Vienna; Professor Hébert, of the Sorbonne, Paris; Professor Beyrich, of the University of Berlin; and Professor Fridolin Sandberger, of Carlsruhe.

May 6th.—Herr Credner, Bergmeister, of Gotha; Dr. Kaup, Conservator of the Museum at Darmstadt; Sign. Gastaldi, of Turin; Professor Pictet, of Geneva: M. Morlot, of Berne; Sign. Sella, of Turin; and Sign. Meneghini, of Pisa.

June 17th.—General della Marmora, of Turin; M. de Kokscharow, of St. Petersburg; Professor Quenstedt, of Tübingen; Dr. Ferdinand Senft, of Eisenach; Count Auguste F. Marschall von Burgholzhausen, of Vienna; Professor Edouard Suess, of Vienna; M. Boucher de Perthes, of Abbeville; M. Lovén, of Stockholm; the Marquis de Vibraye, of Paris; Dr. B. Shumard, of Louisville; M. Henrie Nyst, of Brussels; and Dr. Moritz Hörnes, of Vienna.

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

British Specimens.

Cast of fragment of a tooth of *Mastodon* from Swaffham, Norfolk; presented by C. B. Rose, Esq., F.G.S.

Specimen of Cone-in-Cone structure in slate, from Troutbeck, Keswick; presented by Prof. R. Harkness, F.G.S.

Specimens of Fossil *Coleoptera,* and a fragment of a molar of *Elephas primigenius,* from the Peat of Lexden, near Colchester; presented by the Rev. O. Fisher, F.G.S.

Collection of Bones of the Horse, Ox, Deer, &c. from Walthamstow; presented by N. T. Wetherell, Esq., F.G.S.

Specimen of Pearl-spar from New Treleigh Mine, Cornwall; presented by Captain S. Mitchell.

Specimens of Albertite from Mountgerald, Scotland; presented by A. C. Mackenzie, Esq.

Specimens of Corals from the lower beds of the Middle Lias, from near Cherrington, Warwickshire; presented by J. Kershaw, Esq., F.G.S.

Specimens of Bog-oak, Peat, &c. from Somerset; presented by G. S. Poole, Esq.

Cast of a specimen of *Paradoxides Davidis*, Salt., from the Lower Lingula-flags of St. David's; presented by J. W. Salter, Esq., F.G.S.

Foreign Specimens.

Columnar Brown-coal from near the Basalt of Almerode, Hirschberg; presented by W. J. Hamilton, Esq., Sec. G.S.

Specimen of *Calaïs Newbouldi*, a new Octopod, from Mount Lebanon; presented by J. de C. Sowerby, Esq.

Specimens of *Thecidium Adamsi*, Macd., from the calcareous sandstone of the Miocene beds of Malta; presented by Dr. A. Leith Adams, F.G.S.

Specimens of Gneiss from Bohemia; presented by Sir R. I. Murchison, K.C.B., F.G.S

Collection of specimens illustrating the Alluvial Gold-deposits of New South Wales; presented by Sir Daniel Cooper.

Cretaceous Fossils from Ras Fartak, on the S.E. coast of Arabia; Fossils from the Somali Mountains, collected by Messrs. Burton and Speke; Fossils from the north bank of the River Nerbudda; and Tertiary Fossils from Travancore, S. India; presented by Dr. H. J. Carter, F.R.S.

Fossils from the Valley of Kelat; presented by Dr. Cook, of H.M. Bombay Army.

Limestone with Encrinites from near Timor Koepoeng, Island of Timor; 18 specimens of Tertiary Shells from Tjilanang cleft, Goenoeng Seela, Regency of Bandong, Java; and 18 specimens of Shells from the Colliery "Orange Nassau," Borneo; presented by the Director of the Museum of Practical Geology.

Specimens of Rocks and Pliocene Fossils from Formosa; presented by R. Swinhoe, Esq., H.M. Vice-Consul, Formosa.

Specimens of Rocks from Bohemia; presented by Sir R. I. Murchison, K.C.B., F.G.S.

Collection of Fossils from Japan; presented by Captain Bullock.

Bones from Aurignac; Bones, Sandstone-flag, and Conglomerate from the cavern at Lourde, Hautes Pyrénées; presented by H. Christy, Esq., F.G.S., and M. E. Lartêt, For. Mem. G.S.

Specimens from Bornholm and Jutland; presented by Prof. T. R. Jones, F.G.S.

Specimens of Minerals from British Columbia and California (Queen Charlotte's Island); presented by F. Poole, Esq.

Collection of Rocks and Minerals from Finland; presented by M. Nils de Nordenskiöld, For. Mem. G.S.

Collection of Tertiary Plants, &c., from Tasmania; presented by Dr. J. Milligan, F.G.S.

Collection of Rock-specimens illustrating the district surveyed by the North-American Boundary Commission; presented by H. Bauerman, Esq., F.G.S.

Large collections of Fossils and Rocks illustrative of the Geology of the Colony of Victoria; presented by A. C. Selwyn, Esq.

Specimen of *Flabellum appendiculatum*, Bronn, from the Eocene clays of Rouca; presented by W. Moxon, Esq.

Charts, Maps, etc., presented.

Forty Maps and Charts published by the French Dépôt de la Marine de la France; presented by the Dépôt de la Marine.

Matériaux pour la Carte Géologique de la Suisse. Atlas en 4 Feuilles; presented by Prof. Bernard Studer, Pres. Geol. Comm. Swiss Confed.

Geological Map of England and Wales (Longman and Co.'s Wall Maps, No. 3); presented by Messrs. Longman and Co.

Map and Sections of New South Wales, by W. Keene, Gov. Exam. of Coal-fields; presented by Sir Daniel Cooper, Bart.

Sveriges Geologiska Undersökning på offentlig lekostnad utförd under ledning af A. Erdmann, Sheets 1 to 5, with accompanying memoirs; presented by M. A. Erdmann.

Map of the Province of Canterbury, New Zealand, by J. S. Browning; presented by the Provincial Government of Canterbury, through Dr. Julius Haast, F.G.S.

Geologische Specialkarte des Grossherzogthums Hessen und der angrenzenden Landesgebiete in Maasstabe von 1 : 50000; Sections Erbach and Herbstein-Fulda; presented by the Geological Society of the Middle Rhine.

Ordnance Survey of Great Britain. Maps, 6-inch scale:—Westmoreland, Sheets 2 to 10, 15, 16, 21, 26 to 30, 32, 34, 38, 46. Berwickshire, Sheets 10, 18, 27 to 30. Selkirkshire, Sheets 1, 3 to 10, 11, 13 to 15, 17, 22. Roxburghshire, Sheets 1 to 10, 13 to 27, 29 to 46, 48.—Ordnance Survey of England. 1-inch scale:—Sheets 102, 104, 105, S.E. Sheet 103, N.W.—Ordnance Survey of Ireland. 1-inch scale:—Sheets 5, 6, 11, 17, 31, 102, 182.—Ordnance Survey of Scotland. 1-inch scale:—Sheets 14, 22, 26, 49. Presented by the Board of Ordnance through the Director-General, Colonel Sir Henry James, F.G.S.

Twenty Quarter-sheets of the Geological Survey-map of Victoria; presented by the Colonial Government of Victoria.

Section of a Well at the Tannery of Mr. L. Webb, Stowmarket, Suffolk; presented by G. R. Burnell, Esq., F.G.S.

Sections of Artesian Wells at Grenelle and Passy, near Paris; presented by G. R. Burnell, Esq., F.G.S.

Photograph of Count Marschall; presented by Count Marschall, For. Corr. G.S.

Continuation of a Panoramic view of the Kashmir Mountains and City, taken from the ruins of the Roostan Gurhi, by F. G. Montgomerie, Esq.; presented by R. A. C. Godwin-Austen, Esq., F.R.S., F.G.S.

The following Lists contain the Names of those Persons and Public Bodies from whom Donations to the Library and Museum have been received since the last Anniversary, February 20, 1863.

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

Basel, Natural History Society of.
Berlin, German Geological Society at.
——. Royal Academy of Sciences.
——. Saxon and Thuringian Natural History Society.
Berwickshire Naturalists' Field Club.
Bombay, Royal Asiatic Society of.
Boston (U.S.), Natural History Society of.
——, Trustees of the Museum of Comparative Zoology at.
Breslau. Silesian Society for Fatherland Culture.
Brussels. Royal Academy of Sciences of Belgium.

Caen. Linnean Society of Normandy.
Calcutta. Trigonometrical Survey of India.
——. British Indian Association.
——. Bengal Asiatic Society.
——. Geological Survey of India.
Cambridge (U.S.). American Academy of Arts and Sciences.
——. American Philosophical Society.
Christiania, Royal University of.
Copenhagen. Royal Danish Academy of Sciences.

Darmstadt. Geological Society of the Middle Rhine.
Dijon, Academy of Natural Sciences of.
——. Agricultural Society of the Côte d'Or.
Dresden, Natural History Isis Society of.
Dublin. Royal Dublin Society.
——. Geological Survey of Ireland.
——, Geological Society of.
——. Royal Catholic University of Ireland.

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

France, Geological Society of.

Giessen, Natural History Society of.

Heidelberg, Natural History Society of.

Klagenfurt, Natural History Museum at.

Leeds, Philosophical Society of.
Liége, Royal Society of.
Lisbon, Royal Academy of.
Liverpool. Lancashire and Cheshire Historic Society.
London. Geological Survey of Great Britain.
——, Anthropological Society of.

London, Art-Union of.
——. British Association.
——, Chemical Society of.
——. Royal College of Physicians of England.
——, Royal Horticultural Society of.
——. Institute of Actuaries of Great Britain.
——. Institute of Civil Engineers.
——, Microscopical Society of.
——, Pharmaceutical Society of.
——, Photographic Society of.
——, Royal Society of.
——. Royal Institution of Great Britain.
——. Secretary of State for War.
——. Royal Asiatic Society of Great Britain.
——. Royal Geographical Society.
——. Geologists' Association.
——, Linnean Society of.
——, Mendicity Society of.
——, Palæontographical Society of.
——, Zoological Society of.

Manchester, Geological Society of.
Melbourne. Geological Survey of Victoria.
Milan, Imperial Institute of.
Montreal, Natural History Society of.
Moscow, Imperial Academy of Naturalists of.
Munich. Royal Academy of Sciences.

New York, Geographical and Statistical Society of.
New York. Lyceum of Natural History.
New Zealand. Provincial Government of Canterbury.
——. —— Wellington.
——. —— Auckland.

Offenbach, Natural History Society of.

Paris. Imperial Academy of Sciences.
——. Dépôt Général de la Marine.
——. School of Mines.
Philadelphia. Academy of Natural Sciences.
——. American Philosophical Society.
Presburg, Natural History Society of.

St. Louis, Academy of Sciences of.
St. Petersburg. Imperial Academy of Sciences.
——, Mineralogical Society of.
Stockholm. Royal Swedish Academy.

Toronto. Canadian Institute.
Tyneside Natural History Field Club.

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

Warwickshire Naturalists' Field Club.
Washington. Patent Office.
——. U.S. War Department.
Wiesbaden. Natural History Society, Duchy of Nassau.
Würtemberg, Natural History Society of.

II. List of Persons from whom Donations of Books and Specimens have been received since the last Anniversary.

Abich, Baron, For.M.G.S.
Adams, Dr. Leith, F.G.S.
American Journal of Science, Editor of the.
Ansted, Prof., F.G.S.
Athenæum, Editor of the.

Ball, John, Esq.
Barrande, M. J., For.Mem.G.S.
Beke, Dr.
Biedmann, Dr.
Billings, E., Esq., F.G.S.
Binney, E. W., Esq., F.G.S.
Bischof, Prof., For.Mem.G.S.
Bosquet, M.
Boucher de Perthes, M., For. Corr.G.S.
Branton, John, Esq., F.G.S.
Bullock, Captain, R.N.

Calvert, F., Esq.
Carter, H. J., Esq., F.R.S.
Chambers and Co., Messrs.
Christy, H., Esq., F.G.S.
Churchill and Sons, Messrs.
Colliery Guardian, Editor of the.
Cook, Dr.
Cooper, Sir Daniel, Bart.
Cotteau, Prof.
Coutts, Miss Burdett.
Critic, Editor of the.
Crowe, H. W., Esq.
Cutler, W. H., Esq.

Dana, Dr., For.Mem.G.S.
Daubeny, Dr., F.G.S.
Dawson, Dr., F.G.S.
Delesse, M., For.Mem.G.S.
Deshayes, Dr., For.Mem.G.S.
Deslongchamps, Dr., For.Mem. G.S.
Desnoyers, M.
Deville, M. St.-Claire.
Dewalque, M.
Drach, Dr.
Dulau and Co.
Dupont, M.

Erdmann, M. J. M.

Fisher, Rev. O., F.G.S.
Forbes, Dr. Charles.
Francis, Dr., F.G.S.

Garrigou, M.
Geikie, A., Esq., F.G.S.
Geinitz, Prof. H. B., For.Mem.G.S.
Geologist, Editor of the.
Godwin-Austen, R. A. C., Esq., F.G.S.
Graham, Lieut.-Col.
Guiscardi, Sign.

Haast, Dr. Julius, F.G.S.
Haliburton, R. G., Esq.
Hamilton, W. J., Esq., Pres.G.S.
Harkness, Prof., F.G.S.
Hartley, Sir A. C.
Hébert, M., For.Corr.G.S.
Hector, Dr. J., F.G.S.
Hitchcock, Dr., For.Corr.G.S.
Holmberg, M.
Horner, Leonard, Esq., F.G.S.
Hörnes, Dr., For.Corr.G.S.
Howse, R., Esq.
Hunt, Captain.
Hunt, Dr., F.S.A.
Hutton, T.

Intellectual Observer, Editor of the.

James, Sir H., F.G.S.
Jervis, W. P., Esq., F.G.S.
Jones, Prof. T. R., F.G.S.
Journal of the Society of Arts, Editor of the.
Jukes, J. B., Esq., F.G.S.

Karrer, Dr. Felix.
King, Prof. W.
Kjerulf, Dr., For.Corr.G.S.

Kirkby, J. W., Esq.
Kirshaw, J., Esq., F.G.S.
Kner, Dr.
Koninck, Prof. de, For.Mem.G.S.

Lartêt, M., For.Mem.G.S.
Laugel, M. Auguste, F.G.S.
Lea, Dr. Isaac.
Lecoq, Prof.
Lindsay, Dr. Lauder.
Logan, Sir W., F.G.S.
London Review, Editor of the.
Longman and Co., Messrs.
Lubbock, J., Esq., F.G.S.
Lucy, W. C., Esq., F.G.S.
Lyell, Sir C., F.G.S.

Mackenzie, A. C., Esq.
Mackie, S. P., Esq., F.G.S.
Marschall, Count A. G.
Mayer, M. C.
Meneghini, Prof., For.Corr.G.S.
Miller, Prof., F.G.S.
Milligan, Dr. J., F.G.S.
Mining Review, Editor of the.
Mining and Smelting Magazine, Editor of the.
Mitchell, Captain Samuel.
Mohrenstern, M. G. Schwarz von.
Montagna, Sign. C.
Morton, G. H., Esq.
Moxon, W., Esq.
Murchison, Sir R. I., F.G.S.

Nordenskiöld, Dr. Nils de, For. Mem.G.S.
Noyer, G. V. du, Esq.
Nyst, Dr., For.Corr.G.S.

Omboni, Sign.
O'Riley, E., Esq., F.G.S.
Owen, Prof., F.G.S.

Page, David, Esq., F.G.S.
Parga, M.
Parker, W. K., Esq.
Pattison, S. R., Esq., F.G.S.
Peniston, J., Esq.
Perrey, M. Alexis.
Phillips, Prof., F.G.S.
Poole, F., Esq.
Poole, G. S., Esq., F.G.S.

Ramsay, Prof., F.G.S.
Reader, Editor of the.
Reeve, Lovell, Esq., F.G.S.
Rickard, Major, F.G.S.
Roberts, George E., Esq.
Rose, C. B., Esq., F.G.S.

Salter, J. W., Esq., F.G.S.
Schmidt, Prof.
Selwyn, R. A. C., Esq.
Smith, Dr. A.
Sowerby, J. de Carle, Esq.
Steindachner, Herr F.
Stoppani, Prof.
Studer, Prof., For.Mem.G.S.
Suess, Prof., For.Corr.G.S.
Swinhoe, Consul.

Tate, G., Esq., F.G.S.
Trautschold, Dr.

Wetherell, N. T., Esq., F.G.S.
Winkler, M.
Woodward, S. P., Esq., F.G.S.

List of PAPERS *read since the last Anniversary Meeting, February 20th,* 1863.

1863.

March 4th.—On the Permian Rocks of North-Eastern Bohemia, by Sir R. I. Murchison, K.C.B., F.R.S., F.G.S.

March 18th.—On the Correlation of the several Subdivisions of the Inferior Oolite in the Middle and South of England, by Harvey B. Holl, M.D., F.G.S.

—————— On the Occurrence of large quantities of Fossil Wood in the Oxford Clay, near Peterborough, by Henry Porter, M.D., F.G.S.

—————— On a new Macrurous Crustacean (*Scapheus ancylochelis*) from the Lias of Lyme Regis, by H. Woodward, Esq., F.Z.S.; communicated by Prof. Morris, F.G.S.

April 1st.—On Recent Changes in the Delta of the Ganges, by James Fergusson, Esq.; communicated by the President.

April 22nd.— On the Gneiss and other Azoic Rocks, and on the Superjacent Palæozoic Formations of Bavaria and Bohemia, by Sir R. I. Murchison, K.C.B., F.R.S., F.G.S.

—————— Notice of a Section at Mocktree, near Ludlow, by R. Lightbody, Esq.; communicated by J. W. Salter, Esq., F.G.S.

May 6th.—On the Brick-pit at Lexden, near Colchester, by the Rev. Osmond Fisher, M.A., F.G.S.; with Notes on the Coleoptera, by T. V. Wollaston, Esq., F.L.S.

—————— On the Original Nature and Subsequent Alteration of Mica-Schist, by H. C. Sorby, Esq., F.R.S., F.G.S.

—————— On the Fossil Corals of the West Indian Islands.—Part I., by P. Martin Duncan, M.B. Lond., F.G.S.

May 20th.—Further Observations on the Devonian Plants of Maine, Gaspé, and New York, by J. W. Dawson, LL.D., F.R.S., F.G.S.

—————— Notice of a New Species of *Dendrerpeton*, and of the Dermal Coverings of certain Carboniferous Reptiles, by J. W. Dawson, LL.D., F.R.S., F.G.S.

—————— On the Upper Old Red Sandstone, and Upper Devonian Rocks, by J. W. Salter, Esq., F.G.S., A.L.S.

June 3rd.—On the Section at Moulin Quignon, Abbeville; and on the peculiar character of some of the Flint Implements recently discovered there, by Joseph Prestwich, Esq., F.R.S., Treas.G.S.

June 17th.—On the Relations of the Ross-shire Sandstones containing Reptilian Footprints, by the Rev. George Gordon, LL.D., and the Rev. J. M. Joass; with an Introduction, by Sir R. I. Murchison, K.C.B., F.R.S.

—————— On some Tertiary Shells from Jamaica, by J. Carrick Moore, Esq., M.A., F.R.S., F.G.S.; with a Note on the Corals, by P. Martin Duncan, M.B., F.G.S.; and a Note on some *Nummulinæ* and *Orbitoides*, by Professor T. Rupert Jones, F.G.S.

—————— Notes on the Geology and Mineralogy of Borneo and the adjacent Islands, by Mijnheer Cornelius de Groot; communicated by Sir R. I. Murchison, K.C.B., F.R.S.

1863.

June 17th.—Description of a new fossil Thecidium (*Thecidium Adamsi*) from the Miocene Beds of Malta, by J. Denis Macdonald, Esq., F.R.S.; communicated by the President.

———— On the Sandstones and Shales of the Oolites of Scarborough, with Descriptions of New Species of Fossil Plants, by J. Leckenby, Esq., F.G.S.

———— A Monograph of the Ammonites of the Cambridge Greensand, by H. Seeley, Esq., F.G.S.

———— On a new Crustacean from the Glasgow Coal-field, by J. W. Salter, Esq., F.G.S., A.L.S.

———— On the Occurrence of a Bituminous Substance near Mountgerald, Scotland, by Dr. G. Anderson; in a letter to Sir R. I. Murchison.

———— On the Occurrence of a Bituminous Mineral at Mountgerald, Scotland, by A. C. Mackenzie, Esq.; communicated by Prof. Tennant, F.G.S.

———— On the Occurrence of Rocks of Upper Cretaceous Age in Eastern Bengal, by Dr. T. Oldham, LL.D., F.R.S., F.G.S.

Nov. 4th.—On some Ichthyolites from New South Wales, forwarded by the Rev. W. B. Clarke, by Sir P. G. Egerton, Bart., M.P., F.R.S., F.G.S.

———— Notes on the Geology of a Portion of the Nile Valley north of the Second Cataract in Nubia, taken chiefly with the view of inducing further search for Fluviatile Shells at High Levels, by A. Leith Adams, A.M., M.B., Surgeon H.M. 22nd Regiment; with a Note on the Shells, by S. P. Woodward, Esq., F.G.S.; and a Note on some Teeth of Hippopotamus, by Hugh Falconer, M.D., F.R.S., F.G.S.; communicated by Leonard Horner, Esq., V.P.G.S.

Nov. 18th.—On the Fossil Corals of the West Indian Islands.—Part II., by P. Martin Duncan, M.B. Lond., F.G.S.

———— Notes to accompany some Fossils from Japan, by Captain Bullock, R.N.; communicated by Sir R. I. Murchison, K.C.B., F.R.S.

———— On some Tertiary Mollusca from Mount Séla, in the Island of Java, by H. M. Jenkins, Esq., F.G.S.; with a Description of a new Coral from the same locality, and a Note on the Scindian Fossil Corals, by P. Martin Duncan, M.B. Lond., F.G.S.

Dec. 2nd.—On the Correlation of the Oligocene Deposits of Belgium, Northern Germany, and the South of England, by Herr A. von Koenen; communicated by F. E. Edwards, Esq., F.G.S.

———— On the Liassic Strata of the Neighbourhood of Belfast, by Ralph Tate, Esq., F.G.S.

———— Notes on the Devonian Rocks of the Bosphorus, by W. R. Swan, Esq.; communicated by Sir R. I. Murchison, K.C.B.

Dec. 16th.—Experimental Researches on the Granites of Ireland. —Part IV., by the Rev. Prof. Haughton, F.R.S., F.G.S.

———— Letters relating to recent discoveries of Fossil Reptiles in Central India, by the Rev. S. Hislop; communicated by Prof. T. R. Jones, F.G.S.

1863.
Dec. 16th.—On the Pebble-bed of Budleigh Salterton, by W. Vicary, Esq., F.G.S.; with Notes on the Fossils, by J. W. Salter, Esq., F.G.S.

——— On the recent Earthquake in Manila, by J. W. Farren, Esq.; communicated by the Foreign Office through Sir R. I. Murchison, K.C.B., F.G.S.

1864.
Jan. 6th.—On the Recent Geological Changes in Somerset, and their date relatively to the Existence of Man and of certain of the Extinct Mammalia, by G. S. Poole, Esq.; communicated by Sir Charles Lyell, D.C.L., F.R.S., F.G.S.

——— On the Structure of the Red Crag in Suffolk and Essex, by S. V. Wood, Jun., Esq.; communicated by Searles V. Wood, Esq., F.G.S.

Jan. 20th.—Observations on supposed Glacial Drift in the Labrador Peninsula, Western Canada, and on the South Branch of the Saskatchewan, by Prof. H. Y. Hind; communicated by the President.

——— Notes on the Drift-Deposits of the Valley of the Severn, in the Neighbourhood of Coalbrook-dale and Bridgenorth, by George Maw, Esq., F.L.S.; communicated by J. Gwyn Jeffreys, Esq., F.R.S., F.G.S.

Feb. 3rd.—On the Permian Rocks of the North-West of England and their extension into Scotland, by Sir R. I. Murchison, K.C.B., F.R.S., F.G.S., and Prof. Harkness, F.R.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,—

1. That the thanks of the Society be given to Prof. A. C. Ramsay, retiring from the office of President.

2. That the thanks of the Society be given to Sir P. G. Egerton, Leonard Horner, Esq., and Sir Charles Lyell, retiring from the office of Vice-President.

3. That the thanks of the Society be given to W. J. Hamilton, Esq., retiring from the office of Secretary.

4. That the thanks of the Society be given to George Busk, Esq., Sir P. G. Egerton, Leonard Horner, Esq., Professor T. H. Huxley, and R. 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.

W. J. Hamilton, Esq., F.R.S.

VICE-PRESIDENTS.

R. A. C. Godwin-Austen, Esq., F.R.S.
Edward Meryon, M.D.
J. Carrick Moore, Esq., F.R.S.
Sir R. I. Murchison, K.C.B., F.R.S.

SECRETARIES.

P. Martin Duncan, M.B.
Warington W. Smyth, Esq., M.A., F.R.S.

FOREIGN SECRETARY.

Hugh Falconer, M.D., F.R.S.

TREASURER.

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

COUNCIL.

John J. Bigsby, M.D.
Robert Chambers, Esq., F.R.S.E. & L.S.
P. Martin Duncan, M.B.
Robert Etheridge, Esq., F.R.S.E.
John Evans, Esq., F.S.A.
Rev. Robert Everest.
Hugh Falconer, M.D., F.R.S.
R. A. C. Godwin-Austen, Esq., F.R.S.
William John Hamilton, Esq., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S.
M. Auguste Laugel.
Sir Charles Lyell, F.R.S. & L.S.
Robert Mallet, Esq., C.E., F.R.S.
Edward Meryon, M.D.
John Carrick Moore, Esq., F.R.S.
Prof. John Morris.
Sir R. I. Murchison, K.C.B., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Prof. A. C. Ramsay, F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Alfred Tylor, Esq., F.L.S.
Rev. Thomas Wiltshire, M.A.
S. P. Woodward, Esq.

LIST OF

THE FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1864.

Date of Election.

1817. Professor Karl von Raumer, *Munich.*
1818. Professor G. Ch. Gmelin, *Tübingen.*
1819. Count A. Breuner, *Vienna.*
1819. Signor Alberto Parolini, *Bassano.*
1822. Count Vitiano Borromeo, *Milan.*
1823. Professor Nils de Nordenskiöld, *Helsingfors.*
1825. Dr. G. Forchhammer, *Copenhagen.*
1827. Dr. H. von Dechen, Oberberghauptmann, *Bonn.*
1827. Herr Karl von Oeynhausen, Oberberghauptmann, *Dortmund, Westphalia.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R.S., *Paris.*
1828. Dr. B. Silliman, *New Haven, Connecticut.*
1829. Dr. Ami Boué, *Vienna.*
1829. 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. M. G. P. Deshayes, *Paris.*
1844. Professor William Burton Rogers, *Boston, U.S.*
1844. M. Edouard de Verneuil, For. Mem. R.S., *Paris.*
1847. Dr. M. C. H. Pander, *Riga.*
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. Professor James D. Dana, *New Haven, Connecticut.*
1851. General G. von Helmersen, *St. Petersburg.*
1851. Hofrath W. K. Haidinger, For. Mem. R.S., *Vienna.*
1851. Professor Angelo Sismonda, *Turin.*
1853. Count Alexander von Keyserling, *Dorpat.*
1853. Professor Dr. L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Professor Dr. Karl Friedrich Naumann, *Leipsic.*
1856. Professor Dr. Robert W. Bunsen, For. Mem. R.S., *Heidelberg.*

1857. Professor Dr. H. R. Goeppert, *Breslau.*
1857. M. E. Lartêt, *Paris.*
1857. Professor Dr. H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *Tiflis, Northern Persia.*
1858. Dr. J. A. E. Deslongchamps, *Caen.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. M. A. Delesse, *Paris.*
1859. Professor Dr. Ferdinand Roemer, *Breslau.*
1860. Professor Dr. H. Milne-Edwards, For. Mem. R.S., *Paris.*
1861. Professor Gustav Bischof, *Bonn.*
1862. Señor Casiano di Prado, *Madrid.*
1862. Baron Sartorius von Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*
1864. Professor Paolo Savi, *Pisa.*

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. F. 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.
1844. The Rev. W. C. Conybeare.
1845. Professor John Phillips.
1846. Mr. William Lonsdale.
1847. Dr. Ami Boué.
1848. The Rev. Dr. W. Buckland.
1849. Mr. Joseph Prestwich, jun.
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.

Trust-Account.

Receipts.	£	s.	d.	Payments.	£	s.	d.
Balance at Banker's, January 1, 1863, of the Wollaston Donation-fund	29	14	6	Award of Proceeds to Prof. Senft	18	16	6
Dividends on the Donation-fund for 1863 on £1084 1*s.* 1*d.* Reduced 3 per Cents.	31	8	9	Cost of striking Medal awarded to Prof. Gustav Bischof	10	18	0
				Balance at Banker's (Wollaston-fund)	31	8	9
	£61	3	3		£61	3	3

Valuation of the Society's Property; 31*st December*, 1863.

Property.	£	s.	d.	£	s.	d.	Debts.	£	s.	d.
Due from Messrs. Longman and Co., on account of Journal				59	4	1	Balance in favour of the Society	5143	14	1
Due from Subscribers to Journal				35	0	0				
Due for Authors' Corrections in Journal				35	7	10				
Balance in Banker's hands				365	9	6				
Balance in Clerk's hands				90	8	8				
Funded Property:—										
Consols, at 95	4350*	0	0							
				4350	0	0				
Arrears of Admission-fees (considered good)				88	4	0				
Arrears of Annual Contributions (ditto)				120	0	0				
				£5143	14	1		£5143	14	1

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

JOSEPH PRESTWICH, *Treas.*

Jan. 28, 1864.

* Including the balance of £300 remaining from the Greenough and Brown Bequest-fund.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal (considered good)	35	0	0			
Due for Authors' Corrections	35	7	10			
Due for Arrears (See Valuation-sheet)	120	0	0			
				190	7	10
Estimated Ordinary Income for 1864.						
Annual Contributions:—						
Resident Fellows at £2 2*s.*, and Non-resident Fellows at £1 11*s.* 6*d.*				600	0	0
Admission-fees (supposed)				300	0	0
Compositions (supposed)				250	0	0
Dividends on Consols				132	15	10
Sale of Transactions, Proceedings, Geological Map, Library-catalogues, and Ormerod's Index				100	0	0
Sale of Quarterly Journal				200	0	0
Due from Longman and Co. in June				59	4	1
Balance due from Bequest-fund on Expenditure on Map, Library, and Museum				130	7	3
				£1962	15	0

JOSEPH PRESTWICH, TREAS.

Jan. 28, 1864.

the Year 1864.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes and Insurance	35	0	0			
House-repairs	20	0	0			
New Furniture	50	0	0			
Fuel	35	0	0			
Light	35	0	0			
Miscellaneous House-expenses	75	0	0			
Stationery	25	0	0			
Miscellaneous Printing (Abstracts, &c.)	25	0	0			
Tea for Meetings	20	0	0			
				320	0	0
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	120	0	0			
Assistants in Library and Museum	85	0	0			
Porter	90	0	0			
Housemaid	40	0	0			
Occasional Attendants	20	0	0			
Collector	20	0	0			
				575	0	0
Library				100	0	0
Museum				50	0	0
Diagrams at Meetings				12	0	0
Miscellaneous Scientific Expenditure				50	0	0
Publications: Quarterly Journal	550	0	0			
,, Transactions	5	0	0			
,, Geological Map	100	0	0			
				655	0	0
				£1762	0	0
Balance in favour of the Society				200	15	0
				£1962	15	0

Income and Expenditure during the

INCOME.

	£	s.	d.	£	s.	d.
Balance in Banker's hands January 1, 1863				490	14	10
Balance in Clerk's hands				22	8	4
Compositions received, 1863				210	0	0
Arrears of Admission-fees				25	4	0
Arrears of Annual Contributions				85	1	0
Admission-fees for 1863				340	4	0
Annual Contributions for 1863, viz.—						
250 Resident Fellows	£505	11	6			
27 Non-Resident Fellows	42	10	6			
				548	2	0
Dividends on Consols				132	15	10
Publications:						
Longman and Co., for Sale of Journal in 1862.	47	14	7			
Sale of Transactions	4	18	4			
Sale of Journal, Vols. 1–6	6	7	4			
" Vols. 7–12	9	10	0			
" Vols. 13–15	4	5	6			
" Vol. 16	3	15	6			
" Vol. 17	12	12	10			
" Vol. 18	31	11	4			
" Vol. 19* (1863)	103	18	3			
				224	13	8
Sale of Geological Map	6	16	3			
Sale of Library-catalogues	3	15	0			
Sale of Ormerod's Index	2	1	4			
Sale of Proceedings	0	1	0			
				12	13	7
				£2091	17	3

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

(Signed) JAMES TENNANT, ALFRED TYLOR, } *Auditors.*

Jan. 30, 1864.

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XIX., &c.	£59	4	1
Due from Fellows for Journal-subscription	35	0	0
Balance due from Bequest-fund on expenditure on Map, Library, and Museum	130	7	3
	£224	11	4

Year ending December 31st, 1863.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	24	10	8			
Fire-insurance	3	0	0			
New Furniture	27	8	1			
House-repairs	6	15	0			
Fuel	31	17	0			
Light	32	17	11			
Miscellaneous House-expenditure	73	17	5			
Stationery	23	1	9			
Miscellaneous Printing	20	13	9			
Tea for Meetings	22	10	3			
				266	11	10
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	120	0	0			
Library and Museum Assistants	54	8	4			
Porter	90	0	0			
Housemaid	40	0	0			
Occasional attendants	14	10	0			
Collector	17	10	6			
				536	8	10
Library				104	8	8
Museum				32	0	8
Diagrams at Meetings				6	10	0
Miscellaneous Scientific Expenses, including Postages				38	2	1
Publications:						
Transactions	2	3	9			
Journal, Vol. XVII.	5	17	9			
„ Vol. XVIII.	71	16	0			
„ Vol. XIX.	571	19	6			
				*651	17	0
Balance at Banker's, Dec. 31, 1863				365	9	6
Balance in Clerk's hands, Dec. 31, 1863				90	8	8
				£2091	17	3

* £72 15*s.* 3*d.* of this amount belongs to the expenditure of 1862, being a sum due to Mr. West, omitted in that year's payments, as per note to 1862 accounts.—J. P.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

19TH FEBRUARY, 1864.

AWARD OF THE WOLLASTON MEDAL.

THE Reports of the Council and of the Committees having been read, the President, Professor A. C. RAMSAY, delivered the Wollaston Medal to Sir RODERICK MURCHISON, addressing him as follows:—

Sir RODERICK MURCHISON,—The accident of your retirement from the Council of this Society last year, as one of its senior Members, has enabled us to bestow on you that honour, which, but for your previously unbroken services on the Council for a period of thirty-two years, would, I well believe, have been conferred on you many years ago. The fame of your great original work on the Silurian System, in which you clearly unravelled the intricacies of the Lower Palæozoic rocks on the borders of Wales, was already established before I ever set foot in these rooms; and the whole geological world knows how well that fame has been maintained in many books and memoirs, and also in the field, in the development of the geology of European Russia, and last, not least, in the singular revolution you have effected in the classification of the strata of your native Highlands. To me it is a peculiar pleasure, as President, to be accidentally the means of placing in your hands this medal, because I believe it is impossible to place it in hands that have more worthily wielded the hammer; and, perhaps, on this occasion I may be pardoned for recalling the memory of a time I well remember, when, of all the geologists of weight, you, Sir, were the first who held out the hand of fellowship to me, a young man, when four-and-twenty years ago I was struggling to enter into the ranks of geologists.

Sir RODERICK MURCHISON replied in the following manner:—

Mr. PRESIDENT,—As upwards of forty years have elapsed since I had the good fortune to profit by social intercourse with that eminent man, Dr. Wollaston, and as I was deeply indebted to him for sound advice, which has been of use to me through life, and which he then gave to a willing tyro only in science, you can well believe me when I say that the acquisition of the medal which bears his effigy is an honour which, as an English geologist, I deeply prize.

I receive this medal, Sir, with feelings of gratitude to the Council and yourself, inasmuch as by your award you have recorded the opinion that by my labours I have established some of those landmarks in our science, the elaboration of which was the main object of Wollaston's dying bequest. I further especially value it because, in associating me in memory with the great philosopher, it is, at the same time, a testimony that I retain the goodwill of men among whom I have long laboured, and whom it is my pride to have served in bygone times, during five years as Secretary and four years as President.

I have only to add, Sir, that my gratification has been much increased by receiving this medal at your hands, whilst I can only attribute the too high estimate you have been pleased to make of my researches and works to the appreciation of a warm friend.

Award of the Wollaston Donation-fund.

The President then addressed the Foreign Secretary, and said:—

Dr. Falconer, to you I now deliver the balance of the Wollaston Fund, with the request that you will cause it to be conveyed to M. Deshayes, in testimony of the high value this Society has always attributed to his labours, especially in the field of Tertiary palæontology, with an expression of hope that this donation may be of some use to him in the further prosecution of his important work on the 'Mollusca of the Paris Basin.'

Dr. Falconer replied as follows:—

Sir,—I have great pleasure in being the medium of communicating to M. Deshayes the mark of distinction which the Geological Society has this day, for the third time, conferred upon him by the award of the proceeds of the Wollaston fund. I will make known to M. Deshayes the sustained interest which the Society takes in his researches, which have contributed so importantly to the advancement of our knowledge of the Molluscan fauna of the Paris Basin, and express the hope that this renewed mark of our sympathy may induce M. Deshayes to persevere in laying before the world the latest results of his extended labours.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

PROFESSOR A. C. RAMSAY, F.R.S., &c.

Before entering on the subject which I have chosen for my Anniversary Address, in accordance with the custom of the Society, I must now read the Obituary Notices of those Members of the Society who had distinguished themselves in the prosecution of our science, and whose deaths were reported to us between January 1863 and January 1864.

LUCAS BARRETT, Director of the Geological Survey of Jamaica, was born in London, on the 14th November, 1837. He went to school with Mr. P. Aston, at Royston, where he acquired his first love for geology by collecting fossils of the Chalk. Afterwards he was at University College School, and in his holidays became a frequent visitor at the British Museum, where he was a great favourite with the naturalists. In 1853–54 he passed a year at Ebersdorff, studying German and chemistry, and made a geological tour in Bavaria. In 1855 he accompanied Mr. M'Andrew in a dredging-excursion from the Shetlands to Norway and beyond the Arctic Circle, in which he kept a register of all the operations, after the method of Prof. E. Forbes, and made some good observations on living *Terebratulæ*.

In the same year he was elected a Fellow of the Geological Society of London, being the youngest member yet admitted, and was made Curator of the Woodwardian Museum by Professor Sedgwick.

In the following spring he went out to Greenland, in the hope of extending his researches in the deep-sea zones. This expedition was attended with considerable hardship and expense; but no record remains, beyond the suites of specimens in the British Museum, at Cambridge, and at Isleworth.

In 1857 he made another dredging-cruise with Mr. M'Andrew to the north coast of Spain, and added considerably to his collection of *Radiata*, which remains intact, at Cambridge.

In these years, 1856–58, he delivered most of the geological lectures for Professor Sedgwick, by whose wish he had entered his name and kept one term at Trinity. Very large additions were made to the Cambridge Museum in his time, and he was the discoverer of bones of Birds in the Upper Greensand, and of some new and remarkable forms of Pterodactyle. He also prepared a geological edition of the Ordnance Map of Cambridgeshire, which was published by Macmillan.

In March 1859 Mr. Barrett was appointed to the direction of the Geological Survey of Jamaica on the retirement of Mr. Wall, and thus obtained a more extended sphere of occupation for his enterprising talents. By the following November he had made such progress with the survey of Jamaica as to have finished the first sheet of a geological map, and to send to this Society a notice of the Cretaceous formations of the island. (Quarterly Journal, vol. xvi. p. 324.)

He had ascertained that the copper-bearing slates and purple conglomerates, with their interbedded porphyries and hornblende-rocks, which form the axis of the principal range of the Blue Mountains of Jamaica, supposed, in accordance with the geology of the period, to be "transition rocks" by Sir Henry de la Beche (Geol. Trans. 2nd ser. vol. ii. p. 143), were really of Cretaceous age, containing the characteristic fossils of the Hippurite-limestone. He also ascertained that the "Orbitoidal limestone," formerly regarded as Carboniferous, was at the base of the Miocene series; and from the newest part of the well-known white Miocene limestone he obtained 71 Shells and several Corals, afterwards examined by Mr. H. Moore and Dr. Duncan, the results of which are printed in our Journal.

I am informed that, in his letters, Mr. Barrett gave many valuable details respecting the newest Tertiary strata (Pliocene) of Jamaica; and that he might the better understand their relations, he commenced to dredge the neighbouring sea-bottoms in from 15 to 150 fathoms and upwards, in which he found about 100 species of minute shells similar to those that have been found at similar depths on the coasts of Norway, Japan, and in the Ægean Sea. It would be out of place here to give a list of these forms; but I have been told by Mr. S. Woodward that from them he "acquired the belief that 9-10ths or perhaps 99-100ths of the sea-bed, viz. the whole area *beyond the* 100-*fathom line*, constitutes a single nearly uniform province all over the world."

There still remained for Mr. Barrett the region of the coral-reefs, which cannot be explored with the dredge, and there he expected to find the living representatives of the fossils described by Mr. Moore and Dr. Duncan. In 1862 Mr. Barrett was in England as one of the Commissioners from Jamaica to the International Exhibition; and on his return to Jamaica in the same year, he took with him a diving-apparatus to enable him personally to explore the reefs. Having once gone down safely and successfully in shallow water, he would not wait for the assistance of his friends; and set out on the 19th of December, attended by a negro crew and servants, to the coral-reefs outside Port Royal. At some distance from the land he descended into deep water, provided with 100 feet of air-tubing, and holding the "life-line" only in his hand; and after the lapse of more than half an hour he floated to the surface, but no longer alive. Thus unhappily perished Mr. Barrett, a victim to his own enthusiasm, at the early age of 25. To these sorrowful details I may add that Mr. Barrett was married only a few days before his first voyage to Jamaica; and he has left one child, Arthur, whom he never saw, and who was born at Cambridge, in January 1863, after his own untimely end.

He was the author of eleven memoirs on geological and zoological subjects, chiefly published in the 'Annals of Natural History' and in the 'Quarterly Journal of the Geological Society.'

Though not at any time actively engaged in geological science, the Society has lost by the death of the venerable MARQUIS OF LANSDOWNE, one whose capacious understanding and great accomplishments induced a corresponding sympathy with almost every branch of human knowledge. I have often been struck with the vigorous manner in which, conversing with men of science, he used to master all the salient points connected with any new discovery or adaptation to new purposes of an old one. Eager, earnest, and simple in his demeanour, without affectation or show of needless patronage, every one he conversed with felt not only at his ease, but, however eminent, that he was also in the society of his intellectual equal; and the manly independence of his character was never more strikingly manifested than in a circumstance mentioned by Sir Roderick Murchison in his Anniversary Address of last year to the Geographical Society, in which he states, "when all his friends in the Government had, as his co-Trustees, come to the conclusion that it was expedient to break up the British Museum by severing from it its natural-history contents, Lord Lansdowne, then in the last year of his valuable life, qualified his unwilling assent in a letter, expressing his regret that an adequate expenditure could not have been obtained to keep united those memorials of art, letters, and science in the one great and unrivalled national repository which he had so long admired."

By the death of Mr. John Taylor, which took place on Easter Monday last, in his 84th year, we have lost one of our oldest Fellows—one whose long and useful career has for more than half a century been associated with the objects and the actual working of our Society. Mr. Taylor joined the first founders of our body in 1807, and filled the responsible office of Treasurer from 1816 to 1843, contriving to devote to our interests no small portion of his time, which during that period was closely occupied by the charge of numerous and great undertakings in British and foreign mining-districts.

Born at Norwich, and exhibiting as a boy a strong inclination for scientific pursuits, Mr. Taylor was introduced to the mines of the west by the accident of being taken by some intimate friends to visit the copper-mine of Wheal Friendship, near Tavistock. On this occasion his aptness and energy led to a proposal from the shareholders, in accordance with which, at the age of 19, he was installed there as superintendent, with the special object of reforming abuses which had crept into the administration. His judgment, uprightness, and firm but considerate management of the men under his charge soon achieved success, and within the next few years he was entrusted with the conduct of other enterprises, especially of the ancient tin-mine called Drakewalls, on the Cornish side of the Tamar, and of the construction of a canal from Tavistock to the same river, which had to be carried by a long tunnel through Morewell Down, the various difficulties of which, in a branch of engineering then so little practised, were all to be overcome by his own ingenuity and perseverance. A description of this work was written by Mr. Taylor for our 'Transactions' (1st ser. vol. iv. p. 146), shortly after he had contributed another paper "On the Economy of the Mines of Cornwall and Devon" (vol. ii. p. 308).

Until the year 1812, Mr. Taylor continued to reside at Tavistock, occupied with the introduction of arrangements tending to the well-being of the miners, and with improvements in the machinery. He was on intimate terms with the group of remarkable men who were at that time perfecting the Cornish pumping-engine and its boilers; and he was among the first to appreciate and apply every invention for avoiding accidents, and increasing the "duty" of the steam-engine. Moreover, Wheal Friendship, contiguous to the abundant streams of Dartmoor, offered a fine field for the application of hydraulic power; and, under the fostering care of Mr. Taylor, it became, as it is still, the most notable among our western mines for its powerful water-wheels. Meanwhile his unswerving rectitude and cheerful benevolence, of which his features were an index, had endeared him alike to the employers and employed; and rendered it feasible (for him) after several years passed in London in chemical investigations, to launch undertakings of a far greater calibre. He had proved himself a skilful engineer, a wise manager, and a judicious miner; and in 1819 he succeeded in conjoining a number of mines in Gwennap, under the name of the Great Consolidated Mines, into a vast concern, for many years the largest and most profitable mine in the world. In 1824, led by the popular enthusiasm for the Spanish American Republics, and by Von Humboldt's favourable report of the prospects of the silver-mine, he undertook the direction of speculations on a large scale in Mexico, where the attempt to introduce English machinery and methods, coupled with the difficulty of ensuring good management at so great a distance and with so peculiar a native race, formed no ordinary obstacles to success. He had become famous as an administrator, and, placed at the head of a profession which he had in fact originated, he directed from his London offices, with the aid of his sons and carefully selected captains, mining-adventures in all parts of the globe. Trusted and beloved as he was by men of mark both in the scientific and commercial world, he had only to recommend a project, and a party of his friends would at once prepare the necessary capital. Nor is it unsatisfactory to find that, in despite of occasional heavy losses, inseparable from the nature of the work, the average results were, on tabulating the experience of forty-five years, highly remunerative.

In 1825 Mr. Taylor became a Fellow of the Royal Society, and five years later was one of the first promoters of the British Association, of which body he was appointed Treasurer and Trustee. To its volume of Reports for 1833 he contributed a valuable and laborious Report on the state of knowledge respecting mineral veins.

The liberal bent of his mind induced him also to become an active promoter of the London University College, where he fulfilled the duty of Treasurer for many years.

Besides contributing several papers to our 'Transactions' and 'Proceedings,' and to those of the British Association, Mr. Taylor laboured in other directions to place on a scientific basis the practice of mining, which at his first entry into life was palpably defective at many points. He commenced in the 'Records of Mining,' in 1829, what he hoped would command the attention of the public as a standard periodical for mining and metallurgy; and in the first and only part which appeared he inserted a sensible and well-considered treatise on the education of miners and the proposed establishment of a school in Cornwall. With the same end in view of advancing knowledge, and thereby of furthering the commercial prosperity of those classes in which he was especially interested, he collected and published statistics during a period when scarcely any public record of our mineral produce existed, and contributed important aid to the collection of those valuable Returns which are now annually edited by Mr. Hunt at the Museum of Practical Geology.

It was in great part Mr. Taylor's thirst for knowledge and desire to extend it, coupled with his mental activity, his honour, and thoroughly tolerant spirit, that enabled him so successfully to form arrangements for working mines amid the most various populations. His name was thus well known in Spain, France, and Portugal, in the United States, Mexico, and Cuba, in Australia and California; and it may confidently be said that whoever in these countries, Englishman or native, was acquainted with him will have felt that the death of John Taylor has taken from him a friend.

Mr. Samuel Peace Pratt, F.R.S., F.L.S., was born on the 6th of November, 1789, and was educated at Mr. Clarke's school at Enfield. At Tottenham, where he resided with his parents, he was well known in youth for his great eagerness in the pursuit of the physical sciences, rising before dawn in winter and at daylight in summer to devote himself to his favourite studies. In this manner he took up successively chemistry, botany, mineralogy, astronomy, natural philosophy, and geology. I am told, by one who knew him well, that he first turned his attention to the last-named science in 1812. In 1823 he went to reside at Bath, where he remained about sixteen years, during which period he was an active member of the Bath Literary Institution.

In 1829 he was elected a Fellow of this Society, and in 1831 he read a memoir, published in our 'Transactions,' "On the Existence of *Anoplotherium* and *Palæotherium* in the Lower Freshwater Formation at Binstead, near Ryde, in the Isle of Wight;" and in June 1833 he contributed a paper "On the Osseous Caves of Santo Ciro," near Palermo, in which he showed, from the boring of *Lithodomus,* that the country had undergone recent elevation subsequent to the Mediterranean being inhabited by existing species; and also, in common with Dr. Turnbull Christie, who had observed the same phenomena in 1831, he notices the occurrence in the cave of bones of Hippopotami, teeth of Elephants, and other Mammalia.

In 1843 Mr. Pratt read a memoir "On the Geology of the neighbourhood of Bayonne."

In 1852 he again gave an important memoir to the Society "On the Geology of Catalonia," in which he described a series of formations all highly disturbed and associated with bosses of granite. They range from certain schistose beds beneath the Carboniferous limestone, through Oolitic, up to Eocene and Miocene strata; and in this memoir Mr. Pratt corrected some grave errors inserted in the French map of the district.

In 1837 Mr. Pratt gave "A Description of the Geological Character of the coast of Normandy," in which he corrected some of the views previously published by De la Beche and Elie de Beaumont, and described with great accuracy the strata ranging between the Lias and the Chalk Marl, which he showed are the true equivalents, somewhat modified, of similar strata in England.

Several other memoirs were contributed to this Society, all of considerable value; and one on the coal-deposits of the Asturias to the British Association in 1845, in which he shows that the coal of the district is of true Carboniferous age, and that beneath it are several remarkable beds of hæmatite, one of pure unmixed ore 50 feet in thickness.

Mr. Pratt was also well known to the Geological Society of France, to which body he communicated memoirs.

It must still be fresh in the minds of many Fellows of the Society that we were much indebted to Mr. Pratt for various contributions to the Museum; among others, a collection of Catalonian fossils, and a quantity of Mammalian bones from the caves of Palermo. Also, in conjunction with the late Mr. Daniel Sharpe, he devoted great time and labour to the arrangement of a vast accumulation of specimens of rocks and fossils, both foreign and British. Mr. Pratt also, unassisted, revised the collection of minerals in the Museum; and, indeed, until a few years ago, when his health gave way, Mr. Pratt, known and respected in the Council-room, in the Museum, and at the evening-meetings, was esteemed by all as an able and zealous Member of the Geological Society.

He died last year, at the age of 75.

Eilhard Mitscherlich, the eminent Professor of Chemistry at the University of Berlin, was born on the 7th of January, 1794, at Neuende, near Jever, in East Friesland, where his father was pastor. Here he studied under the historian Schlosser, with whom he went to Frankfort. In 1811 he went to Heidelberg and afterwards to Paris, devoting his attention to the study of history and philology. In 1818 his pursuits took a different direction, and at Berlin he gave himself wholly to the study of the natural sciences, and especially of chemistry. In the last-named science, in 1820 and 1822, he speedily rendered his name famous by his memoirs in the 'Annals of Chemistry and Physics,' "On the relation existing between crystalline form and chemical proportions." In other words, he discovered the law of isomorphism. By this law he first showed that the crystalline form of compound bodies is in relation to the nature of their components and the weight of their equivalents; so that in numerous compound bodies, by virtue of analogies of composition, one of the principal components may be replaced by another without the minerals undergoing any change in their outward form; and this discovery was rendered complete by a second, namely, by that of dimorphism, in which he showed that sulphur has the property of crystallizing under different conditions in two dissimilar forms.

Berzelius, thoroughly appreciating the value of these discoveries, invited the young chemist to Stockholm, where in the laboratory of the great Swede he spent two years; and on his return to Germany in 1822 he was appointed Professor of Chemistry at Berlin, and elected a member of the Berlin Academy of Sciences. Occupied much with crystallography, he greatly improved the goniometer, and thus overcame certain objections to his law of isomorphism, proving that the inequalities in the corresponding angles of certain crystals are not greater in the isomorphous forms than in many of those that possess even the same chemical composition.

The researches of Professor Mitscherlich on artificial crystals threw much new light on the formation of natural crystals. He also made observations on the points of fusion of rocks by heat, and published memoirs "On the volcanic phenomena of the Eifel" and "On the occurrence of boulders of granite and porphyry on the higher Apennines, near Naples," &c. He also published a celebrated manual of chemistry, which went into a 5th edition in 1856.

In 1828 the Royal Society of London elected him one of its foreign members, and in 1829 awarded him the Royal Medal for his discoveries in crystallography; and in 1832 he was elected a foreign member of this Society. In 1852 he was elected one of the few foreign Associates of the Imperial Academy of Sciences of the Institute of France. He died at Berlin in 1863, at the age of 69.

Though contrary to our custom, I may be pardoned for alluding to the death of a gentleman who was not a member of our Society, but who contributed several important papers to our Journal.

The Rev. Stephen Hislop was born at Dunse, in Berwickshire, on the 8th of September, 1817. After passing through the schools of his native village, he attended the Universities of Glasgow and Edinburgh, completing his theological studies at the New College in the latter city. He went out as a missionary to Nágpore, in Central India, during the latter part of 1844. From his youth up he had always given more or less attention to geology; but it was not until the seventh year of his residence in India that he commenced the series of researches which terminated only with his death. When walking with his colleague in June 1851, about two miles from Nágpore, he unexpectedly came upon a specimen of the *Physa Prinsepii*. He was aware that this and a few other Tertiary molluscs, sometimes associated with silicified wood, had been detected by Dr. Malcolmson, Dr. Spilsbury, and others, in various parts of Central India; but, so far as he knew, the occurrence of fossils in the immediate vicinity of Nágpore itself had not previously been suspected. From this period, whatever leisure remained to Mr. Hislop, after the satisfactory discharge of his professional duties, was given to geology. Various military friends joined in the inquiry; mission-tours were turned to good account; and a series of remarkable discoveries was the speedy result. Between one and two years subsequently, Mr. Hislop sent to the Bombay branch of the Royal Asiatic Society a brief paper on the Nágpore researches, which was printed in that Society's Journal for July 1853. Afterwards, in conjunction with the Rev. R. Hunter, his fellow labourer, he transmitted a paper to the Geological Society of London, which was read on June 21st, 1854, and published in the Quarterly Journal for August 1855. Several supplementary papers followed from the pen of Mr. Hislop, of which the most important was a description by himself, when he was in this country on sick-leave, of the Nágpore Tertiary Shells. Professor Owen described and named a Labyrinthodont Reptile from the Nágpore collection—the *Brachyops laticeps.* Professor T. Rupert Jones drew out a brief memoir on the Cyprides. Andrew Murray, Esq., F.R.S.E., took up the subject of the Insect-remains. Sir Charles Bunbury, Bart., described the older series of fossil Plants which had been deemed Oolitic, but which still require further research to determine their precise date. The Rev. Professor Haughton, F.R.S., detected in the Nágpore collection two new minerals, one of which he designated Hislopite. The newer, or Tertiary series of Plant-relics, with some recently discovered Reptilian remains and other fossils, have still to be described.

Mr. Hislop can, however, now no more give assistance in Central Indian research. On the 4th of September last he was drowned, about twenty miles south of Nágpore, while attempting, after dark, to cross the flooded backwater of a river. When thus unexpectedly cut off, he was in the full vigour of his strength, physical and mental, being no more than 46 years old. The contribution for his widow and four orphan children of more than £3000, of which sum about £2000 was raised in India, is an emphatic testimony on the part of the public that the deceased missionary had faithfully discharged the responsible trust confided to him, while yet finding time to advance the interests of his favourite science in no inconsiderable degree.

At the close of my Anniversary Address of last year, I said that I might probably return to the subject on a future occasion; and an opinion having been expressed by some of my friends that a continuation of the investigation applied to the Secondary Formations would be acceptable, I have determined on this occasion to discuss

The Breaks in Succession of the British Mesozoic Strata.

In the previous Address I showed that, in Britain, between the Laurentian gneiss and the Permian strata there are ten physical breaks, or, in other words, unconformities repeated ten times; and each of these cases is accompanied by a sudden and remarkable change of fossils, sometimes in the genera, and always in the species, so much so indeed that sometimes the change in species is altogether or nearly complete. I further connected these interruptions of the continuity of life and the coincident stratigraphical breaks in this way, namely, that they are probably a necessary accompaniment of the influences that produced the change of species, especially if we adopt the view of descent with modification, in so far that the gaps in the geological series of formations indicated by the unconformities, or, in other words, the missing records of palæozoic time are possibly, and I believe probably, much longer than those of which the various existing Palæozoic formations of Great Britain bear witness.

I shall now endeavour to discover how far and in what manner the same kind of reasoning is applicable to the Secondary strata; but before entering fairly on the subject, I must make a few remarks on some points relating to the Palæozoic formations, which are, in my opinion, intimately connected with the newer phase of life of the Mesozoic epoch.

Commencement of the Prevalence of Secondary Genera in Carboniferous times.—First, then, if we examine all the Palæozoic fossiliferous formations in the British series, it is evident that there is towards the end a state of things showing, as it were, an approximation to the peculiar grouping that is characteristic of Mesozoic life. Thus, if we take the bivalve Shells, the Gasteropoda, and the Cephalopoda as tests, we roughly find the proportions given in the Table on the next page.

From the Table, it is evident that, massing the individual formations and ignoring the finer subdivisions, from Lower Silurian to Devonian times, the Lamellibranchiate Mollusks, though equal to or more numerous generically than the Brachiopoda, are much less numerous in species, and the excess of the latter in Upper Silurian times is, perhaps, not greater than we might expect from local circumstances. The same kind of remark applies to the Brachiopoda; but while in the Lower Silurian beds the Lamellibranchiata are to the Brachiopoda as 2 to 5, in the Upper Silurian the proportions approximate to 3 of the former to 4 of the latter; while in the Devonian rocks the proportions are very nearly the same as in the Lower Silurian. It is worthy of remark that the Devonian grouping of bivalves thus approaches closely to that of the Silurian rocks, and is in this very far removed from the Carboniferous grouping*. When we compare the Carboniferous bivalve-fauna with the more ancient palæozoic formations, and specially with the Devonian, we find the proportions of Lamellibranchiate mollusks to the Brachiopoda suddenly reversed, the former being in the proportion of nearly 7 to 3 of the latter. Indeed it may be said that, while individually, as specimens, the Carboniferous Brachiopoda generally outnumber the Lamellibranchiata, the latter, as species, more than double the former. In the scanty and imperfect fauna of the Permian beds an analogous development is found; and in both formations the outnumbering of the Brachiopoda by the Lamellibranchiata strongly points towards the marvellous decline of the one class and the great development of the other in

* More closely analyzed, the Marwood beds form one of the links between true Devonian and true Carboniferous, but their fossils are much closer to the Carboniferous than to the Devonian type.

Table I. *Showing the comparative numbers of* Brachiopoda, Lamellibranchiata, Gasteropoda, *and* Cephalopoda *in the Formations between the Lower Silurian and Cretaceous Epochs.*

	Lamellibranchiata.						Brachiopoda.		Gasteropoda.		Cephalopoda.	
	Monomyaria.		Dimyaria.		Total.							
	Genera.	Species.	Genera.	Species.	Genera.	Species.	Genera.	Species.	Genera.	Species.	Genera.	Species.
Lower Silurian	5	18	10	23	15	41	15	100	16 (?)	20 (?)	5	37
Upper Silurian	3	17	17	59	20	76	16	91	12	37	5	47
Devonian	3	17	16	30	19	47	14	96	11	44	5	45
Carboniferous	9	116	35	166	44	282	16	123	21	167	7	137
Permian	3	5	13	25	16	30	10	23	9	20	1	2
Muschelkalk	8	31	11	32	19	63	15	27	15	27	4	16
Saint Cassian Beds (Bronn).	8	65	15	68	23	133	6	45	27	352	6	89
Saint Cassian Beds (Münster).	..	..	..	..	18	72	5	27	26	191	6	33
Kössen (British)....	8	12	13	20	21	32	2	2	7	15	0	0
Lias..............	14	54	22	70	36	124	9	39	8	32	4	130
Oolites	18	172	50	364	68	536	7	69	47	366	6	137
Cretaceous	13	153	43	173	56	326	14	59	34	129	13	170

mesozoic times. The same inference may be even more specially and strongly drawn in the great development of the order Monomyaria in Carboniferous times.

With respect to the Gasteropoda I am not so confident, and yet I think it probable that the same argument might be applied to them; and there is little doubt that it may be used with safety in reference to the Cephalopoda. In Lower and Upper Silurian and Devonian strata the proportions, with some changes of genera, are not very different, ranging (say) from 37 to 50 species; but, suddenly, in the 7 genera and 137 species of the Carboniferous rocks we have an approximation to the vast development of Cephalopodous life in secondary times, and the resemblance is strengthened by the large proportion of *Nautili* and *Goniatites*, one a prevalent secondary genus, and the other closely allied to *Ceratites* and the *Ammonites*.

In some respects, therefore, the later palæozoic stages in their forms of life are clearly leading, as it were, up to secondary times, and closely foreshadow their advent.

Secondary Formations. New Red Sandstone series.—I now come to the secondary strata themselves. Every geologist knows the thorough stratigraphical break between the palæozoic and mesozoic rocks that marks the commencement of the New Red Sandstone in England, so complete, indeed, that, from Devonshire to Yorkshire, some part or other of that great formation lies as it were at random on almost every principal member of the palæozoic series; in Charnwood Forest, for instance, on so-called Cambrian rocks, in Gloucestershire on Silurian, in Devonshire and South Wales on Devonian strata, in Somerset and Derbyshire on Carboniferous beds, and in Warwickshire and Staffordshire, Shropshire, Lancashire, Derbyshire, and Yorkshire, on all parts of the Permian rocks from the equivalents of the Rothliegende up to a high stratum of the Magnesian Limestone.

The New Red series consists, in England, of the following subdivisions—

Keuper {
Kössen or Westbury beds,
New Red marl with streaks of sandstone,
White and brown sandstone and marl;

Bunter {
Upper variegated sandstone,
Conglomerate or pebble-beds,
Lower variegated sandstone;

and in no part of England is there any symptom of a passage from Permian into the lowermost New Red Sandstone strata; for in Yorkshire and Derbyshire, where they lie apparently at the same angle, the lower variegated sandstone is absent, and the second member, the pebble-beds, lies on the incompleted Magnesian-limestone series; in South Staffordshire the same pebble-beds lie on the middle part of the Rothliegende, or what I consider the ice-drifted erratic boulder-beds; while further west, skirting the older formations from Worcestershire to Flintshire, the lower variegated sandstones (the lowermost English Bunter beds) lie on Permian strata, sometimes above the boulder-beds and sometimes below, until finally they intrude on the Coal-measures. The disturbance, contortion, partial upheaval into land, and vast denudations which the palæozoic rocks underwent before and during the deposition of the New Red Sandstone in the west of Europe is so well known that I need not enlarge upon it; and, on the principles advocated in last year's Address, there is every reason, in the enormous lapse of time indicated by this vast denudation and unconformity, why it should be accompanied by the wonderful generic changes and total change of species that mark the sudden lapse from palæozoic to mesozoic time.

St. Cassian and Kössen beds.—But in our country we have no certain relics of common marine life in the New Red Sandstone to compare with those of the underlying palæozoic formations, and therefore I must transgress a little from the rule I imposed on myself last year, and give a brief sketch of the leading differences between the upper palæozoic marine molluscous faunas and those of the St. Cassian and Kössen beds, well known to be largely developed in the Italian and Bavarian Alps, but the former of which has no representative in England.

As nearly as I can make out from consulting the writings of Gümbel, Escher, Hauer, and others, the order of superposition of these strata is as follows; and I add what I believe to be their English equivalents:—

Continental.	English.
1. Rhætic beds or Kössen beds	Westbury beds, Bone-bed, and *Avicula-contorta* beds.
2. Plattenkalk or Rissoa-beds	
3. Hauptdolomit or Dachstein-beds	
4. Gypsum and Rauhwacke	Keuper marls and sandstones.
5. Lower Muschelkeuper	
6. Lower Keuper limestone	Lower Keuper Sandstone.
7. Letten Keuper or St. Cassian beds	Unrepresented in England.
8. Upper and Lower Muschelkalk	
9. Schwärzlicher Mergelkalk	
10. Bunter Sandstone	New Red Sandstone.

From the foregoing table it is evident that with us, as is well known, the series is so imperfect, that for Nos. 7, 8, and 9, which include the Muschelkalk and St. Cassian beds, we have no terms of comparison with the Continental series. The fossils of the Muschelkalk, including, according to Bronn, 222 species, are so well known to be species of secondary type, that, were it not for their connexion with the St. Cassian beds, it is scarcely essential to my argument that I should say anything about them. But it is different with the St. Cassian beds. These strata, according to the Austrian and Swiss geologists, lie above the Muschelkalk, and yet the fossils they contain are of a more mixed type, and in part characteristically palæozoic. If we take the lists of Bronn, we find that he gives in all the enormous number of 774 species. Thus, he names 44 species of Amorphozoa and 8 of Bryozoa. Of Zoophyta he catalogues 36 species, of which 12 belong to palæozoic genera, namely, *Syringopora*, *Astræa*, *Cyathophyllum*, *Lithodendron*, and *Anthophyllum*. Of the Echinodermata there are 52 species, 39 of which are classed as belonging to the genus *Cidaris*; but none of the genera are truly palæozoic. Of the Brachiopoda there are 45 species and 6 genera, namely, *Terebratula, Rhynchonella, Spirifer, Orthis, Productus,* and *Crania*. Four of these are essentially of palæozoic types; and the genera *Terebratula* and *Rhynchonella,* of which there are 30 species, may be considered as typical of both epochs, although perhaps, as regards mere quantity, more common in mesozoic than in palæozoic times. Of the Lamellibranchiate Monomyaria there are 8 genera and 65 species, 2 of these belonging to the palæozoic genus *Posidonomya*; and of 15 genera and 68 species of Dimyaria, 5 of the genera (including 32 species of *Mytilus, Modiola, Arca, Nucula,* and *Myophoria*) are both palæozoic and secondary. The only Heteropod, *Porcellia,* is of a palæozoic genus; and of the 27 genera (some of them doubtful) and 352 species of Gasteropoda, 4 genera, namely, *Natica* 30 species, *Trochus* 36 species, *Schizostoma* 5 species, and *Pleurotomaria* 46 species, are both palæozoic and secondary.

Of Cephalopoda there are said to be 6 genera and 89 species, namely, *Goniatites* 4, *Ceratites* 1, *Ammonites* 75, *Nautilus* 1, *Conchorhynchus* 1, and *Orthoceras* 7. Two of these genera—*Goniatites* and *Orthoceras*—are essentially palæozoic forms; the genus *Nautilus* is of both ages; one, the *Conchorhynchus,* is peculiar; and the other two are secondary forms. The few remaining Articulata, Crustacea, and Fish may be said to be secondary forms. The number of species altogether is probably greatly exaggerated; but, supposing the exaggeration to be about equal in all the classes and genera, the proportions would remain about the same; and the result would be that, out of 104 genera, 15 are characteristically palæozoic and 11 are mixed. Thus, out of 774 species, 44 belong to the 15 genera mentioned as characteristically palæozoic, while the 11 genera that occur both in palæozoic and secondary rocks yield 180 species, perhaps every one of which is confined to the St. Cassian beds. The broad generalization from this is, that $\frac{1}{7}$th of the genera and nearly $\frac{1}{5}$th of the species have a common palæozoic facies.

Again, if we take Münster's determination, we find that he gives a list and drawings of

Corals	14 genera,	53 species.
Echinodermata ..	4 ,,	35 ,,
Brachiopoda ..	5 ,,	27 ,,
Lamellibranchiata ..	18 ,,	72 ,,
Gasteropoda ..	26 ,,	191 ,,
Cephalopoda ..	6 ,,	33 ,,
Fish	4 ,,	5 ,,
Reptiles	1 ,,	1 ,,
	78	417

Of these, 8 genera and 29 species belong to palæozoic types, and 13 genera (including 104 species) are mixed. This gives very nearly $\frac{1}{10}$th of the genera and between $\frac{1}{14}$th and $\frac{1}{15}$th of the species as belonging to types characteristically palæozoic; and of these, according to Münster's tables, 12 species of the genera *Cyathophyllum, Calamopora, Terebratula, Avicula, Capulus, Natica*, and *Naticella* are found both in the Carboniferous rocks and in the Zechstein. If we add the palæozoic and mixed genera together, and also the species of those genera, we get, according to Bronn, 26 genera in all, out of 104, or $\frac{1}{4}$th, and 224 species in all, out of 774—less than $\frac{1}{3}$rd ($\frac{7}{24}$ths). Münster's lists, analyzed in the same way, give

21 genera out of 79, or nearly $\frac{1}{4}$th;
133 species out of 427, or less than $\frac{1}{3}$rd.

In this respect, therefore, they closely agree; and, judged by a test of this kind (which, though very imperfect, is surely significant), the St. Cassian beds may be said in rough terms, by their catalogued lists of fossils, to be $\frac{1}{3}$rd palæozoic and $\frac{2}{3}$rds mesozoic, although in the rocks themselves the palæozoic genera appear to be comparatively more rare than the others. They may, therefore, most conveniently be classed with the secondary rocks; but the wonder is that, placed as they are said to be above the Muschelkalk, the St. Cassian beds should be so far palæozoic in the character of their fossils, while the underlying Muschelkalk is so essentially secondary. Lying, as they do, in a mountain-region which has undergone the extremes of contorted disturbance and denudation, were it not that the order of superposition has been so strongly asserted by men of mark, one would be tempted to suppose that inversion and confusion of the strata has something to do with the presumed order of superposition, and that the St. Cassian beds are a stage in time nearer to the Zechstein than to the Muschelkalk. In Bronn's catalogue, indeed, they are boldly placed in that position.

New Red Marl or Keuper beds.—But in whatever position the St. Cassian beds may lie in the geological scale, in our own country it is most unlikely that we have any stratigraphical equivalents to these beds; for it is probable that they all belong to a period totally unrepresented in England, which came between the close of our Bunter sandstone and the beginning of the Keuper marls.

We are helped in coming to this conclusion by the circumstance that the white and brown sandstones (water-stones) that lie at the base of the New Red marl lie unconformably on the uppermost member of the New Red sandstone, as shown by Mr. Hull in a cutting of the St. Helen's railway near Ormskirk; and in many places they overlap the Bunter strata altogether and lie directly on various members of the palæozoic rocks. We have thus clear evidence of *a stratigraphical break* in the Trias of England; and the prodigious lapse of time between the close of the Bunter and the beginning of the Keuper periods may be inferred from the two vast developments of marine life during the St. Cassian and Muschelkalk periods of the Continent, between which, according to Münster, there are only 10 species in common. This idea of the great lapse of time between the close of the Bunter epoch and the commencement of the Keuper formations is strengthened by the circumstance that the rock-salt of our Trias lies at the base of the marly series; and as I know of no other

[*To face* p. xlvi.

Note.—April 27.—Since the passage about the Keuper beds (p. xlvi) was printed, I have ascertained that the rock-salt of Cheshire does not lie at the base of, but only low down in, the New Red Marl. In the deep well at Rugby, salt water rose when the Lower Keuper Sandstone (at the base of the Marl) was pierced.—[A. C. R.]

way in which rock-salt is likely to have been deposited in quantity except in salt-lakes, it seems to me that in the occurrence of this salt we have evidence of the upheaval of our Bunter beds into land, which remained above the sea for an indefinitely long period, during which the Muschelkalk and St. Cassian beds were deposited elsewhere, and in certain inland hollows of this land the salt was precipitated from the saturated waters. If so, it is just possible that the salt-beds may be partly the equivalents of the missing strata. But, however this may be, if the Bunter beds formed land surrounding saturated salt-lakes, we have in that circumstance a good reason why the truly marine St. Cassian beds and Muschelkalk should be absent in Britain.

Westbury or Bone-bed series, or Kössen and Rhætic beds.—I now come to those members of the British secondary rocks which are essentially fossiliferous; and before entering on the subject I wish to express my great obligations to my colleague, Mr. Etheridge, without whose wonderful knowledge of secondary species and their range in time it would have been impossible for me with accuracy to have constructed the tables on which much of my reasoning is founded *.

The Bone-beds were considered to form the base of the British Lias until, in the year 1841, they were declared by Sir Philip Egerton to form part of the Keuper series, in consequence of the generic characters of certain Fishes which they enclose. But, notwithstanding this correct determination, they were by most men persistently classed with the Lias, until, in 1860, by an elaborate analysis of the Shells of these strata and of the overlying Lower Lias, Dr. Wright again demonstrated their intimate relation with certain Triassic strata of the Continent.

In consequence of the want of frequent good sections at the base of the Lias, it is uncertain how far these Westbury or Kössen strata are continuous between Lyme Regis on the south and the coast of Yorkshire. This uncertainty is due partly to the soft and clayey nature of the strata, but especially because over more than half of England this base is hidden completely by the northern and other drifts. The chief points where the Westbury beds have been recognized are—Lyme Regis, in Dorsetshire; Up Hill, Watchett, Kelmersden, and Beer Crowcombe, in Somersetshire; Garden or Westbury Cliff, Wainlode Cliff, Combe Hill, Aust Passage, Witworth, and near Tewkesbury, in Gloucestershire; Penarth Cliff, in Glamorganshire; Wilmcote and Harbury, in Warwickshire; and in Needwood Forest, in North Staffordshire. As a general rule, however, from the south part of Leicestershire to Yorkshire these beds have not yet been observed, although when looked for they may perhaps be discovered.

Important as this subformation is in a palæontological point of view, it nowhere attains a thickness of more than from 20 to 50 feet; and it is therefore the more remarkable that throughout all the

* I have for years used such tables in my public lectures; but those now employed for my old tables are improved; and the secondary ones are entirely reconstructed from tables, *many yards in length*, by Mr. Etheridge, in which he shows the range in time of every individual secondary species.

middle and south of England it seems to be perhaps everywhere constant between the top of the New Red marl and the base of the undoubted Lias.

The number of fossils from these beds in England is considerable, comprising 32 genera and 51 species of Shells, 6 genera and 7 species of Fishes, 2 Reptiles, and one Mammal; in all, 41 genera and 61 species. Of these, 13 genera of Mollusca are common to the St. Cassian beds, and 18 to the Muschelkalk, and one species only, *Monotis* (*Avicula*) *decussata*, is common to all three formations, and it is also said to be found in the Lower Lias. Between the New Red marl and the Westbury or Bone-beds no appearance of unconformity has been noticed, though there is a perfectly sudden break lithologically from red marl to black shales; but as we have no fossil Shells in England in the marl, and no Shells at all by which to compare the two formations, there is nothing to be said about the sudden appearance of the new fauna, except that, unless some strata be absent intermediate in date between our Red Marl and the Westbury (Kössen) beds, the lithological change and the difference in colour between the marl and the shale indicate a change in conditions accompanied by a fauna that migrated hither from some other area. Though specifically distinct, yet nearly half of the genera of that fauna being common to the Muschelkalk, the triassic affinities of the group are sufficiently strong.

Lias.—It is remarkable, however, that when we come to the *Lower Lias*, only one species, mentioned above, is common to the two formations, even though there is no marked lithological break, and no unconformity has been observed between them. The exposed sections, however, are so scarce (the junction only having been observed in the southern half of England), that it is not impossible that overlaps may exist in places.

The *Lower Lias* averages from 600 to 900 feet in thickness, and has been always mapped as one indivisible series of clays, shales, and limestones. Nevertheless palæontologists, led by Quenstedt and Oppel (whose views have in England been worked out by Strickland, Wright, and others), have attempted, not unsuccessfully, to divide it into six zones, each of which is partly marked by its own group of fossils, especially by certain Ammonites.

The *Middle Lias*, or Marlstone series, in like manner has been divided (not mapped) into three zones; and

The *Upper Lias* into two zones, the lower being the Upper Lias clay, and the upper the sand, the latter of which, until the appearance of Dr. Wright's paper, was considered a subdivision of the Inferior Oolite.

From Devon and Dorsetshire to Yorkshire all of these divisions are said to be constant, except where, from accidental circumstances, any one of them may chance to lie on some protruding boss of palæozoic rock; and, from bottom to top of the whole series, we cannot assert that anywhere is there actual unconformity between any two of the subdivisions, whether they be analyzed minutely or taken as three grand divisions of Lower, Middle, and Upper Lias.

TABLE II. *Showing the upward Passage of Species through the Zones of the Lias.*

	Zones.	A. Bucklandi.	A. Turneri.	A. obtusus.	A. oxynotus.	A. raricostatus.	A. Henleyi, &c.	A. margaritatus.	A. spinatus.	A. communis.	A. Jurensis.	Inferior Oolite.	Total.	Total contents of the zones. Genera.	Total contents of the zones. Species.	Zones.	
Species passing from the zone of	Ammonites Planorbis to	7	1	0	1	0	2	3	3	0	0	0	17	25	42	A. Planorbis	Lower Lias.
	A. Bucklandi ......to	..	6	4	0	4	3	1	1	1	0	0	20	50	108	A. Bucklandi	
	A. Turneri ....to	..	..	3	0	2	0	0	1	0	0	0	6	8	11	A. Turneri	
	A. obtusus ....to	..	..	..	1	0	0	1	0	0	0	0	2	3	9	A. obtusus	
	A. oxynotus........to	..	..	..	..	0	0	0	0	0	0	0	0	4	6	A. oxynotus	
	A. raricostatus......to	..	..	..	..	..	3	2	1	0	0	0	6	12	18	A. raricostatus	
	A. Davœi et A. Henleyi to	..	..	..	..	..	..	16	12	3	0	0	31	44	82	A. Davœi et A. Henleyi	Middle Lias.
	A. margaritatus ....to	..	..	..	..	..	..	..	7	1	0	0	8	23	38	A. margaritatus	
	A. spinatus ....to	..	..	..	..	..	..	..	..	0	2	0	2	16	37	A. spinatus	
	A. communis ......to	..	..	..	..	..	..	..	..	..	14	1	15	30	55	A. communis	Upper Lias.
	A. Jurensis (sands)..to	..	..	..	..	..	..	..	..	..	..	13	13	28	61	A. Jurensis	
		7	7	7	2	6	8	23	25	5	16	14	120	243	467		

Neither is there any marked sudden change in the lithology of the rocks, except between the brown limestone of the Marlstone proper and the Upper Lias clay.

Now in all the Lias formations of England there are about 243 genera and 467 known species; and if we construct a table of zones distinguished by special Ammonites, after the manner practised by Oppel and Dr. Wright, we find the results shown in the following Table,—premising that none of the species of Ammonites have yet been observed in any zone lower than that in which it is mentioned as commencing; and also that for the species of every kind, those which are common to a low and a high zone, but have not been found in intermediate subdivisions, are assumed to have existed during the deposition of the intermediate members here or elsewhere. For instance, a species passes from the zone of *A. Planorbis* into that of *A. spinatus*, the upper zone of the Middle Lias; and though this species may not have been seen or catalogued in any of the intermediate zones, it is clear that it must have existed during those times, because no one believes that any species, having once passed away, has been re-created or redeveloped. Furthermore, in the Table the same species is never repeated in any two columns throughout the whole series.

On the principles stated above, it appears that 17 species, or rather more than 40 per cent., pass upwards from the zone of *Ammonites Planorbis*, all of which must have lived through the period of time of the zone of *A. Bucklandi*. From the zone of *A. Bucklandi* 20 species, or 18½ per cent., pass upwards; from that of *A. Turneri* 6 species, or more than 50 per cent., pass on; from that of *A. obtusus* 2 species, or more than 25 per cent., pass; from the zone of *A. oxynotus* (which has only yielded 6 species) none have been observed higher in the Lias, while from that of *A. raricostatus*, which forms the top of the Lower Lias, 6 species, or about 33 per cent., pass upwards into the Middle Lias.

In the Middle Lias, from the zone of *A. Davœi*, or *A. Henleyi*, 31 species pass upwards, or very nearly 38 per cent.; and from the zone of *A. margaritatus* 8 species out of 38, or 21 per cent., go into higher horizons. From the zone of *A. spinatus* (the top of the Middle Lias) 2 species only, or about 5½ per cent., pass into the Upper Lias; and from the zone of *A. communis* (the base of the Upper Lias) 15 species, or more than 27 per cent., pass upwards into the zone of *A. Jurensis* or the Upper Lias sands. From the Upper Lias 13 species, or more than 21 per cent., pass into the Inferior Oolite.

The zone of *A. oxynotus*, in which only 6 species are recorded in England, is one but little opened for economic purposes, and this may perhaps account for the scarcity of its fossils. Under these circumstances it is scarcely fair to argue upon it; but, with this exception, I am on the whole struck with two main facts, the first of which has been well stated for England by Dr. Wright, namely, that as regards certain species of Ammonites the lines are apt to be trenchant, though other species in a limited degree pass up and down; and, in the second place, a large proportion of the common species graduate upwards from one division to another, in numbers varying from about 20 to 50 per cent. The only sound exception to this is where a sudden lithological break takes place between the Marlstone and the Upper Lias, in which case only 5½ per cent. pass onwards into the newer formation. Further, it must be remembered that, when the Liassic fossils were named, the tendency among palæontologists to extreme subdivision of species was so strong, that there can be little doubt that trifling varieties have often been exalted into individual species, and the numbers common to more than one subdivision are doubtless larger than I have stated.

Considering that no actual unconformity is known from the bottom of the Lower to the top of the Upper Lias, some geologists may find it difficult to perceive why there should be even such partial breaks in the succession of species, except on the hypothesis that a large proportion of the old species were in each case destroyed at the close of one formation and replaced by the creation of new forms when the succeeding formation began. But I cannot accept this well-worn hypothesis; and in this matter I incline to the idea that, considering the frequent large percentages of passage (ranging as high as 50 per cent.), we are justified in supposing that migration of what were old species here into new areas elsewhere, and of certain older species from other areas into ours, may account for the very incomplete breaks in the succession of Liassic life in England, more especially if, as may have often been the case, there were occasional pauses in the deposition of the strata. An analysis, such as I now attempt, in other regions of Europe will alone help to clear up the question.

Passing upwards in the secondary series we come to the Oolitic rocks, the minor and greater divisions of which are singularly well established.

Oolitic strata.—First comes the Inferior Oolite, which, both on palæontological and physical data, has been divided at Cheltenham into the following minor zones in descending order:—

Ragstone, zone of *A. Parkinsoni*	Upper Trigonia-grit. Gryphite grit. Lower Trigonia-grit.
Upper Freestones, zone of *A. Humphresianus*.	
Zone of *A. Murchisoniæ*	Oolite marl. Lower freestones. Pea-grit.

It is interesting to find, in the first place, that there is no complete break in succession between the Upper Lias and the Inferior Oolite, 13 species, or about 21 per cent., passing from the lower to the higher formation. It would also repay the trouble were any one to analyze the palæontological differences between the subdivisions of the Inferior Oolite, but these differences are so analogous to those of the Lower Lias, that I forbear to state them at present. The percentages of Mollusca common to the various subdivisions are large; and, therefore, though it would be instructive to show the precise percentages of the forms of passage, I must, for want of time, content myself with treating the Inferior Oolite as a whole.

Leaving therefore the details of the Inferior Oolite, I shall now proceed to the larger subject of the numerical relations to each other of the fossils of the different formations into which the Oolitic strata have been divided, by the help of Table III., in which the numbers marked in the columns devoted to the *known*, *new*, and *peculiar species* represent my method of analyzing a series of other tables already alluded to as having been constructed by Mr. Etheridge, in which the range of every known British species in the Oolitic rocks has been carefully laid down.

For the purpose in view I have placed the different formations in serial order, beginning with the Inferior Oolite or lowest member on the left. I have then assigned to each formation four lines, showing the number of *peculiar*, *new*, *known*, and *inferred* species of *Brachiopoda*, *Gasteropoda*, *Cephalopoda*, and so on, that belong to each British formation, together with columns showing the numbers of *new*, *known*, and *inferred* species that pass *upwards* and *downwards* from one formation to another. By *inferred* species I strictly mean species which, though they have not been observed in some one given formation, *yet must have lived during the period represented by that formation in some region or other*, because they are found in formations both below and above. Thus there are 51 known species of Echinodermata occurring in the Inferior Oolite, 19 *of which pass upwards into higher formations*. But *only one species is known in the Fuller's Earth*; *and the remaining* 18, *occurring in the Great Oolite or in other higher formations*, must have lived somewhere or other during the deposition of the Fuller's Earth. I therefore call the 18 species *inferred*, and add to the actually inferred number the number known in the formation, thus getting at the number of British forms known to have lived during the deposition of the Fuller's Earth; and for the sake of brevity in the tables the inferred number added to the new species are included in one of the lines under the term "inferred." A little reflection will show that this method is necessary in order to prove the connexion in fossils of the different formations with each other as a whole, while at the same time every other detail is given as to known, new, and peculiar species, so as to render the table as complete as possible. In a subsequent Table, No. IV., a summary is given of the chief results that may be inferred from the data supplied in No. III.

From the data given in the Table, the first point that strikes us is, that, eliminating the Plants, there are known at present in all the Oolitic formations 242 genera and 1483 species. Of these, 1169 species (more than $\frac{3}{4}$ths of the whole) lie in the lower Oolites, 322 species in the middle, and only 82 species in the upper formations. Further, beginning in the Inferior Oolite with 472 species, the number culminates in the Great Oolite to 718 species, after which it at once declines, and ranges in the different formations from 178 down to 31 species. Of the 471 species in the Inferior Oolite only 13 pass up from the Upper Lias.

Table IV.—*Summary of Tables* III. *and* V. [*To face* p. lii.

Species.	LOWER OOLITE. INFERIOR OOLITE. Pass down.	Species.	Pass up.	Per-centages. Up.	Down.	FULLER'S-EARTH. Pass down.	Species.	Pass up.	Per-centages. Up.	Down.	GREAT OOLITE. Pass down.	Species.	Pass up.	Per-centages. Up.	Down.	FOREST MARBLE. Pass down.	Species.	Pass up.	Per-centages. Up.	Down.	CORNBRASH. Pass down.	Species.	Pass up.	Per-centages. Up.	Down.	Pass down.	Species.	Pass up.
Inferred ..	13	472	138	29	96	138	144	141	98	20	141	718	112	16	73	112	153	105	69	59	105	178	73	41	48	..	..	..
Known ..	13	472	138	29	55	12	22	21	95	18	125	698	89	13	34	22	65	18	28	50	76	152	43	28	29	..	..	..
New	..	461	125	27	..	..	6	6	100	..	..	577	55	10	..	..	41	3	7	..	..	73	11	15	..	..	..	..
Peculiar ..	..	337	..	..	..	..	..	..	..	..	..	517	..	..	..	..	38	..	..	..	..	36	..	..	..	..	..	..

	MIDDLE OOLITE. KELLOWAY ROCK.					OXFORD CLAY.					CORAL RAG.					UPPER OOLITE. KIMMERIDGE CLAY.					PORTLAND ROCKS.							
Inferred ..	73	151	74	49	53	74	140	60	43	36	60	168	20	12	33	20	60	9	15	29	9	31	..	..	..	..	..	..
Known ..	31	107	27	25	34	35	101	24	24	33	52	159	12	7	27	15	55	4	7	26	8	31	..	..	..	..	..	..
New	..	78	18	23	..	..	66	12	18	..	..	105	5	5	..	..	40	2	5	..	..	22	..	..	..	..	..	..
Peculiar ..	..	60	..	..	..	..	52	..	..	..	..	100	..	..	..	..	40	..	..	..	..	19	..	..	..	..	..	..

	LOWER CRETACEOUS. LOWER GREENSAND.					UPPER CRETACEOUS. GAULT.					UPPER GREENSAND.					CHALK MARL.					LOWER CHALK.					UPPER CHALK.		
Inferred ..	..	280	51	18	22	51	234	107	46	26	107	412	109	26	66	109	164	124	76	48	124	255	104	40	20	104	521	..
Known ..	..	280	51	18	11	23	204	80	40	18	68	377	75	20	42	39	93	55	59	40	89	223	69	31	20	104	521	..
New	..	280	51	18	..	..	183	74	40	..	..	305	51	17	..	..	49	33	67	..	..	130	39	30	..	..	415	..
Peculiar ..	..	233	..	..	..	..	109	..	..	..	..	226	..	..	..	..	15	..	..	..	..	90	..	..	..	..	415	..

I shall now briefly examine some of the details.

Inferior Oolite.—The AMORPHOZOA known are few and unimportant. One is known in and confined to the Inferior Oolite; seven have been found in the Great Oolite, one of which, unknown in the intermediate formations, reappears in the Coral Rag.

Of ZOOPHYTA, 32 are known in the Inferior Oolite, 7 of which (about 22 per cent.) pass into the Great Oolite, none of them being known in the Fuller's Earth.

Of ECHINODERMATA 51 species are known, 32 of which only are peculiar, and 19 (37 per cent.) pass upwards, one of these only appearing in the Fuller's Earth and 18 in the Great Oolite.

The ARTICULATA are unimportant all through the Oolites, and so are the POLYZOA; and, therefore, I shall refer for details respecting them to the Table.

But the BRACHIOPODA are of more value in this argument; for of 40 species, all new, which appear in the Inferior Oolite, only one passes upwards.

Of the LAMELLIBRANCHIATA *Monomyaria* 58 are known, 4 of which occur in the Upper Lias, and 27 (47 per cent.) pass upwards, leaving 31 species peculiar to the formation; while of *Dimyaria* 153 species are known, 106 of which are peculiar. Of the remaining 47 species 9 are found in the Upper Lias, and 50 pass upwards (32 per cent.), 48 of which are known in the Great Oolite. If we take the Lamellibranchiata as a whole, there are in the Inferior Oolite 211 species, 75 of which ($36\frac{1}{2}$ per cent.) pass upwards.

It is worthy of remark that in the Cretaceous series these proportions are in some degree reversed, many of the Brachiopoda having a long range through various formations, while in one case, that of the Upper Greensand, all the species of Dimyaria (save one) are restricted to that formation.

Of GASTEROPODA there are 80 species, all new forms, 29 of which (about 36 per cent.) pass upwards.

Of CEPHALOPODA there are 39 species, all new, and only one of these passes upwards into the Great Oolite.

Five species of Fish are known, two of which also pass into the Great Oolite.

The general result is, that, of the more important classes of life, the Brachiopoda and Cephalopoda are most restricted, only one species of each, out of 40 and 39 respectively, passing upwards; while of the Echinodermata, Lamellibranchiata, and Gasteropoda, 37, 47, 32, and 36 per cent. pass upwards, making on an average $36\frac{1}{2}$ per cent. of the whole; while, if we mass all the forms of marine life, we find in the Inferior Oolite 471 species, only 12 of which come up from the Upper Lias, and 138 pass upwards, or more than 29 per cent.

Fuller's Earth.—Very few Inferior Oolite species are found in the Fuller's Earth. In Amorphozoa, Zoophyta, Articulata, Polyzoa, Gasteropoda, Cephalopoda, Fish, and Reptiles our lists mark it as quite barren in *known* species; and of Echinodermata, Brachiopoda, and Lamellibranchiata only 22 species are known. It is, therefore, a sterile formation as regards numbers of species, though individuals

(*Ostrea acuminata, Rhynchonella varians, Terebratula digona,* &c.) often occur in great numbers. The majority of the forms that passed upwards from the Inferior Oolite limestone seem to have fled the muddy bottom of the Fuller's Earth sea, and to have returned to the same area when the later period of the Great Oolite began. The Fuller's Earth, in fact, may be considered only as a comparatively unfossiliferous and inconstant lower zone of the Great Oolite; for it thins out entirely N.E. of Cheltenham, and is overlapped by the Stonesfield Slate, which itself is only an inferior member of the Great Oolite.

Great Oolite.—The leading points respecting this formation are as follows.

Thirty species of Zoophyta are known, 7 of which occur in the Inferior Oolite, and 3 pass upwards. Echinodermata, 44 known and 4 inferred, 48 in all, 18 of which (38 per cent.) are found lower down, and 17 (35 per cent.) pass up. Brachiopoda, 18 species, 4 of which (22 per cent.) occur below, and 9 (50 per cent.) pass upwards. Monomyaria, 83 species, 28 of which (34 per cent.) occur before, and 24 (29 per cent.) after; while of the Dimyaria there are 169 species (160 known), 50 of which come up from older times (29½ per cent.) and 33 pass upwards (19 per cent.). The Gasteropoda are remarkable: of 255 *inferred* species, 250 are *known*, 226 are new, and 215 are confined to the Great Oolite, while only 29 (11 per cent.), have lived on in this area from older horizons, and 19 (about 7½ per cent.) pass upwards; the rest have died out or migrated. It seems likely, however, that the sudden appearance of this vast and unusual number of Gasteropoda was due to local conditions of depth which we cannot trace, and that they both appeared and disappeared so suddenly through migration rather than by sudden creation and extinction, which, indeed, I do not believe under any circumstances ever happened. Of 14 species of Cephalopoda, only one is found in the Inferior Oolite, while another passes upwards to the Cornbrash, and 13 are peculiar to the formation. Fifty species of Fish are known, all peculiar except two, which are common to the Inferior Oolite.

Here, as in the Inferior Oolite, the Echinodermata are by no means very restricted in range; for whether we take the known or the inferred species, more than 30 per cent. pass both up and down; and the result is nearly the same with the bivalve Shells.

Taken as a whole, of 698 known species, 125 are found in lower formations, and 89 species pass up; and of 718 inferred species, 141 (20 per cent.) are found in lower and 112 species (16 per cent.) in higher formations. If, however, we eliminate the unusual and probably accidental presence of so many Gasteropoda, the proportions suddenly rise to 24 per cent. downwards, and 20 per cent. upwards.

It would be tedious to repeat this style of analysis for each of the formations between the Great Oolite and the Portland limestone. Enough has been said to show the manner of proceeding, and by reference to the tables any one can do the rest for himself. It will then be seen that the averages of passage, now up and now down, often range among the Echinodermata and bivalve Shells in the

...es that pass from one Form...

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		CORNBRASH.				...IDGE	UPPER OOLITE.		PORTLAND ROCKS.				
Percentages. Up.	Percentages. Down.	Pass down.	Species.	Pass up.	Percentages. Up.	Pass up.	Percentages. Up.	Percentages. Down.	Pass down.	Species.	Pass up.	Percentages. Up.	Percentages. Down.

Table V.—Showing the Numbers ...

Polyzoa	34	77	Inferred		26
			Known		26
			New		26
Articulata	38	122	Inferred		10
			Known		10
			New		10
			Peculiar		10
			Peculiar		8

L... CRE... LOW... GREENS...

TABLE III.—*Showing the Numbers and Percentages of Species that pass from one Formation to another in the Oolitic Series.*

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LOWER OOLITE.

Groups.	No. of Genera.	No. of Species.	Species.	Inferior Oolite.			Per-centages.		Fuller's-Earth.			Per-centages.		Great Oolite.			Per-centages.		Forest Marble.			Per-centages.		Cornbrash.			Per-centages.	
				Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.
							>	<				>	<				>	<				>	<				>	<
PLANTÆ (Not included in the additions.)	42	128	Inferred																									
			Known		120										8													
			New		120										8													
			Peculiar		120										8													
AMORPHOZOA	4	10	Inferred		1										7	1	14	100	1	1	1	100	100	1	1	1	100	100
			Known		1										7	1	14											
			New		1										7	1	14											
			Peculiar		1										6													
ZOOPHYTA	23	69	Inferred		32	7	22	100	7	7	7	100	23	7	30	3	10	100	3	3	3	100	100	3	3	3	100	100
			Known		32	7	22						23	7	30	3	10						100	1	1	1	100	
			New		32	7	22								23	1	4											
			Peculiar		25										22													
ECHINODERMATA	28	140	Inferred		51	19	37	100	19	19	18	100	38	18	48	17	35	65	17	26	15	58	71	15	21	6	29	100
			Known		51	19	37	100	1	1			32	14	44	13	30	40	6	15	4	27	68	13	19	4	21	100
			New		51	19	37								30	5	17			9	2	22			6	1	17	
			Peculiar		32										26					7					4			
ARTICULATA	8	32	Inferred		10	1	10	100	1	1	1	100	10	1	10	3	30	100	3	3	3	100	38	3	8	5	63	100
			Known		10	1	10								9	2	22								6	2	33	
			New		10	1	10								9	2	22								5	2	40	
			Peculiar		9										7										3			
POLYZOA	14	28	Inferred		3	1	33	100	1	1	1	100	4	1	24	1	4	100	1	1	1	100	50	1	2	1	50	100
			Known		3	1	33								23										1			
			New		3	1	33								23										1			
			Peculiar		2										23										1			
BRACHIOPODA	7	72	Inferred		40	1	3	25	1	4	4	100	22	4	18	9	50	90	9	10	10	100	77	10	13	6	46	75
			Known		40	1	3	25	1	4	4	100	22	4	18	9	50			3	1	33	55	6	11	5	60	100
			New		40	1	3			3	3	100			14	9	64			1	1	100			3	2	67	
			Peculiar		39										5										1			
LAMELLIBRANCHIATA MONOMYARIA	18	171	Inferred	4	58	27	47	96	27	28	28	100	34	28	83	24	29	92	24	26	23	88	64	23	36	12	33	45
			Known	4	58	27	47			5	5	100	28	22	80	17	21	71	5	7	5	71	76	22	33	8	24	26
			New		56	23	41			1	1	100			55	11	20			2					13	4	30	
			Peculiar		31										44					2					9			
LAMELLIBRANCHIATA DIMYARIA	50	368	Inferred	9	153	50	33	96	50	52	50	96	29	50	169	33	20	81	33	41	31	76	48	31	65	25	38	64
			Known	9	153	50	33	83	10	12	12	100	30	48	160	26	16	50	8	16	6	37	40	24	60	18	30	46
			New		144	41	28			2	2	100			119	17	14			8					34	1	3	
			Peculiar		106										99					8					9			
GASTEROPODA	47	367	Inferred		80	29	36	100	29	29	29	100	11	29	255	19	7	48	19	40	16	40	67	16	24	12	50	
			Known		80	29							11	27	250	16	6	13	3	24	2	8	53	9	17	4	24	
			New		80	29									226	8	4			21					8	1	12	
			Peculiar		51										215					21					6			
CEPHALOPODA	6	137	Inferred		39	1	3	100	1	1	1	100	7	1	14	1	7	100	1	1	1	100	50	1	2	1	50	3
			Known		39	1	3						7	1	14	1	7						50	1	2	1	50	3
			New		39	1	3								13										1			
			Peculiar		38										13										1			
PISCES	25	71	Inferred		5	2	40	100	2	2	2	100	4	2	52										2			
			Known		5	2	40						4	2	52										2			
			New		5	2	40								50										2			
			Peculiar		3										50										2			
REPTILIA	10	15	Inferred												8	1	12	100	1	1	1	100	100	1	1	1	100	100
			Known												8	1	12											
			New												8	1	12											
			Peculiar												7													
MAMMALIA	2	3	Inferred																									
			Known												3													
SUMMARY	242	1483	Inferred	13	472	138	29	96	138	144	141	98	20	141	718	112	16	73	112	153	105	69	59	105	178	73	41	48
			Known	13	472	138	29	55	12	22	21	95	18	125	698	89	13	34	22	65	18	28	50	76	152	43	28	29
			New		461	125	27			6	6	100			577	55	10			41	3	7			73	11	15	
			Peculiar		337										517					38					36			

MIDDLE OOLITE.

Groups.	Species.	Kelloway Rock.			Per-centages.		Oxford Clay.			Per-centages.		Coral Rag.			Per-centages.	
		Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.
					>	<				>	<				>	<
PLANTÆ	Inferred															
	Known															
	New															
	Peculiar															
AMORPHOZOA	Inferred	1	1	1	100	100	1	1	1	100	33	1	3			
	Known										33	1	3			
	New												2			
	Peculiar												2			
ZOOPHYTA	Inferred	3	3	3	100	100	3	3	3	100	19	3	16	1	6	100
	Known											3	16	1	6	
	New												13	1		
	Peculiar												12			
ECHINODERMATA	Inferred	6	6	5	83	83	5	6	5	83	13	5	39			
	Known	1	1					1			13	5	39			
	New							1					34			
	Peculiar							1					34			
ARTICULATA	Inferred	5	5	5	100	63	5	8	4	50	40	4	10	2	20	67
	Known					25	1	4	2	50	50	4	8	2	25	67
	New							3	2	67			3			
	Peculiar							1					3			
POLYZOA	Inferred	1	1	1	100	100	1	1	1	100	50	1	2			
	Known										50	1	2			
	New												1			
	Peculiar												1			
BRACHIOPODA	Inferred	6	8	2	25	25	2	8	4	50	100	4	4	3	75	50
	Known	6	6			17	1	6	3	50	100	1	1			50
	New		2					6	3	50						
	Peculiar		2					3								
LAMELLIBRANCHIATA MONOMYARIA	Inferred	12	27	14	44	78	14	18	13	72	50	13	26	4	15	50
	Known	5	19	7	37	64	7	11	5	45	50	13	26	4	15	43
	New		15	5	33			4	3	75			13	1	8	
	Peculiar		10					3					12			
LAMELLIBRANCHIATA DIMYARIA	Inferred	25	39	22	56	59	22	37	13	35	48	13	27	7	26	58
	Known	13	28	8	29	48	13	29	6	21	38	9	24	3	13	44
	New		14	5	36			15	3	20			14	1	7	
	Peculiar		10					12					13			
GASTEROPODA	Inferred	12	23	12	52	86	12	14	9	65	39	9	23	1	4	50
	Known	5	16	4	25	71	5	7	2	29	39	9	23	1	4	50
	New		11					2	1	50			14	1	7	
	Peculiar		9					1					13			
CEPHALOPODA	Inferred	1	36	8	22	21	8	39	6	15	38	6	16	1	6	12
	Known	1	36	8	22	21	8	39	6	15	38	6	16	1	6	12
	New		35	8	23			31					10	1	10	
	Peculiar		28					27					9			
PISCES	Inferred		1					4					1			
	Known		1					4					1			
	New		1					4					1			
	Peculiar		1					4					1			
REPTILIA	Inferred	1	1	1	100	100	1	1	1	100	100	1	1	1	100	12
	Known															
	New															
	Peculiar															
MAMMALIA	Inferred															
	Known															
SUMMARY	Inferred	73	151	74	49	53	74	140	60	43	36	60	168	20	12	33
	Known	31	107	27	25	34	35	101	24	24	33	52	159	12	7	27
	New		78	18	23			66	12	18			105	5	5	
	Peculiar		60					52					100			

UPPER OOLITE.

Groups.	Species.	Kimmeridge Clay.			Per-centages.		Portland Rocks.			Per-centages.	
		Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.
					>	<				>	<
PLANTÆ	Inferred										
	Known										
	New										
	Peculiar										
AMORPHOZOA	Inferred										
	Known										
	New										
	Peculiar										
ZOOPHYTA	Inferred	1	1					1			
	Known	1	1					1			
	New							1			
	Peculiar							1			
ECHINODERMATA	Inferred		7					2			
	Known		7					2			
	New		7					2			
	Peculiar		7					2			
ARTICULATA	Inferred	2	3					1			
	Known	2	3					1			
	New		1					1			
	Peculiar		1					1			
POLYZOA	Inferred										
	Known										
	New										
	Peculiar										
BRACHIOPODA	Inferred	3	6								
	Known	3	6								
	New		3								
	Peculiar		3								
LAMELLIBRANCHIATA MONOMYARIA	Inferred	4	8	3	38	33	3	9			
	Known	3	7	2	29	33	3	9			
	New		4	1	25			6			
	Peculiar		5					7			
LAMELLIBRANCHIATA DIMYARIA	Inferred	7	12	4	33	50	4	8			
	Known	4	9	1	11	50	4	8			
	New		5	1	20			4			
	Peculiar		4					4			
GASTEROPODA	Inferred	1	2					4			
	Known	1	2					4			
	New		1					4			
	Peculiar		1								
CEPHALOPODA	Inferred	1	8	1	12	50	1	2			
	Known	1	8	1	12	50	1	2			
	New		7					1			
	Peculiar		7					1			
PISCES	Inferred		5					3			
	Known		5					3			
	New		5					3			
	Peculiar		5					3			
REPTILIA	Inferred	1	8	1	12	100	1	1			
	Known		7					1			
	New		7								
	Peculiar		7								
MAMMALIA	Inferred										
	Known										
SUMMARY	Inferred	20	60	9	15	29	9	31			
	Known	15	55	4	7	26	8	31			
	New		40	2	5			22			
	Peculiar		40					19			

TABLE V.—*Showing the Numbers and Percentages of Species that pass from one Formation to another in the Cretaceous Series.*

				LOWER CRETACEOUS.					UPPER CRETACEOUS.																								
				LOWER GREENSAND.			Percentages.		GAULT.			Percentages.		UPPER GREENSAND.			Percentages.		CHALK MARL.			Percentages.		LOWER CHALK.			Percentages.		UPPER CHALK.			Percentages.	
Groups.	No. of Genera.	No. of Species.	Species.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.	Pass down.	Species.	Pass up.	Up.	Down.
							>	<				>	<				>	<				>	<				>	<				>	<
PLANTÆ (Not included in the additions.)	9	12	Inferred	..	5	1	20	100	1	1	1	100	17	1	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
			Known	..	5	1	20	..	..	..	..	..	17	1	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
			New	..	5	1	20	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
			Peculiar	..	1	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
AMORPHOZOA	23	114	Inferred	..	14	3	21	100	3	3	3	100	8	3	25	3	12	100	3	3	3	100	43	3	7	4	57	5	4	78	..	..	..
			Known	..	14	3	21	..	..	..	..	..	9	2	22	2	9	..	..	..	..	..	20	1	5	3	60	5	4	78	..	..	..
			New	..	14	3	21	..	..	..	..	..	..	..	22	2	9	..	..	..	..	..	..	..	4	1	25	..	..	74	..	..	..
			Peculiar	..	11	..	..	..	..	..	..	..	..	..	20	..	..	..	..	..	..	..	..	..	3	..	..	..	..	74	..	..	..
RHIZOPODA FORAMINIFERA	20	83	Inferred	..	..	..	..	..	..	21	15	71	94	15	16	16	100	94	16	17	17	100	74	17	23	23	100	29	23	78	..	..	..
			Known	..	..	..	..	..	..	21	15	71	67	2	3	3	100	50	1	2	2	100	45	5	11	11	100	29	23	78	..	..	..
			New	..	..	..	..	..	..	21	15	71	..	..	1	1	100	..	..	1	1	100	..	..	6	6	100	..	..	55	..	..	..
			Peculiar	..	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55	..	..	..
ZOOPHYTA	17	27	Inferred	..	2	..	..	..	..	9	1	11	25	1	4	..	..	..	..	..	..	..	..	..	3	..	..	..	..	10	..	..	..
			Known	..	2	..	..	..	..	9	1	11	25	1	4	..	..	..	..	..	..	..	..	..	3	..	..	..	..	10	..	..	..
			New	..	2	..	..	..	..	9	1	11	..	..	3	..	..	..	..	..	..	..	..	..	3	..	..	..	..	10	..	..	..
			Peculiar	..	2	..	..	..	..	8	..	..	..	..	3	..	..	..	..	..	..	..	..	..	3	..	..	..	..	10	..	..	..
ECHINODERMATA	27	135	Inferred	..	10	2	20	20	2	10	3	30	8	3	36	7	19	47	7	15	6	40	22	6	27	4	15	7	4	61	..	..	..
			Known	..	10	2	20	13	1	8	2	25	8	3	36	7	19	33	4	12	3	25	19	5	26	2	8	7	4	61	..	..	..
			New	..	10	2	20	..	..	8	2	25	..	..	33	5	15	..	..	8	3	..	..	..	21	4	19	..	..	57	..	..	..
			Peculiar	..	8	..	..	..	..	6	..	..	..	..	..	..	..	..	..	5	..	..	..	..	17	..	..	..	..	57	..	..	..
ARTICULATA	38	122	Inferred	..	10	4	40	11	4	38	22	58	45	22	49	20	41	91	20	22	20	91	59	20	34	26	76	44	26	59	..	..	..
			Known	..	10	4	40	11	4	38	22	58	31	9	42	9	21	60	3	5	3	60	48	14	29	18	62	44	26	59	..	..	..
			New	..	10	4	40	..	..	34	20	53	..	..	27	6	30	..	..	2	2	100	..	..	14	7	50	..	..	33	..	..	..
			Peculiar	..	10	..	..	..	..	14	..	..	..	..	24	..	..	..	..	..	..	..	..	..	7	..	..	..	..	33	..	..	..
POLYZOA	34	77	Inferred	..	26	5	19	100	5	5	4	80	50	4	8	3	38	100	3	3	3	100	50	3	6	5	83	10	5	49	..	..	..
			Known	..	26	5	19	100	2	2	2	100	50	4	8	3	38	..	..	..	..	..	..	..	3	2	66	10	5	49	..	..	..
			New	..	26	5	19	..	..	..	..	..	..	..	4	..	..	..	..	..	..	..	..	..	3	2	66	..	..	44	..	..	..
			Peculiar	..	21	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	1	..	..	..	..	44	..	..	..
BRACHIOPODA	14	59	Inferred	..	25	7	24	58	7	12	11	92	42	11	26	19	73	83	19	23	18	78	72	18	25	16	64	76	16	21	..	..	..
			Known	..	25	7	24	17	1	6	4	67	35	8	23	18	78	80	12	15	10	67	67	14	21	12	57	76	16	21	..	..	..
			New	..	25	7	24	..	..	5	5	100	..	..	15	12	80	..	..	3	3	100	..	..	7	4	57	..	..	5	..	..	..
			Peculiar	..	18	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	..	..	..	3	..	..	..	..	5	..	..	..
LAMELLIBRANCHIATA MONOMYARIA	13	153	Inferred	..	49	10	20	55	10	20	15	75	24	15	62	18	29	90	18	20	19	95	48	19	40	17	42	41	17	41	..	..	..
			Known	..	49	10	20	33	5	15	9	60	22	13	60	16	27	60	3	5	5	100	34	12	35	12	34	41	17	41	..	..	..
			New	..	49	10	20	..	..	10	8	80	..	..	47	9	20	..	..	2	2	100	..	..	20	6	30	..	..	24	..	..	..
			Peculiar	..	39	..	..	..	..	2	..	..	..	..	38	..	..	..	..	..	..	..	..	..	14	..	..	..	..	24	..	..	..
LAMELLIBRANCHIATA DIMYARIA	43	173	Inferred	..	82	9	11	33	9	27	7	26	10	7	74	1	1	16	1	6	6	100	86	6	7	1	14	20	1	5	..	..	..
			Known	..	82	9	11	23	5	22	5	23	10	7	74	1	1	20	1	5	5	100	86	6	7	1	14	20	1	5	..	..	..
			New	..	82	9	11	..	..	18	4	22	..	..	67	1	1	..	..	..	..	..	..	..	1	1	100	..	..	2	..	..	..
			Peculiar	..	73	..	..	..	..	14	..	..	..	..	66	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
GASTEROPODA	34	129	Inferred	..	30	5	17	16	5	31	8	26	13	8	62	1	2	50	1	2	2	100	11	2	19	2	11	100	2	2	..	..	..
			Known	..	30	5	17	10	3	29	6	21	13	8	62	1	2	50	1	2	2	100	11	2	19	2	11	100	2	2	..	..	..
			New	..	30	5	17	..	..	26	6	23	..	..	54	..	..	..	..	1	..	..	..	..	17	2	12	..	..	..	..	..	..
			Peculiar	..	25	..	..	..	..	20	..	..	..	..	53	..	..	..	..	..	..	..	..	..	15	..	..	..	..	..	..	..	..
CEPHALOPODA	13	170	Inferred	..	28	5	18	9	5	54	17	31	41	17	41	19	46	37	19	51	28	55	33	28	54	4	7	21	4	19	..	..	..
			Known	..	28	5	18	4	2	51	14	27	31	11	35	14	40	30	14	47	25	53	33	28	54	4	7	21	4	19	..	..	..
			New	..	28	5	18	..	..	49	13	27	..	..	24	14	58	..	..	32	22	69	..	..	26	4	15	..	..	15	..	..	..
			Peculiar	..	23	..	..	..	..	36	..	..	..	..	10	..	..	..	..	10	..	..	..	..	21	..	..	..	..	15	..	..	..
PISCES	45	89	Inferred	..	..	..	..	..	..	3	..	..	..	..	1	..	..	..	..	..	..	..	..	..	2	2	100	2	2	85	..	..	..
			Known	..	..	..	..	..	..	3	..	..	..	..	1	..	..	..	..	..	..	..	..	..	2	2	100	2	2	85	..	..	..
			New	..	..	..	..	..	..	3	..	..	..	..	1	..	..	..	..	..	..	..	..	..	2	2	100	..	..	83	..	..	..
			Peculiar	..	..	..	..	..	..	3	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	83	..	..	..
REPTILIA	12	31	Inferred	..	4	1	25	100	1	1	1	100	12	1	8	2	25	100	2	2	2	100	25	2	8	..	..	..	..	13	..	..	..
			Known	..	4	1	25	..	..	..	..	..	..	..	7	1	14	..	..	..	..	..	25	2	8	..	..	..	..	13	..	..	..
			New	..	4	1	25	..	..	..	..	..	..	..	7	1	14	..	..	..	..	..	..	..	6	..	..	..	..	13	..	..	..
			Peculiar	..	3	..	..	..	..	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	6	..	..	..	..	13	..	..	..
SUMMARY	333	1362	Inferred	..	280	51	18	22	51	234	107	46	26	107	412	109	26	66	109	164	124	76	48	124	255	104	40	20	104	521	..	..	..
			Known	..	280	51	18	11	23	204	80	40	18	68	377	75	20	42	39	93	55	59	40	89	223	69	31	20	104	521	..	..	..
			New	..	280	51	18	..	..	183	74	40	..	..	305	51	17	..	..	49	33	67	..	..	130	39	30	..	..	415	..	..	..
			Peculiar	..	233	..	..	..	..	109	..	..	..	..	226	..	..	..	..	15	..	..	..	..	90	..	..	..	..	415	..	..	..

proportions of 30, 50, and even 80 or 85 per cent.: and, what to me was unexpected, it appears that from the lower to the middle Oolites the community or passage of species is in larger proportion than it is between some of the minor subdivisions themselves; for, of 178 inferred Cornbrash species, 73, or nearly 41 per cent., pass upward; while, on the same principle, of 151 species of the Kelloway rock, 74 species, or about 49 per cent., are found in older formations. Of 152 known Cornbrash species, 43, or 28 per cent., pass upward. From the Coral Rag to the Kimeridge clay, of 168 inferred species, 20, or only about 12 per cent., pass upward; while it is worthy of remark that from the Upper to the Middle Oolite, of 60 species that lived in the period of the Kimmeridge clay, 20, or about 33 per cent., are also found below. The Coral Rag species representing the difference of percentage had migrated or become extinct.

The greater inferences that may be drawn from this general survey of the phenomena are:—

1. That there are 13 species common to the uppermost part of the Upper Lias and the Oolite. The break is by no means complete.

2. That progressively from the lowest to the highest Oolitic formations, large percentages of species pass upwards without any approach to a total break either in the whole or in individual groups, excepting in the instance of the Cephalopoda of the Inferior and the Great Oolite.

3. That species often disappear from an intermediate formation to reappear in a higher one, and the principle of migration and return is thus established.

4. That, notwithstanding migration and passage of species, it might perhaps be safely inferred that between the lowest and the highest Oolitic formation many forms had disappeared altogether, so greatly are their numbers diminished in the higher strata.

5. It seems not unlikely that, notwithstanding the large community of species, the succession of the Oolitic formations is not unbroken by minor gaps unrepresented by strata, of the kind explained in my last Address. We are aided in this conclusion by a consideration of the physical conditions under which the Oolitic rocks present themselves. Thus the Inferior Oolite attains its maximum development near Cheltenham, where it can be subdivided at least into three parts. Passing north, the two lower divisions, each more or less characterized by its own fossils, disappear, and the Ragstone north-east of Cheltenham lies directly upon the Lias, apparently as conformably as if it formed its true and immediate successor, while at Dundry the equivalents of the upper freestones and ragstones (the lower beds being absent) lie directly on the exceedingly thin representative of the Upper Lias. In Dorsetshire, on the coast, the series is again perfect, though thin. Near Chipping Norton, in Oxfordshire, the Inferior Oolite disappears altogether, and the Great Oolite, having first overlapped the Fuller's Earth, passes across the Inferior Oolite, and in its turn seems to lie on the Upper Lias with a regularity as perfect as if no formation anywhere in the neighbourhood came between them. In Yorkshire the changed type of the Inferior

Oolite, the prevalence of sands, Land-plants, and beds of coal, occur in such a manner as to leave no doubt of the presence of terrestrial surfaces on which the Plants grew, and all these phenomena lead to the conclusion that various considerable oscillations of level took place in the British area during the deposition of the strata both of the Inferior Oolite and of the formations that immediately succeed it.

Again, near Kempston, in Bedfordshire, the Cornbrash and Kelloway rock are both absent, and the Oxford clay was pointed out to me by Mr. Howell, resting directly and apparently quite conformably on the Great Oolite. The fragmentary character of the Portland rocks is confessed by all.

It is probable that the oscillations of level that these phenomena indicate may be intimately connected with the loss of old and the appearance of new species in our area; for it is certain that apparent conformity, as in the case of the Great Oolite lying on the Upper Lias, is often deceptive, and is in itself no positive proof of direct sequence; and it is not unlikely that during gaps in the regular sequence of formations, of some of which we may have no traces remaining, many old forms died out or changed, and new ones, at intervals, migrated hither. At the same time, it is clear that the breaks in succession in these mesozoic strata are very different in magnitude from those of the palæozoic epoch that were accompanied by total unconformity *.

Purbeck and Wealden Strata.—We now come to a period in the geological history of the British marine mesozoic rocks in which, though not accompanied by much apparent physical disturbance, the break in the succession of *species* is as great as in any part of the palæozoic series. I allude to the total change of species that marks the introduction of the marine Cretaceous formations.

That this break in palæontological succession was accompanied by an enormous lapse of time is proved by the presence of the Purbeck and Wealden strata lying between the Oolitic and Cretaceous series; and, but for them, when the two series come in contact, so conformable, apparently, are the Cretaceous to the Oolitic rocks, that, unlike some of the cases cited with regard to the palæozoic formations, we have, by disturbance and denudation of the Oolite strata previous to the Cretaceous epoch, no very obvious hint of the enormous lapse of time that lay between the two great marine periods.

It is needless for my argument specially to analyze the contents of the Purbeck and Wealden strata. Of the 4 species of Plants, 90 Insects, several Mammalia, 10 Cyprides, 1 Echinus, 17 Lamellibranchiate Mollusks, 14 Gasteropoda, 18 Fish, and 11 Reptiles now known in the Purbeck rocks, a considerable proportion of the forms are common to the three subdivisions of the formation, and none of them, unless doubtfully *Paludina elongata*, pass up into the Wealden beds. In the latter there are known 19 species of Plants, 11 Cyprides, 25 Lamellibranchiate Mollusks, 8 Gasteropoda, 12 Fish, and 18 Reptiles; and all of these, with one doubtful exception, are

* They are, however, somewhat comparable to the relations of the Lower and Upper Llandovery rocks to each other, or to the variations in the subdivisions of the Magnesian Limestone, which were formed during minor oscillations of level.

new. If this series of freshwater beds be perfect, I confess that this change is hard to account for, although we have something slightly analogous to it, for example, in the great delta of the Mississippi, in which the old delta contains a number of terrestrial remains of Mammalia not represented in the new. It may be, as has been suggested to me by Mr. Jenkins, that the limestones of the Purbeck series were lake-deposits, while it is evident to every one that the Wealden strata are delta-formations.

But, however this may be, the great extent and thickness (nearly 2000 feet) of these deposits speak of a period when vast neighbouring areas must have formed a continent, the inland drainage of which gave birth to a river apparently equal to the largest streams of the living world; and the upheaval of that land to afford this drainage, and its subsequent depression, if my views be correct, must have occupied a time sufficiently long to have resulted in the extinction, by migration and modification, or otherwise, of all the Oolitic species, and their replacement by migration of other forms when the same area was reconverted into sea. As with the palæozoic rocks, *time* is the accompaniment of this total change; and if we adopt for species and genera the theory of descent with modification, the idea of needful time is prodigiously strengthened, even though we may not believe that all the Cretaceous forms are the direct descendants of those found in the British Oolites.

On taking a general view of the Cretaceous fossils of England, the first thing that strikes us is that, while in the Oolitic strata by far the large proportion of species occur in the Lower Oolites (most of these being in the Great Oolite), in the Cretaceous rocks the reverse is the case, the Lower Greensand only yielding 280 known marine species, and the upper formations 1082, while of these no fewer than 521 occur in the Upper Chalk.

If, going further, we analyze their distribution, the following are some of the chief results drawn from Table V.:—

Fourteen species of Sponges are known in the Lower Greensand, only three of which pass upwards, namely, two into the Upper Greensand and one into the Chalk. The two known species of Corals are peculiar to the formation; and of 10 Echinodermata, only two pass upward, one of these being one of 8 species known in the Gault. Of 10 species belonging to the Articulata, 4 pass into the Gault; while of 26 Polyzoa, 5, or 19 per cent., pass into higher horizons. Twenty-five species of Brachiopoda are known in the Lower Greensand, 7 (24 per cent.) of which pass upward, 1 into the Gault, the others into higher horizons. Of 49 species of Monomyaria, 10, or 20 per cent., pass upward; while, of 82 Dimyaria, only 9, or about 11 per cent., survive in higher formations; in other words, the larger proportion of the deep-sea forms remain. Of 30 species of Gasteropoda, 5, or nearly 17 per cent., are found in younger strata. It thus happens that, of 186 bivalve and univalve Shells, 31, or about $16\frac{2}{3}$ per cent., pass upward. Of 28 Cephalopoda, 5 (18 per cent.) pass upward, and 23 are peculiar to the Lower Greensand. No Fishes are known in it; and of 4 Reptiles, one is found in the Chalk.

The general result of these numbers is, that of 280 species of all kinds known in the Lower Greensand, 233 are peculiar, and 51, or only about 18 per cent., pass from the Lower to the Upper Cretaceous strata. It is important to observe that this break and disappearance of so many species in succession is accompanied by a stratigraphical break as well; for, round the Weald, it is known that in some of the very few exposures of junctions, the Gault has been seen lying on eroded surfaces of Lower Greensand, while in the western and middle parts of England, on the west and north of the great Chalk escarpment, the frequent and sudden overlaps of the Lower Greensand by the Gault leave no doubt that the upper formation lies actually unconformably on the lower, and the time occupied by the denudation has been with us unrepresented by any stratified formation.

I must refer to Table V. for the proportions of species common to the Gault, Upper Greensand, Chalk Marl, Lower Chalk, and Upper Chalk; and an attentive consideration of the numbers will show, what is well known, that between any of these subformations there is no approach to a break so great as that between the Lower Greensand and the Upper Cretaceous series, whether we take the inferred or the known species. This fact is further accompanied by the circumstance that, comparatively marked as the lithological distinctions of the Upper Cretaceous subformations are, it is over great part of England impossible to draw a precise line of demarcation between them. Thus, in places surrounding the Wealden area there is apparently a gradual passage from Gault to Upper Greensand, for the Gault becomes pale and white above, and the Upper Greensand white and marly below; and in Buckinghamshire, Bedfordshire, and Hertfordshire it is difficult to draw a line of precise value between the top of the Upper Greensand and the base of the Chalk, for both are equally white and the greensand is exceedingly calcareous. The Chalk-marl is a local variation; and though Mr. Whitaker has, over a considerable area, defined a line between Lower and Upper Chalk on physical grounds, it has not yet been universally proved for England. Both in a physical and, partly, in a palæontological sense, indeed, the whole of the Upper Cretaceous divisions may almost be spoken of as making one formation lithologically subdivided.

The more prominent relations of the fossils in these subformations are as follows:—Of Sponges, Foraminifera, Corals, Echinodermata, Articulata, and Polyzoa, large proportions as a rule pass upwards and downwards.

Of 12 species of inferred and 6 of known Brachiopoda, none are peculiar to the Gault; of 26 inferred and 23 known species, only 3 are peculiar to the Upper Greensand; of 23 inferred and 15 known forms, none are peculiar to the Chalk Marl; and of 25 inferred and 21 known species, only 3 are peculiar to the Lower Chalk.

Of 20 inferred and 15 known Monomyarian Mollusks in the Gault, only 2 are confined to that formation; and while, out of 60 known species in the Upper Greensand, 38 are peculiar to it, not one known species is peculiar to the Chalk-marl; and out of 40 inferred and 35 known forms, only 14 are peculiar to the Lower Chalk.

But when we come to the Dimyarian Mollusks and the Gasteropoda, the case is different; for though, out of 27 of the former and 31 of the latter (inferred forms) in the Gault, 7 and 8 pass upwards, yet out of 74 Dimyaria and 62 Gasteropoda in the Upper Greensand, only 1 of each goes into the Chalk-marl. With the Cephalopoda, however, the proportion of forms of passage is much greater, for 17 inferred (31 per cent.) and 14 known species (27 per cent.) pass upward from the Gault, and 19 inferred and 14 known species (46 and 40 per cent.) pass into higher formations from the Upper Greensand. I incline with Mr. Godwin-Austen to attribute the disappearance of the Dimyaria and Gasteropoda to the deepening of the area, accompanied, not by extinction, but by mere migration of species.

If we mass the whole, the result is that, out of 234 inferred, 204 known, and 183 new forms in the Gault, 107, 80, and 74 pass upwards, giving the proportions of about 46, 40, and $40\frac{1}{2}$ per cent., and 109 species are peculiar.

Of 412 inferred, 377 known, and 305 new species in the Upper Greensand, 109, 75, and 51 pass upward in the proportion of 26, $19\frac{1}{2}$, and about $16\frac{2}{3}$ per cent.; while if we eliminate those forms specially liable to be affected by change of depth and conditions, namely, the Dimyaria and Gasteropoda, the number of species that pass upward rises to 39 per cent.

In the Chalk Marl, of 164 inferred, 93 known, and 49 new species, 124, 55, and 33 pass up, giving proportions of 76, 59, and 67 per cent. In the Lower Chalk, of 255 inferred, 223 known, and 130 new species, 104, 69, and 39 pass into the Upper Chalk, in the proportions of about 40, 31, and 30 per cent. Here the story ends as far as we know it in England; for of the 521 species known in our Upper Chalk, all, with the exception of *Terebratula caput-serpentis* and a few Foraminifera, have apparently become extinct during that vast period that elapsed between the close of the Cretaceous and the beginning of the Eocene epoch in England—a period of which we have no trace in this country, except in the erosion of the Chalk and the unconformity of the Eocene beds upon it.

I would fain have continued this discussion, and examined the connexion between stratigraphical breaks and breaks in the succession of species in the Tertiary epochs; but, though scarcely as a connected whole, on this subject much has already been done, and for the present I must close with our secondary strata, trusting, if worth the pains, to carry on the subject in a special memoir at some future time.

The general results obtained from this review of the British secondary strata may be summed up very briefly.

Between the Bunter and Keuper strata there is a true stratigraphical break, but so difficult to make out, that, until within the last few years, the sandy beds at the base of the New Red marl were considered part of the Bunter sandstone. Indeed it is only in one place observed by Mr. Hull, in a cutting on the St. Helen's railway, near Ormskirk, that anything like actual unconformity has been observed, and even there the appearances are scarcely more marked than in many a large case of false bedding, where an upper stratum lies on the edges of the oblique lamination below. Yet between these formations there is, in England, a gap represented on the Continent by two important sets of strata, the Muschelkalk and St. Cassian beds, containing two great assemblages of fossils perfectly distinct from each other. No one could have dreamed of this merely from an examination of the English Bunter and Keuper strata.

Such a fact as that stated above ought to act as a thorough caution against the frequent assumption that even a formation like the Lower Lias is complete; and if of the Lower Lias, far more so of the whole of the Lias series; and stronger still is the warning that may be drawn from such phenomena against the supposed completeness of the Oolitic formations. Conformities are often *accidental*, and amid the obscurities of the Lower Lias plains of England they may well be deceptive: in the Oolitic series we have seen that they are so.

From the base of the Lias to the Portland stone there is no thorough break in the succession of species between any two formations. Only in two cases does the break approach completeness, and in most of the others a goodly proportion of forms are common both to lower and upper formations. I believe, therefore, we are fairly justified in the inference that, with regard possibly to the Lias and very probably to the Oolites, the partial breaks in succession of species resolve themselves into a mixed question of migration and of actual gaps among the formations unrepresented by strata, and that these gaps, if any, imply spaces of what to us may be called lost or unrepresented time, long in themselves, but short compared with that which lay between the close of the Portland stone and the beginning of the Lower Greensand; for

In the Cretaceous series, alike in the comparatively shallow-water beds that commence and in the deep-sea beds that close the deposits, the break between Oolitic and Cretaceous species is so complete, and, what is almost more important, the difference in genera is so great, that I cannot but connect these facts with the lapse of a vast epoch in time, which with us is represented in part or altogether by the Purbeck and Wealden strata.

In other words, making, as we can often do, all liberal allowances for diversities of marine and terrestrial conditions, I cannot resist the general inference that, *in cases of superposition, in proportion as the species are more or less continuous, that is to say, as the break in life is partial or complete, first in the species, but more importantly in the loss of old and the appearance of new allied or unallied genera, so was the interval of time shorter or longer that elapsed between the close of the lower and the commencement of the upper formation*; and so it often happens that strata a few yards in thickness, or, more notably still, *the absence of these strata*, may serve to indicate a period of time as great as the vast accumulations of the whole Silurian series.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 4, 1863.

James C. Richardson, Esq., Glanrafon, near Swansea; The Hon. John Leycester Warren, 32 Lower Brook Street, and Tabley House, Cheshire; John Bell Simpson, Esq., Ryton West House, Blaydon-on-Tyne; William Bath Kemshead, Ph.D., M.A., of Cambridge House School, Southsea; and Brinsely de Courcy Nixon, Esq., 17 Bury Street, St. James's, were elected Fellows.

The following communications were read:—

1. *On some* Ichthyolites *from* New South Wales, *forwarded by the* Rev. W. B. Clarke. By Sir P. de M. Grey Egerton, Bart., M.P., F.R.S., V.P.G.S., &c.

[Plate I.]

The specimens forwarded to me for examination from the Rev. W. B. Clarke, of St. Leonards, near Sydney, N. S. W., are but two: one, a fragment of ironstone, containing the middle portion of a Fish, found at Chapel Hill, near Campbelltown; the other, a piece of indurated shale showing the anterior half of a Fish, labelled as having been found in Cockatoo Island.

These specimens are accompanied by three photographs endorsed as follows:—

1. Fish in grey shale, Cockatoo Island, near Sydney. Found in

excavating for the dry dock. The shale is a bed between thick beds of the great sandstone or Hawkesbury rocks, below the Wianamatta beds.

2. A fossil Fish from the same locality.

3. A fossil Fish from Parsonage Hill, near Paramatta (Wianamatta basin).

In addition to these the box contained a cast of the specimen of *Urosthenes australis*, named and described by Professor Dana, of the United States Exploring Expedition. The specimen of which this is a cast was found at Newcastle, on the Hunter River, in the same block from which the Plants described by Professors M'Coy and Morris were derived. On comparing this with the description given in the 'Annals and Magazine of Natural History' (2nd ser. vol. ii. 1848, p. 149), I am inclined to consider *Urosthenes* more nearly allied to *Pygopterus* than to *Palæoniscus*. The powerful heterocercal tail, the general form of the body, the large size, and the backward position of the dorsal and anal fins, are all characteristic features of *Pygopterus*, whereas I am unable to detect any material point of resemblance between *Urosthenes* and *Palæoniscus*. The dorsal fin is situated immediately over the *anal* fin *, and both these organs are shorter and placed nearer to the tail than they are in the genus *Pygopterus*. These features and the smooth character of the scales of *Urosthenes* sufficiently distinguish it from *Pygopterus*.

Of the two specimens forwarded by Mr. Clarke the larger one consists of a part only of the body of a Fish of moderate size, a foot or rather more in length. The ironstone-nodule in which it is contained is traversed through the middle by a fault, the effect of which has been to disfigure the hinder half of the specimen. It appears as if a portion of the integument, together with a group of fin-rays, had been thrown down from the opposite flank, thus giving the appearance of greater breadth of body than existed in nature. The anterior half of the specimen retains its natural outline, and is pretty well preserved. It measures $3\frac{1}{4}$ inches in depth, and, probably, represents a portion of the trunk immediately behind the dorsal fin; but as none of the fins are preserved *in situ*, this is mere conjecture. The scales are small and very numerous; each one is marked by two or three deep longitudinal sulci, and is invested with a thick coating of dense ganoine. I am inclined to think that the larger of the two specimens found at Cockatoo Island, of which a photograph is sent, is referable to the same genus as this specimen from Chapel Hill. If this conjecture be correct, we gain additional evidence of some value in ascertaining the affinities of the genus. The depth of the two fishes is about the same; so also are the characters of the scales, as far as can be determined in the absence of the original from which the photograph was taken. The pectoral fins are comparatively small. The ventral fins, of large size, are situated about

* The dorsal fin is described, in the 'Annals of Natural History,' as being over the anterior part of the *caudal* fin. This is an impossibility, since any interspinous bones of the caudal vertebræ carrying fin-rays must necessarily belong to the caudal appendage.

the middle of the abdominal line. The dorsal fin is inserted rather nearer to the tail than are the ventrals. The dislocated fin-rays before alluded to in the specimen from Chapel Hill may have belonged to the anal fin. All evidence of the form of the tail is deficient. On comparing these characters with those of known genera, there is little doubt that the affinities to *Acrolepis* are very prominent. The position of the several fins, the form and ornamentation of the scales, and the general figure of the body are all points of resemblance with that genus; at the same time, in the absence of more conclusive evidence as to many other essential points, I must hesitate to pronounce any opinion as to the identity of the Australian with the European genus. I would rather suggest a provisional name, and designate this Fish as *Myriolepis Clarkei* until more satisfactory materials shall come to light, to clear up the doubtful points in the anatomy and natural affinities of this interesting extinct Fish.

The other specimen sent by Mr. Clarke is a lump of indurated grey shale, containing the head and anterior two-thirds of a Pycnodont Fish very much resembling the genus *Platysomus*. The scales are perhaps narrower in antero-posterior dimensions than in those *Platysomi* hitherto described, and the articulating rib on the inner surface of the scales is decidedly stronger. These peculiarities would scarcely indicate more than specific characters. A photograph, however, of a second specimen, evidently of the same species and found in the same locality, shows the posterior portion of the Fish (deficient in the other), and here we find some striking discrepancies from the corresponding parts in the *Platysomi*. In the last-named genus the dorsal fin commences at the culminating point of the dorsal ridge, and extends thence to the upper lobe of the caudal fin, the component rays diminishing very gradually in length from first to last. The anal fin is the exact counterpart of the dorsal fin. In Mr. Clarke's photograph these fins do not occupy half that space, but commence much nearer to the tail, and decrease very rapidly in the length of the rays. In *Platysomus* the dorsal fin contains from 80 to 100 fin-rays, whereas in the Australian Fish it has only 30. The caudal fin also shows very different characters in the two genera. *Platysomus* has a very well marked heterocercal tail, whereas, as far as can be perceived in the very faint photographic record of this organ in the Australian specimen, no trace of such structure can be detected. The cranial bones and the scales are neatly ornamented with fine granulations. The strength of the articulating rib of the scales has been already alluded to; so firm is the union of the scales by the splices effected by this structure, so peculiar to the Pycnodont family, that not a single dislocation is to be seen in the specimen. In allusion to this mechanism, I propose to name this genus *Cleithrolepis* (κλεῖθρον, a lock; λεπὶς, a scale), and the species *C. granulatus*.

There remains one photograph to be considered, representing a Fish found at Parsonage Hill, Paramatta. After the closest scrutiny, I have been unable to detect any difference between this Fish and the genus *Palæoniscus*, save only in the position of the dorsal fin, which is more advanced than in any species of *Palæoniscus* with which I am acquainted. It is placed at nearly the centre of the back, as in the genus *Pholidophorus*, instead of more or less behind this point, as in the *Palæonisci*. The tail (if the detached fragment belongs, as is stated, to the specimen) is a true heterocercal form undistinguishable from that of *Palæoniscus*. The position of the dorsal fin, although not a feature of generic importance unassociated with other discrepancies, gives nevertheless a specific character to this fish, and I propose to name it *Palæoniscus antipodeus*.

The result, then, of the examination of these specimens (in so far as materials so imperfect and scanty can be said to lead to any result) is the supposition that they give indications of four genera of fossil Fishes—one allied to *Pygopterus* (*Urosthenes*, Dana), one allied to *Acrolepis* (*Myriolepis*, Eg.), one allied to *Platysomus* (*Cleithrolepis*, Eg.), one undistinguishable from *Palæoniscus*, Agassiz. If, therefore (as I believe), the object Mr. Clarke has in view in asking an opinion on the characters of these specimens has reference to the probable age of the Australian coal-bearing strata, I fear he will be disappointed with the result, since no positive conclusions as to generic or specific identity can be deduced from the materials sent for examination; but with regard to the larger question of geological period, there appears to be sufficient evidence to stamp these remains as belonging to the Palæozoic age. Although the geographical range of genera and species at some periods in the sequence of the sedimentary deposits of our globe has been shown to be immeasurably greater than at the present day, it would nevertheless be rather unreasonable to expect to find a coincidence in this respect between the organisms of our British strata and those of our antipodes. If, however, it is allowable to apply to bygone periods the knowledge we acquire from the study of actual nature, we may argue that, as in the existing Fauna and Flora we find beyond the range of generic extension certain representative forms (as, for instance, the Gorillas and Chimpanzees of Africa, represented by the Orangs of Borneo, the Manatees of the Atlantic, by the Dugong of the Indian seas, the Crocodiles and Pythons of India, by the Caymans and Boas of America, and the Vandas and Ærides of the East, by the Angræca of Africa and Madagascar), so it may have been in the primæval world. If then we consider the Australian genera as the representatives of those Northern forms to which they are most nearly allied, we may briefly allude to the circumstances under which the latter occur in the European and North-American scale of deposits. The genus *Palæoniscus* extends from the Keuper to the Coal-measures, both inclusive. It contains nearly fifty described species—a greater number than can be claimed by any other genus of Ganoid fishes. The individuals appear to have swarmed in some seas, and especially in those of the Permian and Carboniferous periods. *Pygopterus* ranges from the Magnesian Limestone to the Coal-measures, comprising four species from the former and eight from the latter formation. *Acrolepis* has a similar range, and numbers nine species from the Permian and one from the Coal-measures. *Platysomus* contains two species from the

[*To face p.* 5.]

The following figure was inadvertently omitted in Pl. I.

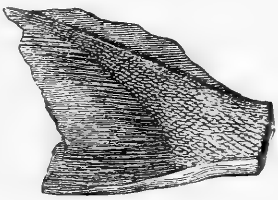
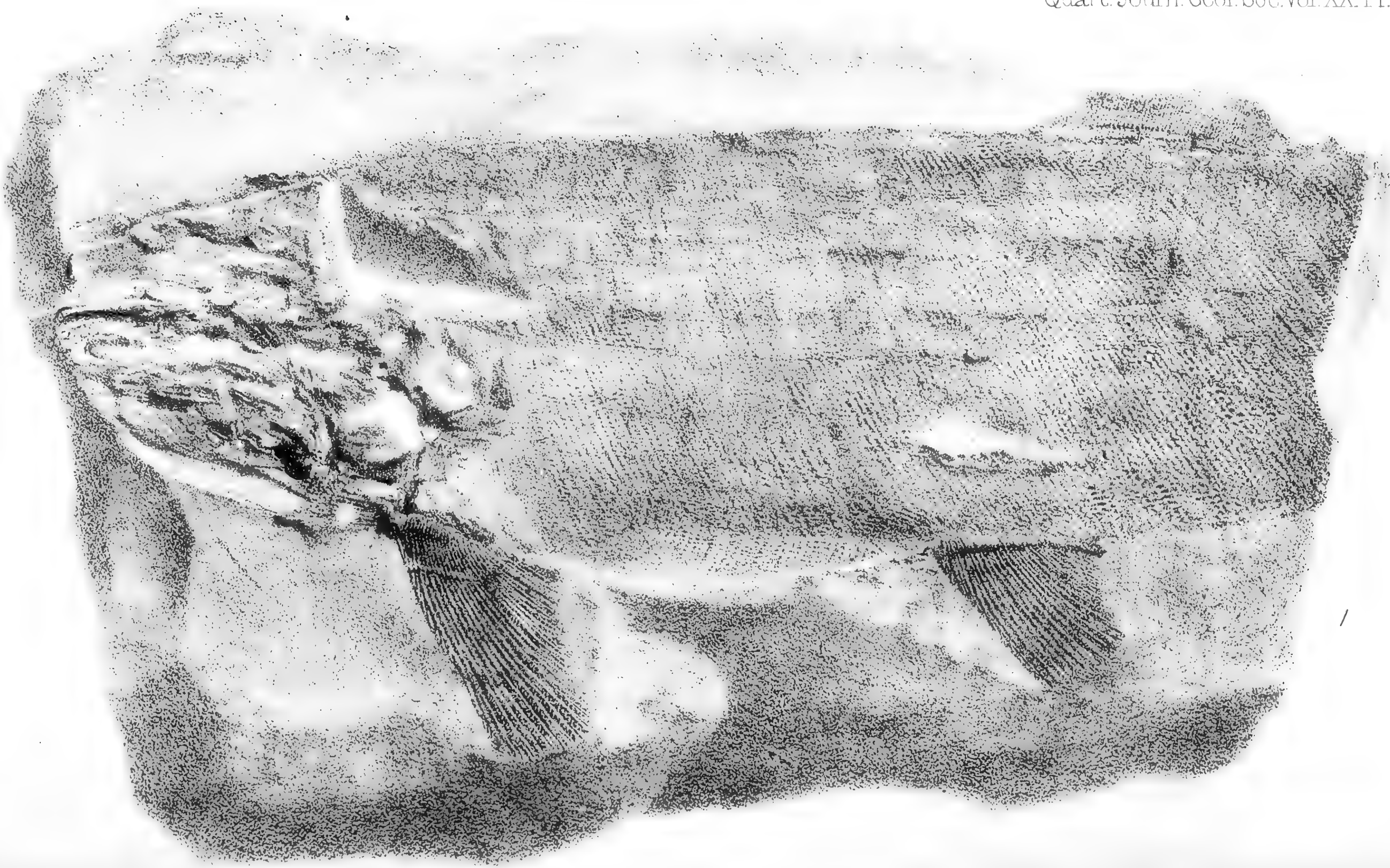


Fig. 5. Tail of *Palæoniscus antipodeus*, Eg. From a photograph. One-half the natural size (see p. 4).



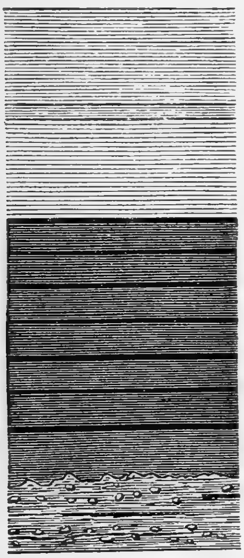
J. Dinkel lith. ad nat.

W West imp

ICHTHYOLITES FROM NEW SOUTH WALES.

Coal-measures (there is good evidence of a third), and nine from the Permian system. *Palæoniscus* and *Pygopterus* are common to Europe and America; but *Acrolepis* and *Platysomus* have not yet been recorded beyond the confines of Europe, unless some of the Russian species may be from the Asiatic territories of that empire. Taking the four genera in combination, the localities in which they are associated in greatest numbers are the Kupferschiefer beds of Richelsdorf and Mansfeld; they also occur in considerable numbers in our own Magnesian Limestone; but when we descend into the Coal-measures, although *Palæoniscus* is abundant and *Platysomus* not scarce in some localities, *Pygopterus* is partial in occurrence, and *Acrolepis* so scarce that I have only seen it from one locality, namely, Carluke in Lanarkshire; so that I know of no one locality of Coal-measure age in which they simultaneously occur.

Postscript.—Since the above notice was written I have received a letter from Mr. Clarke, dated April 7, 1863, in which he says, "The Fish with heterocercal tail like *Palæoniscus* comes from my Wianamatta beds, which are above the beds with the Cockatoo Island Fish, and therefore fully from 1000 to 2000 feet above the Coal-beds at Newcastle in which the *Urosthenes* was found."—"The sequence of beds is this:—



Plants, considered to be Oolitic by Prof. M'Coy, occur throughout."

[P. M. G. E.]

EXPLANATION OF PLATE I.

Fig. 1. *Myriolepis Clarkei*, Eg. From a photograph. Nearly two-thirds the natural size.

2. *Cleithrolepis granulatus*, Eg. From a specimen. Natural size.
3. *Cleithrolepis granulatus*, Eg. From a photograph. Rather more than one-half the natural size.
4. *Palæoniscus antipodeus*, Eg. From a photograph. One-half the natural size.

2. *Notes on the* Geology *of a Portion of the* Nile Valley north of the Second Cataract in Nubia, *taken chiefly with the view of inducing further Search for* Fluviatile Shells at High Levels. By A. Leith Adams, A.M., M.B., Surgeon H.M. 22nd Regiment. *With a Note on the* Shells; by S. P. Woodward, Esq., F.G.S.: *and a Note on some* Teeth *of* Hippopotamus; by Hugh Falconer, M.D., F.R.S., F.G.S.

[Communicated by Leonard Horner, Esq., V.P.G.S.]

Contents.

I. *Introduction.*—The following observations were made during November 1862 and the two following months, when engaged with my friend the late Mr. A. H. Rhind, F.S.A., in making the usual boat-voyage from Cairo to the Second Cataract and back*. That distinguished antiquary's knowledge of ancient Egyptian history, and his having formed a design of investigating the Nile-levels with reference to the records of the country, afforded me great advantages in carrying out my intentions in connexion with the still older memorials of the river-valley. Although well aware of the imperfections of these notes, I am not without hope that they may prove of interest to the scientific inquirer. Every field-naturalist knows how difficult it is to work at two widely different subjects at the same time,—such was my case on the above occasion; for with gun and hammer (as former experiences have taught me) I found it no easy matter to fulfil the requirements of an ornithologist and also to study the minutiæ of geology, especially as during our late excursion I seldom remained more than a few hours in any one locality; moreover, when starting for Egypt, I had no idea of the nature of the geological work before me, and, therefore, I was not provided with the necessary instruments for the exact determination of heights. I am conscious, however, that any error in this respect falls short of the truth, inasmuch as, in each case, I invariably adopted the minimum of our united surmises. This confession I consider absolutely necessary with reference to such an important discovery as the finding of freshwater Shells at the altitudes herein recorded.

Before proceeding to my subject, I may remark that my late companion continued his survey to the Delta. Being sensible of the great amount of care and diligence Mr. Rhind brought to bear on

* The specimens accompanying the paper are in the Society's Museum; the names of Shells quoted are on the authority of Mr. S. P. Woodward: see p. 19.

his portion of our inquiries, I cannot help expressing a hope that his valuable researches will soon be published.

II. *Physical character of the Nile Valley in Nubia, from Selsileh to the Second Cataract.*—After passing Selsileh, about thirty-six miles below the First Cataract, and proceeding southwards, the physical aspect of the Nile Valley is seen to change rapidly. The bed of the river gradually narrows, until it is hemmed in on both sides by rocks and steep banks, either of sandstone or granite, which appear as bold crags and rugged and worn cliffs, and, as you approach Wadi Halfeh, as isolated conical hills of sandstone; and hogs' backs, or elevated plateaus, alternate with wide expanses of desert covered, as usual, with a reddish-white sand.

1. *Sandstone and Sand-drift of Nubia.*—The siliceous sandstone of Nubia has a perfectly parallel stratification, and, except at its junction with the granitic rocks, very few traces of disturbance are observable; on the contrary, the absence of fissures and rents is remarkable, and would appear, in conjunction with other facts, to indicate that the rate of upheaval had been slow. There is likewise reason to suppose, from the wear and tear so evident everywhere on the surface, that the degradation and denudation have been enormous, perhaps far beyond what the geologist would expect from atmospheric influences alone; the sandstone of Nubia, however, crumbles readily, especially the grits and large-grained varieties. The finer particles are drifted about by the wind, and, from the proximity of the desert to the river, the latter is constantly receiving materials which mix with its mud, and form soil and sand-banks, which are ever being added to or removed, according to the direction and force of the currents. The physical aspect of Nubia is therefore undergoing considerable change, especially in the neighbourhood of the Nile; so that the even and perfectly horizontal stratification of the high lands is continuous with that of the flat-topped isolated hills in the neighbourhood, showing vast valleys of denudation, and what a tremendous scouring the country has undergone at one time or other. Although a great portion of the Nile-deposit is evidently the result of denudation going on towards its origin, the vast degradation taking place even between the First and Second Cataracts affords ample materials for the formation of alluvial and arenaceous deposits along its course northwards. The sandstone is of various sorts, and differs in consistence, being either fine-grained* and of divers shades of colour, most frequently of a light yellowish white, or a gritstone†, of considerable variety as to the size of its rounded pebbles, which are mostly composed of quartz and hornblende, and are frequently as big as walnuts. The finer particles, forming the matrix, become the sport of the winds; thus the plain is often observed covered with pebbles or angular fragments of the harder portions of the sandstone. The drifting of the sands of the Nubian desert in certain localities, as at Faras (the Phtharis of Pliny), below Wadi Halfeh, and for some distance along the left bank, produces remarkably constructed dunes, composed of a mixture of fine sand with the de-

* See Specimen No. 1. † See Specimen No. 2.

cayed twigs of the tamarisk, which grows abundantly in the district. These sand-hills have a rounded appearance, and vary as to size, many being fully 90 feet in height: on their sides and tops are tamarisk-bushes, which, being constantly enveloped in the sand-drift, get packed so closely that a perpendicular section of the mound has the exact appearance of a hay-rick, the small twigs being deposited any-how, whilst fresh bushes are sprouting up on the surface. To all appearance, these accumulations are very old. Again, along the edge of the desert, and in the arable tracts, the acacia and other bushy trees and shrubs form obstacles to the sand, which is seen extending in long tails and wreaths behind them. It takes much labour to prevent the encroachment of the Nubian desert, and now that the population has been decreasing of late years by the emigration of the able-bodied men to Lower Egypt, the advance of the sand on the cultivated districts is becoming more apparent; for instance, north of Ibrim, 65 miles north of Wadi Halfeh, I noticed that the desert has covered a great alluvial plain, which had formerly been under cultivation, and is approaching the river, so that the trunks of the palm-trees are completely surrounded with sand for upwards of 15 feet from their roots.

2. *Alluvial Heaps of lateral Water-courses.*—Although rain seldom falls in Nubia, yet, when such is the case, the fall is remarkable for its violence, as testified by the water-courses and their heaps of alluvium, &c. At the embouchures of these torrents high banks of soil are to be seen, doubtless the washings from the ancient Nile-deposits on the higher grounds, where the organic remains, to be noticed presently, are found. A breccia of great hardness, and formed of rounded as well as angular fragments, may be often traced at intervals along the bottom and sides of these water-courses, and, from its always underlying the alluvial deposits, it would appear to be more ancient. I have no doubt that it has also been formed by these torrents, which, however, are often local, and only flow occasionally and during thunderstorms. The alluvial heaps have been mistaken for ancient deposits of the Nile; it is therefore important to distinguish them from what are, without question, the result of the river's currents. There is a peculiarity of these torrent-made heaps which I found to be regular; they are situated at the entrances, and have been deposited on one side, as if caused by back-water,—a result of the current receiving a check, and being dammed back by the cultivated land, which runs across the mouths of the ravines, and is often very much higher than the bed of the torrent. On the surface, and throughout the alluvial banks, is observed *a hard, concretionary, tufaceous, and nodular substance,* which effervesces readily with acid, and has all the appearance of containing a large amount of carbonate of lime; it is usually met with in small fragments, which are strewed over the surface, or it runs in veins throughout the bed; sometimes it is found in masses upwards of a foot in thickness, or forming sticks* or small tubes run together† in irregular-shaped masses. It is plentiful all over the alluvial banks of Nubia and northwards, wherever

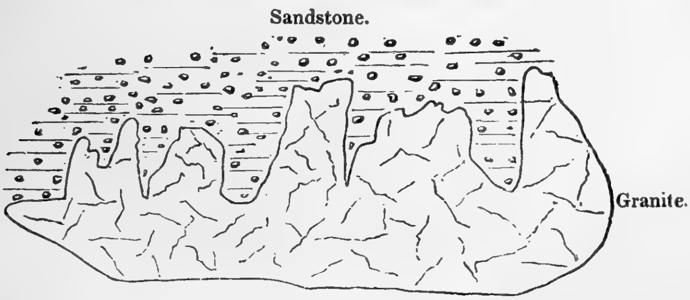
* See Specimens Nos. 3 and 4. † See Specimen No. 5.

the soil has been undisturbed and exposed to the action of the atmosphere for a length of time. The formation is going on at present, and is caused, no doubt, by some affinity between the air and the chemical components of the river-alluvium. When met with on the sands of the desert, it indicates an alluvial deposit underneath. Among the ancient river-deposits on the plain eastward of Wadi Halfeh, at the foot of the Second Cataract, this substance abounds, either in the shape of nodular fragments * on the surface, or in masses mingled with the soil. It has a great resemblance to the *Kunkar* of India, with which it appears to me almost, if not absolutely, identical †.

3. *Terraces of the Valley; their Cliffs and Caves.*—Taking a general view of the Nile Valley between the First and Second Cataracts, one is struck with the regularity with which *terrace-cliffs* and *flats* continue; indeed, except at broken intervals, these appearances are pretty clearly defined even as far down as Selsileh, about 36 miles *below* the First Cataract. At first there may be some difficulty in tracing these levels, but after a little experience their presence becomes evident; and, except where the soil has been removed by the action of rain, &c., I had no difficulty in finding abundance of river-shells at altitudes of *at least* 120 feet above the highest Nile of the present time.

The junction between the sandstone and granitic rocks is not always observed to be even or regular, as we find the latter often, as it were, dovetailing into the sandstone above, as here represented (fig. 1).

Fig. 1.—*Diagram showing the Line of Junction of the Granite and Sandstone in Nubia.*



In this way we can suppose the insular prominences of the Cataracts to have been caused by the softer sandstone being washed away.

The point of junction between the two rocks is often marked by layers of rounded water-worn pebbles, or coarse gravelly sand, which, however, may be frequently seen running in veins throughout

* See Specimen No. 6.

† Veins of oxide of iron are common between Thebes and Gofu, and are best seen on the face of the recent alluvial banks, where they run horizontally for several miles in the form of reddish bands.

beds of fine-grained sandstone. Purple-coloured veins likewise pass through the latter, and fine particles of hornblende and various-coloured grains of quartz give a variegated appearance to certain cliff-sections.

Along the Nile Valley, north of the First Cataract, where the rocks come close to the river, are numerous caves and caverns, both in the Sandstone and in the Nummulitic Limestone of Lower Egypt. At Gebel Aboofaydee, near Siout (280 miles below the First Cataract), I noticed water-worn caves 60 to 70 feet above the highest Nile; and below Ibrim, in Nubia, on the right bank, under the old stronghold (supposed to be the Primis Parva of the Romans), are numbers of cavities, at various levels above the surface of the river, and at heights far exceeding the reach of its greatest inundations in the present day. The larger caves show the characteristic alternation of contraction and dilatation of water-worn openings; those within reach of the river contain a fine clay, formed from that held in solution by the river, and not the washings of currents. This mud is evidently the accumulations of years*; it is much sought after for making the excellent water-jugs of Egypt, and is moreover exceedingly well adapted for preserving organic remains, which, however, from the nature of the Nubian climate, are never likely to be found in the caverns inland. I examined several Fox- and Hyæna-dens among the Nubian and Egyptian ravines, and, although they contained abundance of bones of animals recently killed, there was no dripping from the roofs or any soil to cover them up, as would have been the case in countries where rain falls in quantity and with regularity.

4. *Relation of Temples and Caves to the River-level.*—We were enabled to record undoubted changes in the direction and bed of the river at several points by means of the temples and stelæ, and by an examination of its present action. Close to the famous rock-temple of Abu-Simbul is a smaller temple where the Nile at its height washes the door-sill. Again, in the little square-shaped excavation on the face of the rock, a stone-throw further northwards, there is a seated figure, said to be of the same period as the last, sometime between B.C. 1322 and 1388, on the legs of which, about midway between the knees and ankles, I marked the limit of the high Nile of the present day; moreover the deep soundings along the left bank close by these two records, and the shallows and sand-deposits going on on opposite banks, show very clearly that the current continues to set in on the left bank, which it is wearing away up to the cliffs in which the above memorials are constructed.

The old temple at Ombos (22 miles north of Assuan), founded in the reign of Ptolemy Philometor (about B.C. 200), is built on a heap of alluvium which is now being rapidly undermined, whilst the ancient course of the stream is clearly traceable on the left bank, where sand-banks and shallows are now being formed.

At Selsileh the river has evidently changed considerably within

* The sedimentary deposits, when dried, split up into fine horizontal laminæ of great thinness. See Specimen No. 8.

the historical period, and is still encroaching on the left bank; for at high Nile it rises halfway, or nearly so, up the inner wall of a grotto of the time of Amenophis III., about B.C. 1430; and there is a stele on the face of the rock to the north, where the lower lines of the hieroglyphics have been worn away by the river, during the annual inundations, up to the first line, which marks the present limits of the Nile, and contains the above king's oval: further northwards, at a short distance, is a grotto bearing the oval of Tuthmosis III. (the predecessor of Amenophis), where the Nile once every year washes the bodies of a set of River Triads up to their necks, or about 4½ feet above the threshold of the grotto. Soundings showed the river deepest along the left bank, and a deposit of sand going on in the centre and towards the right bank. These examples are given with a view of showing the local changes in the river's course within the historical period; in fact, the Nile is constantly changing, and clearing away and making new channels, often running afresh on ground it may have abandoned several times in its history.

5. *The Granitic Rocks of the Nile Valley.*—The first appearance of granitic rocks north of the Second Cataract is at Abhôr, where some masses of syenite rise above the water, about three miles below Kalabshe (35 miles south of Assuan); and again, a short way further down, a ridge of syenite, or red felspathic granite, with veins of quartz, rises to a height of several hundred feet, through which the river runs. The strike is E.N.E. and W.S.W. This ridge is about two miles broad. Along the line of junction the sandstone, which occurs on both flanks, north and south, is tilted up and much disturbed, showing evident marks of the granitic rocks having protruded through the latter rock. The Nile flows placidly through the ridge, with perpendicular cliffs on either side, and makes its exit at a gorge not more than 250 yards broad, where, at midchannel, our lead-line ran out 63 feet. Following the line of contact between the two rocks on the left bank, the polished "slickensides" of the granite is seen rising at a high angle, with the sandstone shattered and broken up in rubbly disordered masses. The joint-planes of the granite appeared to be perpendicular. Throughout the river's course among these cliffs, many projecting rocks narrow its channel, but do not increase the velocity of the current. Here and there bulgings and bays occur, made, perhaps, by back-waters and swirls, when the river stood at much higher levels; all testifying to a former state of things, and offering a strange contrast to the orderly course the river is now pursuing. On the south flank of the ridge the junction between the unstratified rocks and the sandstone is clearly shown; on the left bank, above two Sheiks' tombs, in a narrow gorge, the same phenomena as those just noticed on the north side are observed. Looking northwards from the tombs, numerous granitic masses stand out on the bank of the river, through which ravines may be seen, containing huge heaps of alluvium; the latter run along the sheltered windings far above the reach of the highest modern inundation of the Nile, and clearly point to ancient channels, long since abandoned,—the most westerly being upwards of half

a mile from the river, and the surface of its alluvial banks some 50 to 60 feet above the modern level of high water.

Syenite is the chief rock at the Second Cataract. Like the Cataract of Assuan, the waters flow placidly for some distance through the rocky barrier to a ridge of granite, through which they burst with great force and considerable noise. Afterwards the waters disperse in numberless rock-channels, where the velocity is gradually lost, to again unite and form the steady slow river which flows on at a uniform rate until it is again sent dashing through the granitic rocks of the First Cataract, when all its troubles cease, and hence to the Mediterranean scarcely a ripple disturbs its even surface. At the termination of the Second Cataract or Rapid, a short way above Wadi Halfeh, the last pinnacle of syenite is seen jutting up, with a sand-bank forming the usual "crag and tail," which on a larger scale have produced the Island of Philæ above, and that of Elephantine below, the Cataract of Assuan.

6. *Freshwater Shells on the Terraces.*—An examination of the older rocks of the Second Cataract shows former levels of the river, more especially on the left bank, south of the sandstone-cliff at Abusir, around the base of which the river is now excavating, as is evident from the masses of rock which have fallen down. On the above-named levels and for a long way southward, and upwards of a mile inland, I noticed abundance of river-shells* (*Unio pictorum*, *U. lithophagus*, and *Paludina bulimoides*) strewn over the surface of the sands. On the right bank of the river there are indications of old channels, perhaps better marked than those noticed on the left. I did not, however, examine that locality, and the Shells found in the above situation did not then, as afterwards, attract my attention to seek for them among the soil underneath the sand-drift, whence, I have now no doubt, they were washed. At Derr, the capital of Nubia (eighty miles north of the Second Cataract), the cultivated tract of alluvium extends from the river eastward about 600 or 700 yards, until bounded by a rough and steep face of sandstone, 40 to 50 feet in height, in which is excavated a temple of the time of Rameses the Great, about B.C. 1355. On the top is a level plain, extending north and south, and gradually rising eastward, towards a bare range of conical hills. The surface of this plateau is very stony, and, as usual, is covered with angular fragments of hard sandstone and rounded pebbles from the grit, and coarser varieties of that rock. Under these occurs a scanty reddish-brown soil, containing natron, which the natives use as a top-dressing for their fields. In the excavations, and throughout this soil, I found abundance of *Cyrena fluminalis*†, a species identical with the common Shell of the Nile. It occurred in great numbers from the margin of the plateau, immediately above the temple, eastward for upwards of a mile and a half. The height of this flat land varies, according to our estimations, from 130 to 110 feet above the highest mark of the Nile's inundation in the present day. The following sketch will

* See Specimens Nos. 1 and 2.

† See Specimen No. 3.

perhaps better explain the appearances of this portion of the country (fig. 2).

Fig. 2.—*Diagram-section of the Nile Valley at Derr.*

Right bank. Left bank.

E. W.

1. Nile. 2. Highest reach of the modern inundation. 3. Alluvial plain of Derr, cultivated to near the Temple (4). 5. The plateau containing the Fluviatile Shells. 6. The rounded, irregularly shaped sandstone-hills. 7. The Desert and its sand-drift, down to the limits of the Inundation.

The left bank was not examined.

Below the level of the above plateau, and a little further down the river on the opposite bank, is the Temple of Amada, which existed in the time of Tuthmosis III., about B.C. 1490.

Looking southward from Korosko, forty-four miles north of Derr, an excellent view of the above flat can be obtained, and its sweep around the river-valley can be easily traced. About 25 miles northward on the same terrace-flat, and at elevations of 100 feet and more, I found the same *Cyrena** in the same reddish sandy soil, and in excavations made by the natives. Along with these, strewn on the surface, in crannies of the rocks, and under detached masses, I found quantities of the small spiral univalve, *Bulimus pullus*.

This species and the above-mentioned *Cyrena* were traced inland for upwards of three-quarters of a mile from the river, and until the country became broken up into ravines and rugged worn cliffs. The abrupt appearance of the left bank, rising rapidly to an eminence, and the flat plateau opposite appeared to indicate that the ancient bed of the river was on the right side.

The following (fig. 3) is a sketch of the above district at the village of Gharbea, in the Wadi el Arabi, a few miles north of Korosko.

Fig. 3.—*Diagram-section of the Nile Valley at Gharbea, north of Korosko.*

Right bank. Left bank.

E. W.

1. Nile. 2. High Nile. 3. Cultivated tract. 4. Plateau containing *Cyrena fluminalis* and *Bulimus pullus* †. 5. Broken country. 6. Conical hills of sandstone. 7. Sandstone-hills and desert down to the water-mark (2).

* See Specimen No. 4. † Specimen No. 5.

The flat on the right bank at Dakke (172 miles north of Wadi Halfeh) was found to be not quite 100 feet above the level of the river; and, as usual, it was covered with the same soil and loose stones noticed at Derr, Korosko, and the last-named locality. I traced the *Cyrena fluminalis** among the natron-soil for upwards of a mile inwards, and the *Bulimus* for another half-mile to several hills, and to a desert plain which was covered with drifted sand. *No trace of Shells could be met with at corresponding heights on the left bank.* The alluvium extends from the river for a long way beyond the Temple of Dakke, which, like that at Maharraka, is built upon it. I may here remark that neither the *banks* of alluvium now forming nor these more ancient accumulations seem to contain many Shells; it is only on ancient bottoms, where the currents were not strong, and depositing much, that these remains appear most abundant. The great alluvial heaps seem to have been deposited by rapid currents, which may not have carried Shells along with them. I have often been struck with the absence of any traces of animal structures in the *alluvial banks* of the river, which fact I cannot account for in any other way.

The above-mentioned high levels were traceable along the slopes at broken intervals on to Gertassee. On a plateau behind the village, some 60 to 80 feet above high Nile, *Cyrena fluminalis, Unio lithophagus*?, and *Paludina bulimoides* † were found in abundance.

The granitic rocks, reappearing about six miles below Gertassee, continue on both sides of the river, in the shape of high rugged ridges, to Debod, 18 miles south of Assuan, on the left bank, where there is an excavation or bay, from the granite not having protruded so high as in other situations; in consequence of this the sandstone overlies the latter. West of the village is observed a terrace-cliff, more or less covered with sand and shingle; it is traceable around the basin to where the river narrows again southwards. There, at various points, some 60 to 70 feet above the river's level, were found abundance of the three last-mentioned Shells ‡. The desert has intruded greatly on the plateaus and alluvial banks; the latter rise in great heaps along the side of the old basin, so that it is now scarcely possible to define the limits of either. This is an interesting locality for several reasons. There stands the ruined temple, probably at least 2000 years old, on comparatively recent river-deposits, over which are strewed the tufaceous nodules so frequently noticed on the surface of these beds. In these banks the ancient race excavated their catacombs and caverns, whose ghastly remains are now spread at the entrances, and bleach on their sunny slopes; whilst a few feet higher is the above-mentioned plateau, with its immeasurably more ancient memorials spread over or in the now scanty soil, in the hollows and the crevices of the granitic rocks.

7. *Ravines east of Philæ, with Alluvium and Freshwater Shells.*——From Debod the river runs between hills of granitic rocks, having high bands of alluvium on each side, to the top of the First Cataract.

* Specimen No. 6. † Specimens Nos. 7, 8, 9,
‡ Specimens Nos. 10, 11, 12,

Opposite Philæ are banks and heaps of river-deposit, some 30 feet higher than the modern limit of the inundation; eastward a fine broad valley opens out and stretches in that direction, curving gently northwards, when it sweeps round to join the river below Assuan, as will be noticed presently; its northern side, for some distance from the river, is formed of granitic eminences, with valleys which run northwards in divers windings to meet the former at Assuan. The above-mentioned valley is more or less covered with sand-drift and washings from the slopes on each side. A perpendicular section of 25 feet is well seen in the bank of a torrent-bed, about a mile from the river, on the southern side of the valley; and this shows the following succession:—

1. River-alluvium overlain by sand-drift.
2. Stratified sand and gravel.
3. Conglomerate.
4. Coarse white sand.

A similar section is perceived in another part of the valley to the north, showing much the same order of beds. The height of the first section may be from 35 to 40 feet above high Nile. Among the alluvial beds and ancient deposits in the ravines northwards, also strewing the surface where the rain had washed down the slopes, were abundance* of *Ætheria semilunata, Iridina Nilotica*, and *Bulimus pullus*, at heights varying from 40 to 60 feet above the level of the river.

Nowhere in the Nile Valley is the vast force and fury of the storms that now and then burst on Nubia better attested than among the shattered rocks and ravines eastward of the First Cataract. I penetrated several miles in that direction, finding abundance of river-shells either among the soil in the hollows or strewn on the surface, impressing me strongly with a belief that the river had at one time forced its way through these ravines, just as it now makes its way through the others westward. The sandstone was again noticed between the pinnacles of granite, and even topping them in many places; whilst (as at Kalabshe) upturned masses lay along their flanks. These appearances led me to infer that, in all probability, these granite-rocks had been united at one time by sandstone, and that the river had washed away the intermediate and softer rock; moreover, that the sandstone, between the granitic projections in the present course of the stream, had given way to a greater extent, causing the river to sink to lower levels and thus abandon its ancient channels eastward. Is such a result likely to have taken place more readily during a general rise of the river-valley?

8. *Philæ.*—Opposite Philæ, on the left bank, which is very steep, the remains of a terrace-cliff are definable, but so overwhelmed by drift as to render our endeavours to procure remains a failure. The monuments of Philæ show that, at least within the last 2200 years, the river has changed very little in any way. There is an opening

* Specimens Nos. 13, 14, 15.

in the western wall for entrance at high Nile; and there are many holes in its south-western angle for attaching boats at different levels of the water, all suited to the present rise and fall of the river. Midway in the easternmost channel, opposite Philæ, we found a depth of 50 feet. That the river has subsided much since it flowed through its eastern channels is most probable; moreover, to account for the enormous sinking which has taken place, we can, according to what has been shown with reference to its ancient levels at and above the cataract, come to some such a conclusion as this—that the *primæval Nile was a larger and more rapid river than the Nile is now.*

9. *Assuan and vicinity.*—Proceeding down the river, terrace-cliffs are visible on the left bank. On one of these, nearly opposite Assuan, I found a few specimens of *Cyrena*; but I had not leisure to institute a careful inspection of the higher plateaus, some of which seemed fully 100 to 120 feet above the river. Proceeding eastward from Assuan, in a direction parallel to the valley opposite Philæ, I met with abundant proofs of ancient levels. Granitic ridges and boulders were observed interspersed among the old banks of alluvium in the ravine near the town; further east, a long ridge of sandstone runs northwards (with a white tomb at its extremity); from this point a vast valley runs north and south, marked by mounds of alluvium, being the continuation of the great valley opposite Philæ, which concentrates, with the other ravines, in one great plain, debouching on the river a little way below the town, as already stated. Abundance of river-shells strew the beds, and are met with along the banks, chiefly along the eastern side of the largest channel, as it sweeps round towards the river. Another excellent panorama of the Cataract may be seen from a Sheik's tomb on the top of a hill directly opposite Assuan. From the terrace-cliffs on the left bank to the eastern bank of the great ravine, the distance, in a straight line, may be about $2\frac{1}{2}$ miles.

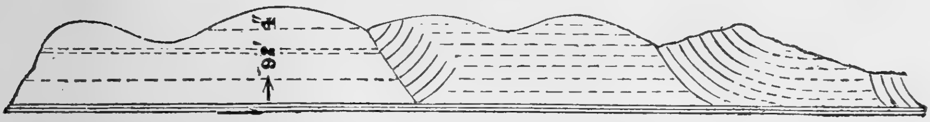
After leaving Assuan the river-valley opens out; and along its right bank, at divers elevations, from 20 to 30 feet above the highest Nile, may be seen abundance of freshwater Oysters (*Ætheria semilunata*)*, not only scattered in enormous quantities throughout the soil, but adhering in numbers to their old rocky bottoms. At the village of Bahveech, opposite the Island of that name, I met with beds of these Shells among the old alluvium now being dug out of the crevices of the rock, besides *Cyrena* and *Iridina*, which were likewise plentiful.

10. *Ombos and vicinity.*—The temple of Ombos has been already mentioned (p. 10) with reference to the wearing away of its alluvial foundation and the change of the river's course within the historical period. Standing among the ruins and looking on the fine broad valley, we noticed numerous high beds and banks of soil dotting the surface. One in particular is well worthy of attention, being perhaps the greatest alluvial accumulation visible throughout the river's course from Wadi Halfeh to the sea; it runs along the left bank a short way below Ombos, at a place called Maneche, display-

* Specimen No. 16.

ing a perpendicular section of stratified mud, which I ascertained by measurement to average between 80 and 90 feet in height*. The lines of bedding are not always parallel, but, as the accompanying sketch (fig. 4) shows, are also oblique, which I conceive might result from the mud having been deposited by eddies and swirls.

Fig. 4.—*Diagram-section of an Alluvial Bank at Maneche, below Ombos.*



The surface is, as usual, covered with drifted sand and pebbles. I found no organic remains in this bed; but my examination was not sufficiently extensive to enable me to speak confidently on that point.

Besides the above, I noticed, for the first and last time, on its southern flank, a great bed of stratified sand, red and variegated; throughout were interspersed rounded and oval masses† of sandstone, of a black colour externally, becoming paler towards their centres, and varying in size from small oblong sticks to flat oval-shaped lumps several feet in length. In consistence this sand-bank appeared firm and indurated. Again, on the opposite bank, a mile below Ombos, we noticed quantities of a white substance‡, in the shape of roots of trees, interspersed throughout the alluvial deposit.

The before-mentioned old mud-beds are in all probability the deposit of the river; but the variegated red sand and its nodules are very different from any formation that I have seen in the Valley of the Nile. From the general appearance of the surrounding country, it seemed to me an excellent locality for studying the earlier deposits of the river. No doubt between Assuan and Selsileh, where the country opens out, the early Nile had time to deposit the débris which it could not lay down in its narrow mountain-course above the First Cataract.

11. *Selsileh and vicinity.*—The white limestone of Thebes is seen for the first time on the right bank above Selsileh, but disappears before you reach the sandstone-gorge through which the river passes. This opening is made in a ridge of fine-grained sandstone crossing the valley almost due east and west. At the entrance to the river's channel, on each side, for some distance, are great banks and dome-shaped hillocks of alluvium, evidently washed against the flanks of the ridge by the river in former times; as usual, these are covered with nodules of the concretionary tufaceous substance. On the right bank a great bed of alluvium has banked up what had evidently been an old river-channel, as the Shells found in the neighbourhood and other appearances indicate. Again, abundance of *Cyrenæ* were

* Specimen No. 7, to contrast with the usual sedimentary deposit No. 8.
† Specimen No. 9. ‡ See Specimen No. 10.

found on terrace-cliffs throughout the river's course, especially on the ridge on its left bank, some 80 to 90 feet above the most ancient of the temples and grottos, and, wherever any soil has been left, also strewing the surface of the loose sand. I noticed in the above situation several great rents and slips in the rocks, running N.E. and S.W.: these are rarely observed in the sandstone, unless in the neighbourhood of the granitic protrusions, none of which could, however, be seen, at least in the neighbourhood of the gorge. With reference to Sir Gardner Wilkinson's hypothesis, that the barrier at Selsileh dammed back the river and produced the rise recorded at Semneh, there can be but one opinion. When the locality has been even casually examined, it is evident that, supposing the height of the river to have been equal to that of the plateaus above-mentioned, its waters would not only flow through the large gorges right and left of the present entrance, but almost top the ridge altogether; moreover, granted even a barrier as high as the very summit of the ridge, then even the utmost effect on the rise of the river southwards could not have extended beyond a few miles. I believe a closer examination of the locality than I had an opportunity of making will afford more convincing proofs of the impossibility of any obstacle so far down affecting the rise of the river even at the First Cataract.

After leaving Selsileh, terrace-cliffs are seen running along both banks to within a few miles of Edfu, and wherever the hills approach the river, until the limestone appears near Esneh, where the river-valley opens out and all traces of high grounds are lost.

III. *Conclusion.*—From the evidences adduced, it appears to me that there is reason to infer that the Nile in early ages was a rapid river; and that the force of the stream has been steadily declining, at least since the upheaval (?) of the valley ceased; therefore the wearing process has diminished: for this reason the bottom contains more mud, and in consequence may even be rising, on the whole; and this latter opinion Mr. Rhind seemed disposed to hold. His observations, however, tend to show that the change has been scarcely perceptible within the long historical period furnished by the records, excepting, as already shown, at certain points, caused by a change in the direction of the river's force: perhaps a similar change, or the giving way of a barrier close to Semneh, as Mr. Horner remarks *, might explain the fall of the river there.

* "Observations on the Discovery, by Professor Lepsius, of sculptured marks on rocks in the Nile Valley in Nubia; indicating that, within the historical period, the river had flowed at a higher level than has been known in modern times," by Leonard Horner, Esq., F.R.S., &c. Edinburgh New Philosophical Journal for July 1850.

See also 'Letters on Egypt,' &c., by Lepsius (Bohn, 1853, 12mo), pp. 30 and 238, and his reply to Mr. Horner's "Observations," p. 530.

Note on the Freshwater Shells *collected in* Nubia *by* Dr. Leith Adams. By S. P. Woodward, Esq., F.G.S., A.L.S.

The Shells and fragments of Shells from Egypt collected by Dr. Leith Adams are not all determinable—at least with such materials for comparison as are contained in the British Museum.

The fragments of a *Unio* resembling the British *U. pictorum* may belong to a species called "*U. lithophagus*" in the National Collection. The little *Bulimus* is identical with the common Indian *B. pullus*, but we have no Egyptian specimens. The remaining four species are common Nile Shells of the present day. The following is a list of the species, the numbers attached referring to those on the specimens:—

Fossil Specimens.

No. 7.	Unio "lithophagus"?. Paludina bulimoides.
8, 9.	Cyrena fluminalis, var. trigona.
10.	Bulimus pullus; Wadi el Arabi.
11.	Cyrena fluminalis, var.
12. 13.	Cyrena fluminalis, var. Unio "lithophagus"?. Paludina bulimoides.
14.	Ætheria semilunata. Cyrena fluminalis. Iridina nilotica. Bulimus pullus.
15.	Ætheria semilunata. Unio "lithophagus"?.

Recent Specimens.

Cyrena (Corbicula) fluminalis; Nile above Thebes.
Paludina bulimoides; First Cataract.

[S. P. W.]

Note on some Teeth *of* Hippopotamus *from* Nubia. By Hugh Falconer, M.D., F.R.S., F.G.S.

(Abstract.)

Dr. Falconer described two molars imbedded *in situ* in a fragment of the left maxillary of a very large Hippopotamus. The specimen is reported to have been dug up near the old temple of Kálábshé in Nubia, and it was forwarded to the Society by Dr. Leith Adams with his paper. Dr. Falconer was of opinion that although the teeth are as large as in the majority of fossil specimens of *Hippopotamus major*, the Kálábshé remain does not present characters sufficient to distinguish it from the existing species of that country—*Hippopotamus amphibius*.—[H. F.]

November 18, 1863.

Charles Tylor, Esq., F.L.S., 24 Holloway Place, Holloway, N.; and William Brightmore Mitchell, Esq., 16 Broom Hill, Sheffield, were elected Fellows.

The following communications were read:—

1. *On the* Fossil Corals *of the* West Indian Islands.—Part II. By P. Martin Duncan, M.B. Lond., F.G.S., &c.

[Plates II.–V.]

Contents.

I. Introduction.

Immediately after the first part of this communication was read*, Mr. Lonsdale forwarded to the Society's Museum a large collection of specimens from San Domingo, and a manuscript in which many of them were described. Ten years had elapsed since the latter had been written, and for that period some most important fossils have been lost to science. Several of the species had been described by me before Mr. Lonsdale's MS. came to hand†; and during the last few years the knowledge of the anatomy and classification of the *Zoantharia* has so increased, that the results of the careful studies of ten years ago are now the common property of naturalists.

The collection forms part of Col. Heneken's gift to the Society, and Mr. Lonsdale's manuscript contains elaborate descriptions of many, but not of all the species, and having usually the generic name alone appended.

Mr. Lonsdale wished his essay to be placed in the Library of the Geological Society, and gave me permission to make such extracts as I might think fit. In describing the new species of this collection, reference will be constantly made to Mr. Lonsdale's MS.; but their diagnosis was studied irrespectively of his elaborate labours; and, although I venture, now and then, to differ from him, I am most anxious to testify to the loss the Society has incurred by his long retention of a most able essay.

The specimens about to be described were derived from the Nivajè, Angostina, and Postrero shales, the tufaceous limestone, and the Cerro Gordo district,—the Miocene strata of San Domingo. A few were collected from the silt of a Sandstone plain, and, from the nature of the Corals, it is evident that this locality contains the washings of the raised reefs as well as recent forms.

I have also described some new species from Jamaica and Antigua.

* See Quart. Journ. Geol. Soc. vol. xix. pp. 406 *et seq.*

† *Astræa endothecata*, nobis; *Dichocœnia tuberosa*, nobis; *Placocyathus Barretti*, nobis; *Astræa cylindrica*, nobis.

Concerning the mutual affinities of the fossil Coral-fauna of the West Indian Islands, and the recent Coral-fauna of the Pacific Ocean, South Seas, and Indian Ocean, as well as of the European and West Indian Miocene Coral-faunæ, the generalizations which were the result of the study of the species described in the first part of this communication are strengthened and are rendered more striking by the examination of the recent accession to the Heneken Collection.

Ceratotrochus duodecimcostatus, *Trochocyathus latero-spinosus*, and *Stylophora raristella*, well-known European Miocene species, are contained in the collection; the genus *Pocillopora* is also represented, although unknown in the present Caribbean seas. There are several specimens of a new *Trochocyathus* possessing some unusual anatomical peculiarities which lessen the distance between the *Turbinolidæ* and the *Astræides*; whilst some magnificent simple Corals are intermediate between the genera *Montlivaltia* and *Circophyllia*. Two species of a new genus, belonging to the family of *Compound Astræans*, are described; they present the greatest elaboration of structural details I have ever seen amongst Corals, and are most complicated.

II. List of the Species.

Family Turbinolidæ.

	Locality.
*1. Ceratotrochus duodecimcostatus, *Edwards & Haime.*	Yellow shale of Angostina, San Domingo.
*2. Placocyathus Barretti, *nobis*	Postrero shale, San Domingo.
*3. —— variabilis, spec. nov., et 4 varr.	Nivajè shale, San Domingo.
*4. —— costatus, spec. nov.	Nivajè shale, San Domingo.
5. Trochocyathus latero-spinosus, *Edwards & Haime.*	Nivajè shale, San Domingo.
*6. —— abnormalis, spec. nov.	Nivajè shale, San Domingo.
7. —— profundus, spec. nov..........	Jamaica.

Family Stylophorinæ.

8. Stylophora raristella, *Edwards & Haime.*	Silt of the Sandstone plain, San Domingo.
9. —— affinis, *nobis*, var. 2	Cerro Gordo and Nivajè shale, San Domingo.

Family Astræides.

*10. Dichocœnia tuberosa, *nobis*, var. .	Tufaceous limestone, San Domingo.
11. Stephanocœnia intersepta, *Edwards & Haime.*	Silt of the Sandstone plain, San Domingo.
*12. Caryophyllia affinis, spec. nov. ...	Tufaceous limestone, San Domingo.
*13. Antillia (Montlivaltia) ponderosa, *Edwards & Haime*, sp.	Nivajè shale, San Domingo.
*14. —— dentata, gen. et spec. nov. ...	Nivajè shale, San Domingo.
*15. —— Lonsdaleia, gen. et spec. nov.	Nivajè shale, San Domingo.
*16. —— bilobata, gen. et spec. nov. .	Nivajè shale, San Domingo.

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* Described, more or less completely, by Mr. Lonsdale under various generic names.

	Locality.
*17. Teleiophyllia grandis, gen. et spec. nov.	Nivajè shale, San Domingo.
18. —— navicula, gen. et spec. nov. .	Nivajè shale, San Domingo.
19. Mæandrina sinuosissima, *Edwards & Haime*.	Silt of the Sandstone plain, San Domingo.
20. Astræa Antillarum, *nobis*, var. ...	Chert? of Antigua.
21. —— brevis, spec. nov.	Nivajè shale, San Domingo.
22. Plesiastræa distans, spec. nov. ...	Silt of the Sandstone plain, San Domingo.
23. —— globosa, spec. nov.............	Silt of the Sandstone plain, San Domingo.
24. —— spongiformis, spec. nov. ...	Silt of the Sandstone plain, San Domingo.
25. —— ramea, spec. nov. et var. ...	Silt of the Sandstone plain, San Domingo.
*26. Solenastræa Verhelsti, *Edwards & Haime*, var.	Tufaceous limestone, San Domingo.
27. Siderastræa grandis, *nobis*	Silt of the Sandstone plain, San Domingo.

Tabulate Coral.

*28. Pocillopora crasso-ramosa, spec. nov.	Nivajè shale, San Domingo.

III. Description of the Species.

1. Ceratotrochus duodecimcostatus, Edwards & Haime.

A very fine specimen possessing the characteristics of this well-known form, is 1½ inch high, and $\frac{9}{10}$ inch broad at the calice.

From the yellow shale of Angostina, San Domingo. In Europe, from the Vienna basin, Turin, &c. Coll. Geol. Soc.

2. Placocyathus Barretti, nobis.

Two varieties of this species were noticed in the first part of this communication as coming from San Domingo; a specimen of the typical form is amongst the collection under examination, and it is now noticed because it has not hitherto been recognized in San Domingo.

From the Postrero shale, San Domingo, and the Miocene of Jamaica. Coll. Geol. Soc. and Brit. Mus.

3. Placocyathus variabilis, spec. nov. Plate II. figs. 1 *a*–1 *c*.

Placocyathus? species 1, Lonsdale MS.

Mr. Lonsdale has described two species of *Placocyathus* from the Heneken Collection; the first is founded on five specimens, and the second on one. The following are the specific characters of the first.

**Corallum flabelliform, curved below and sharply pedicellated. The curve is in the plane of the major axis. The upper half of one side has a deep indentation, but the opposite surface is almost uniformly convex. The extremities are obtusely rounded. Calice, an elongated oval, modified by the indentation, principally occupied by the septa, and having a long and narrow central fossa, not deep,

** The descriptions prefixed by a double asterisk are abbreviations of those in Mr. Lonsdale's MS., and the portions between inverted commas are copied from that memoir.

and bounded below by the lamellar columella. The margin is straight, and the calice rather shallow. Septa about 210, or six complete cycles and part of a seventh; their distribution is irregular. The lamellæ of the first three cycles, and a portion of the fourth, are of equal dimensions, and range to the fossula; those of the fifth are much shorter, and the rest are rudimentary. All the upper extremities are free and boldly arched, the largest projecting upwards $\frac{1}{10}$ inch beyond the calicular margin. The lamellæ of the first four cycles are nearly equal in thickness, and the thickness does not vary in any part of their course. The sides are minutely papillated with unequal and irregular granules; sometimes they are arranged in rows parallel to the outline of the lamellæ, and adjacent to the edge they are very frequently in short, close-set, minute ridges. The papillæ on the edges are the upper extremities of these ridges. Pali occur as rounded lobes in front of the lamellæ referable to the penultimate and antepenultimate cycles, but there is some want of uniformity; they vary in size, and are solidly united to the lamellæ, with which they agree in structure. Columella thin, lamelliform, essential, and continuous; the upper edge is lobed and sharp. Epitheca pellicular, smooth, glistening, and consisting of "delicate superimposed laminæ, flakes of which may be detached mechanically. It permits the costæ to be faintly seen, and is minutely granulated at the upper extremity." Costæ faintly visible, except close to the calicular margin; at that part they exhibit "a thin granulated edge with clear interspaces; but a little lower the edge thickens, becomes nearly, and the sides are, contiguous." "Throughout the remainder of the specimen the costæ may be traced, maintaining a slightly convex outline." Instead of conforming to the shape of the corallum and radiating from the pedicel to the calice, the costæ, both before and behind, are straight, parallel, and run at right angles to its margin. The lateral costæ incline to the pedicel, as is usual in flabelliform Corals, and the most external of the parallel series joins them. Wall very dense and thick. Interior much filled up below by hard coral-salts. Height $1\frac{1}{10}$ inch; length of long axis $\frac{6}{10}$, of short $\frac{7}{10}$ inch; breadth of fossula $\frac{1}{20}$ inch and more, depth $\frac{3}{20}$ inch; Locality, Nivajè shale. Coll. Geol. Soc.

Variety 1*. Plate II. figs. 2 *a*–2 *c*.—Corallum flabelliform, much compressed, marked by growth-rings; pedicel sharp and curved. Calice long, straight, and without indentation. Costæ parallel to a slight extent, but only for a short distance downwards, thence they converge to the base, and some join the lateral costæ. The costæ are alternately large and small, and are granulated on the free margin, there being two or three series of granules on the larger and one on the smaller. Epitheca badly developed, and deficient in some places where the costæ project. Height $1\frac{2}{10}$ inch; length $1\frac{6}{10}$ inch; breadth $\frac{5}{10}$ inch.

From the Nivajè shale. Coll. Geol. Soc.

Variety 2.—Corallum very solid and heavy from filling up. Calice

* This and the three following varieties are not described in Mr. Lonsdale's MS.

very slightly indented in more than one spot. Costæ converge from the calice to the pedicel, are very distinct and crowded, those of the higher orders not reaching far down, all nearly equal and linear; they are convex and not papillated. Epitheca almost rudimentary. Height probably 2 inches; length $1\frac{6}{10}$ inch; breadth $\frac{8}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

Variety 3.—Corallum small and heavy. Costæ converging and granular. Epitheca well developed, and marked by series of granules (3 or 4) over the path of the costæ, where these are not produced.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

Variety 4.—A form intermediate between the type and variety 3. It has a large corallum and an indented calice, which is very open, and the pali are indistinct. Epitheca well developed.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

The next species has a greater affinity with the recent *Placocyathus apertus*, Edwards & Haime, than any other of the genus; but the structural differences are specific. Mr. Lonsdale has described it as "*Placocyathus*, species 2." It differs from the var. 2 of *P. Barretti*, nob. (Foss. Cor. West. Ind., &c., Quart. Journ. Geol. Soc. vol. xix. p. 428), in having more prominent and subcristiform costæ.

4. Placocyathus costatus, spec. nov. Pl. II. figs. 3 *a*, 3 *b*.

Placocyathus, species 2, Lonsdale MS.

**Corallum flabelliform, compressed, curved in the direction of the major axis, especially inferiorly, and finely pedicellated. It is marked by irregular lines of growth. The sides are lobed unequally, and they expand rapidly in the upper half of the specimen. The extremities are irregularly rounded, and diverge greatly as well as suddenly in their upward range. Pedicel small. Calicular margin horizontal, and with a wavy lobed outline. Calice irregularly elliptical, and widely open at the extremities, but less so midway. Septa numerous, crowded, often wavy, thin, broad, rounded, and but little exsert; in six systems of six cycles, the orders of a seventh being occasionally noticed. Septa of the first, second, and third cycles nearly equal, those of the fourth narrower and thinner; those of the higher order are small, in accordance with their rule. Laminæ very little thicker at the wall than elsewhere, granulated laterally and on the free rounded margin. Pali rounded, small, thin, and irregularly developed; very generally placed before the penultimate, and rarely before the antepenultimate series. The columella is a thin granulated plate with an undulating edge, and is very feebly developed. The costæ, except those of the higher orders, are sharp from the point of their appearance or interpolation; the largest are visible throughout and are subcristiform; the lateral costæ are not more developed than the others; all are somewhat wavy, and, where not abraded, are granular. The varying length of the costæ is remarkable: the principal project slightly at the calicular margin. Epitheca pellicular and papillated. The wall is dense and the interior of the corallite is well filled up with dense coral-salts. Height $1\frac{2}{10}$ inch; length $2\frac{2}{10}$ inches; breadth $1\frac{2}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

5. TROCHOCYATHUS LATERO-SPINOSUS, Edwards & Haime.

A variety with small spines.

From the Nivajè shale, San Domingo. Turin Miocene. Coll. Geol. Soc.

There are several more or less perfect simple Corals found in the Nivajè shale which are allied to the *Trochocyathi*, but which present structural peculiarities not as yet admitted to belong to the same family. MM. Milne-Edwards and J. Haime divide the *Aporose Madrepores* into families with and without endothecal dissepiments. The *Turbinolidæ* have their interseptal loculi open from the top to the bottom of the Coral, no dissepiments closing it in any way, whilst the *Astræides* possess the dissepiments. With regard to the *Turbinolidæ*, which contain, amongst other genera, *Trochocyathus*, *Paracyathus*, and *Cœnocyathus*, these authors observe that (Hist. Nat. des Corall. vol. ii. p. 8), "Ces cloisons sont aussi toujours dépourvues d'endothèque." And in the monograph of the Corals from the Gault (Brit. Foss. Corals, part 1. p. 69, Palæontograph. Soc.) there is the following observation: "By their general form all these Corals (certain *Trochosmiliæ* of the family *Astræides*) much resemble many species belonging to the division *Cyathininæ*, but differ from them and all other *Turbinolidæ* by having interseptal dissepiments." Accordingly the family of all simple Corals must be determined by the presence or absence of an endotheca. In differing from this opinion, I am fortunately supported by nature, and also by an admission of Milne-Edwards and his late and much-lamented colleague. In a careful dissection of many corallites of a well-marked specimen of the recent *Cœnocyathus anthophyllites*, Edwards & Haime, I found interseptal dissepiments (see Pl. V. fig. 4); and in vol. ii. p. 52 of MM. Edwards and Haime's work above quoted it is thus written—"Les cloisons sont serrées, très-peu débordants, peu inégales, très granulées, et présentent sur leurs faces des *rudiments de traverses lamelleuses*." This refers to the genus *Paracyathus*. The value of the absence or presence of an endotheca is therefore seriously impaired as a means of diagnosis, and the *coup de grace* is given to it by the discovery of the Corals now about to be described, which before dissection came decidedly under the genus *Trochocyathus*, but which, after, must be admitted to be *Trochocyathi* with endotheca. Their pali, lateral crests, and general habit will not admit of their belonging to the family *Astræides* (*Trochosmiliæ*): and if, after reconsideration and careful internal examination of numerous other *Trochocyathi* *, no endothecal laminæ should be found, the new forms will be placed in a new genus; but as it is, I place them provisionally amongst the *Trochocyathi* with crests (*armées*).

* I have lately found dissepiments (endothecal) in some specimens of *Trochocyathus cornucopiæ* from the Tertiaries of Malaga.

6. Trochocyathus abnormalis., spec. nov. Pl. II. figs. 4 *a*–4 *c*.
New genus, Lonsdale MS.

Corallum simple, long, compressed, strongly curved in the plane of the minor axis, and with the usual shape of the elongated *Trochocyathi*. The inferior end is small and pedicellate, and presents no sign of adhesion; and the upper, or calicular margin, is slightly arched, the centre of the large axis being on a higher plane than that of the other. The corallum diminishes in bulk gradually from above downwards. The calice is elliptical, and its fossa deep. The septa are numerous, alternately large and small, in six systems; there are two perfect systems of four cycles at opposite sides of the great axis; and in full-grown individuals there are five perfect cycles in the remaining systems, but they are imperfect in small specimens. Septa exsert, rounded and arched at the wall, vertical where the inner edge forms the boundary of the fossa, those of the lateral systems being most developed; below the margin, in sections, the primary and secondary septa are nearly alike, and the tertiary also where there are five cycles. Laminæ stout, smooth above, granular, showing both a biplated composition and a small groove, which, passing through the wall, is continuous with the interlaminar space of the septa and costæ. Columella long and narrow, sharp and uneven on the free surface; it is composed of long dissepiments joining the pali and the endothecal tissue laterally. Pali stout, and remaining attached to the columella (in transverse sections); they are granular, rounded above, and marked by one or more lines parallel with the free edge; they are seen before all the septa, except those of the last or rudimentary cycle, those of the primary and secondary septa being subequal, and larger than the others. The costæ are much more prominent at the base than at the calicular margin, the costa of the great curvature being more or less crested and spined below, but nearly plane above. The primary costæ of the sides are, now and then, slightly crested near the base, as is also the costa of the small curvature. The intermediate costæ are small, flat, distinct, and granular. Endotheca exists in the form of oblique laminæ, which extend between the septa and close-in the interseptal loculi, more or less; the dissepiments are stout and inclined. The lower part of the interior of the corallum is filled up and is solid.

Height of largest specimen $2\frac{2}{10}$ inches, of smallest $1\frac{2}{10}$ inch; length of largest calice $\frac{8}{10}$ inch, of smallest $\frac{6}{10}$ inch; breadth of largest calice $\frac{6}{10}$ inch, of smallest $\frac{5}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

This species is closely allied to the European species of the Turin Miocene with crests, except with regard to the endotheca.

7. Trochocyathus profundus, spec. nov. Pl. V. figs. 3 *a*–3 *c*.

Corallum simple, tall, subturbinate, slightly compressed, with a twisted pedicel, which presents a mark of former adherence. Corallum curved, but unevenly, and not quite in the plane of either axis. Calice elliptical and open, with a very deep fossa. Septa delicate, but little exsert, arched at the wall, and with their inner margin nearly perpendicular. The laminæ are a little thicker at the wall than elsewhere, and are granular. There are six systems of five cycles, the primary and secondary septa being nearly equal. The columella projects considerably at the bottom of the fossa, and is long, sharply convex, not very broad, and almost subcristiform above. Pali long, delicate, often curved, most visible before the penultimate, but existing also before the antepenultimate septa. Costæ distinct to the base; the largest are subcristiform at the margin and on the body of the Coral, and all are tolerably well developed and granular. Epitheca pellicular and granular. Length of calice $1\frac{1}{10}$ inch; breadth $\frac{8}{10}$ inch; depth of fossa $\frac{1}{2}$ inch; height of Coral $1\frac{6}{10}$ inch.

From the Jamaican Miocene. Coll. Brit. Mus.

This species has but a very distant alliance with one known form —the *T. lineatus*, and its long and rather flat columella and delicate pali approach it to the *Placocyathi*.

8. Stylophora raristella, var. 1, Edwards & Haime.

A large cylindrical corallum with a central cavity; it is an immense branch of a large variety of the well-known European Miocene form. Thickness of branch $2\frac{1}{2}$ inches.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

9. Stylophora affinis, var. 2, nobis.

The first variety has small calices and a wide granulated intercalicular space. This second variety has a slightly projecting upper lip to the calices, and verrucosities on the surface of the Coral.

From the Nivajè and Cerro Gordo shales, San Domingo. Coll. Geol. Soc.

10. Dichocœnia tuberosa, var., nobis.

A variety of this species occurs in the tufaceous limestone; it is characterized by closer calices, which are very fissiparous.

Coll. Geol. Soc.

11. Stephanocœnia intersepta, var., Edwards & Haime.

This Coral has thinner and less dense walls than the type.

From the silt of the Sandstone plain, San Domingo. This is a recent species, being found in the American seas and in the South Pacific (Lamarck).

The specimens are in different conditions, one alone being rolled and semifossil; the others are well preserved and light.

12. Caryophyllia* affinis, spec. nov. Pl. III. fig. 1.

Caryophyllia, spec. nov., Lonsdale MS.

**Corallum simple, straight, "cyathiform oval," and tall; it presents a large irregular base of former attachment. Costæ numerous, furnished with sharp spines which project upwards, and which, with

* I have adopted the generally received nomenclature, but the genus is now called by Milne-Edwards *Lithophyllia*.

the laminæ, are granular; they are visible to the base, but are smaller and less spinous there; two large costæ have a smaller rib between them, and it, in its turn, has a smaller one on either side. Calice oval-elliptical and deep. Septa numerous, crowded, the largest exsert and rounded at the wall, passing soon downwards and then inwards, ending in an angle over the inner vertical edge; they are lacerated above, are thickest at the wall, and granular; six systems of five cycles, and a few orders in one system of a sixth cycle.

The septa of the first three cycles are subequal, and the others are much smaller. Endotheca well developed, and between the costæ there are traces of exotheca. Height 3 inches; length of calice $2\frac{1}{2}$ inches; breadth $1\frac{8}{10}$ inch; depth of fossa $\frac{8}{10}$ inch; length of largest costal spine $\frac{1}{6}$ inch.

From the tufaceous Sandstone, San Domingo. Coll. Geol. Soc.*

This species is closely allied to the *Caryophyllia lacera*, Edwards & Haime, existing in the American seas, and has but little resemblance to the Southern Pacific species.

In the first part of this communication (Quart. Journ. Geol. Soc. vol. xix. p. 442) it was stated that probably a new genus would have to be formed to admit certain simple Corals allied to *Montlivaltia* and *Circophyllia*, and the specimens now under consideration render it imperative. The comparative diagnosis of the three genera is as follows:—

Montlivaltia. Epitheca membraniform, well developed. Columella none, or formed by septal spines. Septa with close and irregular teeth.

Circophyllia. Epitheca none, or rudimentary. Columella large and papillary. Septa in rounded lobes.

Antillia (gen. nov.). Epitheca membraniform, well developed. Columella well developed, essential. Septa both in rounded lobes and as in *Montlivaltia*.

Antillia, gen. nov.

Montlivaltia (pars), Edwards & Haime.
Circophyllia (pars), Edwards & Haime.

Coral simple, with more or less dentate septa, a columella, an epitheca, and both an endotheca and exotheca. Costæ variously granulated, tuberculated, spined or crested.

13. Antillia ponderosa, Edwards & Haime, sp. Pl. V. fig. 5.

Montlivaltia ponderosa, Edwards & Haime.
Circophyllia, species 1?, Lonsdale MS.

A small specimen of this Coral is amongst the Heneken Collection; it is a young individual, having a well-marked columella and a dense membraniform epitheca marked with transverse ridges. It is limpet-shaped, slightly compressed, and has a shallow fossa. There are six

* Mr. Lonsdale's MS. contains an elaborate description of this Coral.

systems, and five incomplete cycles. Height $\frac{12}{10}$ inch; length $\frac{17}{10}$ inch; breadth $\frac{15}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

A specimen with the epitheca worn off shows the costæ and the remains of the exotheca. It forms Mr. Lonsdale's *Circophyllia*, species 1, No. 1.

The large specimen figured in Pl. V. fig. 5 is from the Jamaican Miocene; it is described in Quart. Journ. Geol. Soc. vol. xix. p. 441, and should have been figured in Pl. XVI. of that volume. Its columella is very distinct.

14. Antillia dentata, spec. nov. Pl. III. figs. 2 *a*–2 *c*.

Circophyllia, species (new), Lonsdale MS.

Corallum simple, straight, subturbinate, slightly compressed above, with a nipple-shaped pedicel which does not present any trace of a former adherence. Full-grown individuals are tall and slightly compressed, have an ovato-elliptical calice, a subcylindrical upper part, which is slightly constricted near the calicular margin, and a conico-convex inferior extremity, terminating in a constricted pedicel, which is flattened inferiorly and marked by a small circular basal process, whence visible costæ radiate. Calice elliptical in outline, on an even plane; widely open, shallow, and presenting a small central deep fossula, bounded below by the columella, and laterally by the vertical inner edges of the larger septa. Between the fossula and the calicular margin are the septa, which, arched at the wall, pass inwards, almost in a straight line, at an angle of 45°, the upper margin of the larger septa being terminated at the fossula in a vertical line which forms their inner edge. The septal boundary to the fossula is formed by twenty-four lamellæ, and the interseptal loculi extend deeply by the side of the columella. There are six systems of septa and five cycles; the lamellæ are well developed, and there is little difference between the primary, secondary, and tertiary, which are long, straight, a little larger at the wall than the others, arched at the wall, but little inclined, and marked on their upper margin by very prominent, angular, and projecting serratures. Near the fossula the serratures cease, and a round lobe is generally seen. The lamellæ are larger at the wall than elsewhere, and taper gradually; they are broad and granular, especially towards the inner half; for, externally, the oblique dissepiments appear almost to replace the granules by their connexion with the septa. The septa of the fourth and fifth cycles are smaller, those of the last being the smallest, and reaching but a little way from the wall; the others are midway in size between the fifth and the third cycles, and are serrate. The granules are prominent, variable in size, and not crowded. The columella is seen at the bottom of the fossa; its surface is flat, and is formed by the blunt terminations of the constituent twisted sclerenchyma; it is not papillose, but dense and spongy. Costæ numerous, corresponding with the septa, much covered by epitheca, and visible at the mammillary pedicel. Where they are covered by epitheca, they are only to be distinguished by the faint lines which denote the intercostal spaces, a slightly convex elevation between the lines being over the rib. In transverse views the costæ are wedge-shaped, their bases being continuous with the lamellæ; the angle is external, rounded, and marked by a series of small blunt tubercles, whilst the sides are papillated like the lamellæ, and marked by the exothecal dissepiments, which moreover pass in front of the costæ. There is but one row of tubercles to each rib, and the free extremity is often sharply spined. The costæ, inferiorly, are more delicate than superiorly, and are thinner and closer; the distinction between their orders is moreover greater at the base than above, where they are nearly equal. The costæ project at least $\frac{1}{10}$ inch from the wall, and the intercostal furrows are well marked. Endotheca abundant, vesicular, and uniting the lamellæ, especially externally. The dissepiments are very inclined, bound unequal areas on the sides of the lamellæ, and stretch across the interseptal loculi; they do not form a spiral arrangement, but separate each interseptal space into several compartments. The dissepiments unite with the tissue of the columella. The exotheca is well developed; the dissepiments are inclined downwards and outwards between the costæ, and range across these, being there transversely arched or straight; here and there they form oblique layers, which fill up the intercostal space and even hide the costæ. The epitheca is membraniform and fully developed, extending upwards close to the calicular margin; it is marked by transverse bands and by growth-rings, as well as by longitudinal striæ. The epitheca is evidently closely attached to the costæ, but has been separated by the violence to which fossils are often subjected. The wall is distinct, and flanked by exothecal and endothecal dissepiments.

A very interesting point in the development of this species is the fact that, when very young, the septal and costal numerical development is nearly if not quite as great as in the full-grown form. A younger specimen than the type, which has not yet commenced its upward and cylindrical growth, suggests the close alliance between *A. ponderosa* and the species under consideration. Height $2\frac{8}{10}$ inches, of small form $1\frac{6}{10}$ inch; breadth of calice $1\frac{6}{10}$ inch; length $1\frac{9}{10}$ inch; length of columella $\frac{7}{10}$ inch; breadth $\frac{2}{10}$ inch; height of inner septal margin $\frac{2}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

15. Antillia Lonsdaleia, spec. nov. Pl. III. figs. 4 *a*–4 *e*.

Circophyllia, species 2, Lonsdale MS.

**Corallum straight, tall, subturbinate, slightly compressed, with a constricted calicular margin and a sharp mammilliform pedicel. Calice rounded at each end, and more or less flat and compressed laterally. Septa numerous, crowded, thin, long, exsert, having an external and internal arched lobe, the last being on a lower plane than the first, and terminating in a vertical inner edge which bounds the fossula. Upper margin of the external lobe finely dentate, that of the internal and paliform lobe being less so. The septa of the first three cycles are equal, and reach to and bound the fossula; they are distinctly bilobed. Those of the fourth are nearly as long; their internal lobe is small and does not reach to the fossula; whilst those of the fifth only possess the external lobe, and terminate internally, not far from the wall, in a serrated edge, which is only visible in sections. There are six systems of septa of five cycles, with several orders of a sixth. The laminæ are granular, and are marked by the endothecal dissepiments, the areas enclosed by these markings being granular. Near the septal margin the granules are ranged in linear series, and often merge into more or less vertical lines, which end at the margin, and give a bluntly toothed appearance to the inner lobe. The granules are continued up to the sides of the teeth of the upper lobe. The granules near the margin of the inner lobe are often smaller and more closely set than below. Between the lobes is a deep depression, which separates the calice with the fossula into three distinct parts, an inner, middle, and outer. In large specimens the laminæ are often a little curved, but in all there is a little greater thickness externally than at the fossula. The fossula is long, deep, and narrow. The columella is essential, but its bulk is composed of the ends of the septa and the terminations of the innermost dissepiments. Costæ produced above, and less so below; they are subequal above, but midway and below some smaller are interpolated; they are marked with transverse tubercles or ridges, generally papillated on the crest. The sides of the costæ adjacent to the margin are boldly papillated; the intercostal furrows are narrow, and diminish in depth inferiorly. The endotheca is well developed and vesicular. The exotheca is scantily developed, and rarely passes to the costal edge. The wall is much thicker near the base than above, and there is much consolidation of the lower part of the corallum. The epitheca is strong, membraniform, and marked by transverse ridges, but is little affected by the costæ beneath: it appears often to wear off during fossilization.

The larger specimens are rather compressed, and have a tendency to be grooved in front and behind. The columella appears to diminish in development as the Coral grows in height. The septa attain a high numerical development early*. Height of large specimen 3 inches, small 2 inches; the smallest in the collection $1\frac{4}{10}$ inch; length $2\frac{3}{10}$, $1\frac{9}{10}$, $1\frac{6}{10}$ inches; breadth $1\frac{6}{10}$†, $1\frac{6}{10}$, $1\frac{3}{10}$ inch; height of inner margin of septa $\frac{3}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

16. Antillia bilobata, spec. nov. Pl. III. fig. 3.

Circophyllia, species 3, Lonsdale MS.

**Corallum simple, straight, turbinate, and very much compressed, so as to appear more or less bilobate; it is somewhat constricted above and pedicellate below. Calice somewhat like the figure of "8"; its area is sometimes smaller than that of a transverse section of the Coral half an inch below the calicular margin; it is constricted centrally, has

* For full details of the construction see Lonsdale's MS.

† The constricted calice is not measured, but the wall just below it.

a long, narrow, and deep fossula, is shallow, and presents a wavy margin on an even plane. Septa very numerous, crowded, often curved, but generally straight, a little thicker at the wall than elsewhere, rounded externally and not bilobed, marked by a slight uneven serration on the upper edge and by small papillæ. The lamellæ are granular. There are six systems of five cycles, and several orders of the sixth. There is a long columella and a deep fossula. The endotheca is abundant, and the wall is well developed. Costæ large above, projecting outwards at the calicular margin from $\frac{1}{10}$ to $\frac{2}{10}$ inch; edges rounded and completely occupied by transverse ridges or rows of tubercles, and at the upper extremities traversed by an extension of the series of papillæ, which range along the middle of their lamellæ. Exotheca occasionally crossing the costal edges; its dissepiments are inclined, and form cells. Epitheca well developed and membraniform. Height of Coral $2\frac{1}{2}$ inches; breadth 2 inches; length $2\frac{8}{10}$ inches; length of calice $2\frac{1}{2}$ inches.

From the Nivajè shale, San Domingo. Coll. Geol. Soc. and Brit. Mus.

The genus is represented in the Tertiaries of Southern India and Scinde.

The three specimens next to be described are from the Nivajè shale. One has been the subject of an elaborate essay by Mr. Lonsdale (see MS. on San Domingan Corals, Libr. Geol. Soc.), and the others were examined by me before the reception of his valuable memoir. Mr. Lonsdale had but one specimen, and the points which caused him great trouble were fortunately easily determined by the examination of a second, which was all the time in the Collection at Somerset House. On the other hand, certain portions of the fine Coral described by Mr. Lonsdale afforded explanations concerning the structure of a part of the specimen I had noticed. The determination of the position of the genus and even of the subfamily of the Coral in the classification of Edwards and Haime is difficult, and Mr. Lonsdale, with a view to prevent the rapidly increasing complexity of this classification, decided to link the form provisionally with the *Eusmilinæ*, under the genus *Rhipidogyra*. Had the specimen I have studied been before Mr. Lonsdale, he would have rejected the subfamily under which he was justified in arranging his fossil.

According to Dana and Edwards and Haime, the Corals of the great family *Astræidæ* consist of forms whose septal margins are perfect, smooth, and entire (*Eusmilinæ*), or whose septal margins are armed with teeth or spines (*Astræinæ*). In theory, and in the case of recent Corals, this division affords great facilities; but in rolled and fossil Corals it is constantly at fault, and where there are so many grades between a spine and a smooth surface, such as granules and papillæ, it is of little practical worth. Thus the important genus *Montlivaltia* was classified by Edwards and Haime amongst the *Eusmilinæ*, but now it is found amongst the *Astræinæ*; and these authors, whose philosophic exertions to facilitate the study of Zoophytes cannot be sufficiently acknowledged, have cast a doubt whether the *Astrocœniæ* be not possessed of dentate septa. On an examination of the septa of certain species of the *Eusmilinæ*, fine granular projections and papillary eminences amounting to a serrate edge were noticed, and in certain species of *Astræinæ* no greater structural additions to the septa were observed. Series of granules and papillæ on the sides of the lamellæ of *Eusmilinæ* are very frequently terminated on the free edge of the septa by corresponding points, and the septa thus marked are quite as liable to be deemed of an Astræan nature as the septa of many species of *Isastræa*, *Thamnastræa*, *Siderastræa*, &c.

After an elaborate examination of this point, Mr. Lonsdale adds, "The foregoing statements are deemed sufficient to justify caution in using the outline of the edge of lamellæ as the basis of subfamilies."

The lamellæ of the fossil noticed by Mr. Lonsdale are highly granular and papillated, the series of points ending on the free septal upper margin, rendering it regularly and finely papillary. He considered the Eusmilian peculiarity to remain, because the distinction between papillated and smooth-edged septa had not been considered zoologically. In the specimen I have described, the papillæ evidently carry upwards with them a portion of the laminated sclerenchyma of the septa, and a very visible serration results which cannot be admitted as Eusmilian.

The genus *Rhipidogyra*, like many others, has had grave changes made in its diagnosis since its formation, and even in a few years it has lost several species, but gained a columella! It is now a fossil genus, and it is quite possible that, as in the cases of *Montlivaltia* and *Thecosmilia*, two tolerably common genera, the Eusmilian characters will have to be rejected.

A reference to the description of the genus (Hist. Nat. des Coralliaires, vol. ii. p. 214) will render it evident that there is much confusion concerning the species to be comprehended in it, and the short notices of those recognized would imply that they had not been determined from good specimens. Thus *Rhipidogyra occitanica* is dismissed with a reference to *R. Martinana*, which in its turn has three lines allotted to it. But, fortunately, Reuss has described a specimen of *R. occitanica* from Gosau, and notices both the markings of the lamellæ by series of fine granules and the presence of an epitheca inferiorly on the base of the Coral. His description of *Rhipidogyra undulata* is but slightly given by Edwards and Haime, and it contains (Denkschr. der Wiener Akad. der Wiss., 1854, p. 93) a notice of the granular condition of the lower costæ. Granular septa and costæ are thus added to the diagnosis of the genus, and a decided epitheca also.

The genus is distinguished from *Pachygyra* by the absence of "a false costal cœnenchyma" *. Now this conveys the impression that the *Rhipidogyræ* have no tissue between the costæ and the exothecal dissepiments, and there is no mention of any in the descriptions of the species. In Michelin's vertical section of *Rhipidogyra* (*Lobo-*

* Edwards and Haime, *op. cit.* p. 214.

phyllia) *Martinana* (Icon. Zooph. pl. 66. fig. 46) there are no exothecal dissepiments. They exist abundantly in the San-Domingan fossils, and, with the serrate free edge of the septa, constitute marked structural distinctions from the acknowledged peculiarities of *Rhipidogyra*. If the septa of *Rhipidogyra* are ever determined (as I believe they will be, as better specimens are found) not to be Eusmilian, the presence of exothecal dissepiments will constitute a great reason for not uniting the San-Domingan forms with that genus. The Corals formerly called *Rhipidogyra plicata* and *Rhipidogyra Danaiæ*, Edwards and Haime, have large endothecal cells, but not a vestige of exotheca, and they are now classified with the genus *Eusmilia*.

These remarks have been considered necessary on account of the many points in which the fossils under consideration agree with the genus *Rhipidogyra*.

Teleiophyllia, gen. nov.

Corallum long, low, narrow, and pedicellate. Calices confluent, forming a nearly straight series. Septa numerous, close, granular, serrate. Costæ free and granular. Columella lamellar and long. An endotheca, an exotheca, and an epitheca, all well developed.

It occupies the place amongst the *Astræides* filled by *Rhipidogyra* amongst the *Eusmilinæ*, and merits an acknowledgment of its structural perfection in its generic appellation.

17. Teleiophyllia grandis, spec. nov. Pl. III. figs. 5 *a*, 5 *b*.

Rhipidogyra ?, Lonsdale MS.

**Corallum : " the specimen is greatly expanded in the range of the major axis, but the height and breadth are small. It sprang from a minute inverted cone ($\frac{2}{10}$ inch high), and terminated inferiorly in a little pedicel which could have afforded support only to the cone. From this commencement the Coral extends almost horizontally in opposite directions, and, as just stated, very considerably, while the increase in breadth is relatively trifling. The under surface is rounded, yet elliptically rugose, and slightly narrowed towards the extremities. The sides are almost vertical; the preserved extremity is also vertical and rounded. The margin of the calice is straight. The normal outline may be said to have been straight." Calice nearly straight, the slight flexure being probably accidental; it is nearly flat or slightly convex. It is fully occupied by septa, the principal ranging from the wall to the columella, and the interspaces being small. The traces of a fossula are too slight to admit of the structure being positively stated to exist; but the range of the columella is very distinct as a small ragged ridge. The septa are in series, and the calices are not distinguishable.

Between every pair of thick septa occurs a thinner one, with occasionally a rudimentary point indicating the commencement of another cycle. " The upper margin is arched from the exterior to the columella, but the curvature is not uniform, being greatest externally; it is also sharp, whether the plate be thick or thin, and surmounted by a single row of transversely compressed tubercles—the upward terminations of the rows of lateral papillæ. The inner edge does not abut against the columella in general, being separated, for the greater part, from it by an interspace." The sides of the lamellæ constantly present arched fractured laminæ. Fragments of the endotheca, and the vesicular areas bounded by them, are beset with papillæ, in general irregularly distributed, but sometimes arranged in curved ascending rows. Out of the range of the endotheca the papillæ are arranged in ascending series which appear to radiate from below. The interseptal loculi exceed the lamellæ in thickness, and are crossed by the dissepiments of the endotheca. Columella: where well seen it is essential, lamellar, thick, perforated here and there, and connected with the septa by small dissepiments.

Wall: it consists of a solid layer which crosses the interseptal loculi; its thickness is variable but never great, and sometimes the layer is rudimentary, indistinct, or wanting. In vertical sections a perpendicular layer, more or less continuous, occurs about $\frac{1}{10}$ inch from the exterior, and is flanked on each side by a vesicular structure; it is sometimes wanting altogether, or is represented by detached points. Endotheca and exotheca: "these structures are noticed conjointly on account of the position they occupy. The endotheca consists of numerous arched laminæ, and presents, in vertical sections, a vesicular composition over the whole surface, from the columella to the wall. They are inclined downwards and inwards. Their outline and extent are irregular. The exotheca resembles structurally the endotheca, but is, of course, outside the thin wall, and the dissepiments are inclined externally," the vesicles dipping in an opposite direction to those of the endotheca. The exothecal dissepiments enclose spaces of various sizes, extend to the costal edge, and often completely fill up the intercostal spaces to the level of the costæ. "The costæ radiate in every direction from the small base, and extend along the under surface, conforming to its outline; but they bend upwards on arriving at the margin of the sides and extremities—ranging thence to the summit in closely set parallel fine ridges, crested with a single row of transversely compressed tubercles. The thickness of the costæ and their equivalent septa is equal; it is greatest at the wall and least at the free edge. Their sides are marked by the exotheca, and often by papillæ."

"Epitheca: this structure is best shown on the under surface, but patches of it occur on the sides and near the calicular margin. In the first-mentioned area it presents a solid, thickish, detachable layer (membraniform), elliptically rugose, and marked by minor lines of increment, and in the best-preserved portions the subjacent costæ are barely visible. On the sides it is thinner, and the range of the ribs is evident. Reproduction fissiparous." Height $1\frac{6}{10}$ inch; length 5 inches; breadth $\frac{8}{10}$ inch; 16 large and 11 rudimentary septa in $\frac{5}{10}$ inch; from 2 to 3 endothecal vesicles in $\frac{1}{10}$ inch; costæ project $\frac{1}{10}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

18. Teleiophyllia navicula, gen. et spec. nov. Pl. IV. figs. 1 *a*, 1 *b*.

Corallum long, narrow, low, and more or less boat-shaped; not quite straight, but a little flexuous; more or less angular below, vertical, convex, and falling-in on the sides; it is prow-shaped at the extremity (one remains only). In vertical section the outline is cordate. Probably it had a pedicel like the first species. Calicular surface slightly sinuous, narrow, and shallow, with convex septa, not meeting, but bounding the indistinct fossula. Calices not distinguishable. Septa close, crowded, very numerous, highly granular laterally, the series of granules terminating at the free arched and thin margin in regular dentations. The septa are exsert, and for the most part reach well inwards; a few exist more delicate than the others, which are nearly equal in length, breadth, and thickness. Generally a large septum is succeeded by one a little smaller, but often two equal-sized septa are found together. The laminæ are thin, and very little thinner within than without, or at the wall; they are marked by a series of granules, or raised lines, which pass upwards and more or less obliquely to the free surface, whose dentations are equal, sharp, and well developed. 20 septa in $\frac{1}{2}$ inch. Although the space between the inner margins of the septa is filled with matrix and some ferruginous deposit, it is tolerably clear that the columella is lamellar, and that the exsert septa bound a deep and narrow fossula. Costæ equal in number to the septa; but below sometimes three unite in one, to be continued along the lower edge to the pedicel. All are nearly equal, highly granular laterally, and thin externally, projecting $\frac{1}{20}$ inch from the wall. They all have a relation to the median inferior rib, and pass off from this, bifurcating and trichotomizing to reach the sides of the Coral, where they become parallel and single. Endotheca vesicular and abundant; the dissepiments attached to the septa pass downwards and inwards from the wall, enclosing granular areas. The exotheca is also abundant and vesicular, the costæ presenting attached dissepiments and granules. The wall is a very thin vertical lamina attached to the endotheca and exotheca, and connecting the septa. Epitheca exists along the lower edge as a membraniform investment to the large median costæ and their interspaces.

The specimen is about one-half of its original length. Height $\frac{1}{2}$ inch; at the centre $\frac{4}{10}$ inch; length (real) $1\frac{4}{10}$ inch; breadth $\frac{1}{2}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

19. Mæandrina sinuosissima, Edwards & Haime.

Worn specimens are found in the silt of the Sandstone plain, San Domingo. The species is recent, and inhabits the American seas.

20. Astræa Antillarum, var., nobis. Pl. IV. fig. 2.

With more distant calices than the type, produced costæ, and a less perfect development of the third septal cycle. The exact locality is not known, but the Coral, from its mineralogical characters, appears to have been obtained from Antigua. Brit. Mus.

21. Astræa brevis, spec. nov. Pl. IV. figs. 3*a*, 3*b*.

Corallum small, irregularly convex above, and slightly concave below. Corallites short, irregularly distant, and radiating. Calices circular, tolerably elevated, their height varying; the margin is rather sharp, and the external wall is marked by very distinct costæ. The septa are very slightly exsert, largest at the wall, arched, the radius of the curve being directed upwards and inwards, passing but a little way inwards before descending abruptly; they are dentate on the free margin. In six systems of three cycles, with a septum of a fourth in some half-systems; primary septa the largest, the tertiary being small. The laminæ are perfect, join the columella by ascending processes, and are slightly granular. Costæ well developed, passing downwards and outwards from the margin: the primary are equal to the secondary, and there is some variation in the size of the tertiary; they are dentate, and appear to be covered with a fine epitheca, and their course is often in a curve. In transverse and vertical sections the costæ are seen to project far from the wall, and to be marked by oblique and abundant exothecal dissepiments; the tertiary costæ being much less projecting than the others. The columella is large, lax, and papillary. The fossa is deep. The endotheca is not well developed, but the dissepiments extend to close to the calice. Diameter of calices $\frac{1}{5}$ inch; height of the corallum $\frac{9}{10}$ inch. The costæ are very marked in this species, and with the papillary columella and short calices distinguish it from its allies; it is related both to *Astræa cylindrica*, nob., and to *Astræa cavernosa*, Edwards & Haime.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

Amongst the specimens from the silt of the Sandstone plain of San Domingo, there are four well-marked species of a genus hardly as yet recognized as belonging to the present West Indian Coral-fauna*, but which is well known in that of the Indian Ocean, South Sea, and Pacific. A fossil species has been described from the Saucats Miocene, *Plesiastræa Desmoulinsi*, Edwards & Haime, *op. cit.* p. 492, and the new forms are found in various degrees of fossilization. These San-Domingan species† form, with one exception, a subgenus; they are globular in shape, and there is usually much distance between the corallites, the interval not being filled by costæ, but with an amount of exotheca which is Solenastræan in its development, for the costæ are very small, and the cœnenchymatous cells are largely developed.

22. Plesiastræa distans, spec. nov. Pl. IV. figs. 4*a*, 4*b*.

Corallum globular, with a very small surface of former adherence below, and with a slightly gibbous calicular surface. Calices wide apart, circular, but slightly elevated above the surface, which is

* Duchassaing and Michelotti (Mem. Acad. Turin, 2nd ser. vol. xix. p. 279, 1861) describe a species of *Plesiastræa* (recent) from St. Thomas, but do not give a figure. Milne-Edwards does not describe any West Indian species.

† They are very remotely allied to the species from St. Thomas.

marked by costæ covered with a thin and very granular epitheca; the calices are generally equal in size, and are more numerous above than at the sides, where their costal prolongations, more or less covered by epitheca, reach downwards to the base. Septa crowded and very slightly exsert; those of the first and second orders are subequal, and are thicker at the wall than at the columella; all have lateral spiniform granules, and the tertiary orders rarely curve towards the secondary. In six systems of three cycles, with occasionally a septum of the fourth cycle interpolated. Pali wedge-shaped and subequal, placed before the primary and secondary septa. Columella papillary. Calicular fossa very shallow. Costæ subequal at the surface, extending on to the intercalicular space, and covered with a finely and profusely granular epitheca; they appear large in relation to the septa, and are separated by linear grooves. In transverse sections, and in vertical views of fractured corallites, the costæ are seen to be very small, and to be represented by longitudinal series of sharp granules; their appearance on the surface is accounted for by the great development of the exothecal tissue, which constitutes, as in the genus *Solenastræa*, the means of corallite junction. Occasionally the exothecal cells, which are convex above, appear to form dense transverse bands. The endotheca is delicate; the dissepiments are but slightly inclined, and extend well to the columella. The laminæ of the septa are very granular. The wall is distinct and well developed. Height of corallum $1\frac{8}{10}$ inch; diameter of calices $\frac{4}{30}$ inch; distance between calices $\frac{1}{10}$ (more or less) inch.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

23. Plesiastræa globosa, spec. nov. Pl. IV. fig. 5.

Corallum globose and large, with a small base. Calices close, but not crowded, circular, and but very little above the surface, equally distributed over the whole corallum, and very equal in size. Septa but slightly exsert, largest at the wall, granular on the sides, slightly dentate above and unequal. In six systems of three cycles, the primary and secondary reaching the columella and having small pali, whilst the tertiary do not extend so far. The costæ are subequal, short, and covered with epitheca, which is hardly granular. In transverse sections they are small but not granular. Columella lax, but papillary above. Fossa deeper than in the last species. Exotheca cellular, connecting the corallites, but not so abundant as in the last form. Endotheca very scanty. The epitheca covers-in the intercalicular spaces, and often has a groove in it midway between the calices. The youngest corallites have twelve equally developed septa. Height of corallum $3\frac{1}{5}$ inches; diameter of calices $\frac{1}{10}$ inch; width of intercalicular spaces $\frac{1}{20}$ inch.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

Several specimens are semifossil, and in one the formation of casts has been completed.

24. Plesiastræa spongiformis, spec. nov. Pl. IV. figs. 6 *a*, 6 *b*.

Corallum globose, or globose above, and having a truncated peduncle below. Calices very close and crowded, barely projecting above the surface. Fossa very shallow, especially in aged corallites. Septa subequal, and resembling those of the former species. In six systems of three cycles. Pali before the primary and secondary orders. Columella cylindrical or flattened in the younger specimens, and almost styliform in the older. Costæ subequal, more projecting laterally than in *P. globosa* or *P. distans*, and, being well separated on the free surface, and not covered by epitheca, they often appear to end in a line of exotheca. Exotheca cellular and tolerably developed. Endotheca scanty. Epitheca rudimentary. Height $1\frac{4}{10}$ inch to $2\frac{3}{10}$ inches; diameter of calice rather less than $\frac{1}{10}$ inch.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

25. Plesiastræa ramea, spec. nov. Pl. V. figs. 1 *a*, 1 *b*.

Corallum in gibbous masses or more or less cylindrical processes with irregular swellings. Calices distant, very slightly exsert, circular, and unequal in size. Septa thick at the wall, thin internally, unequal in size according to the orders; finely dentate above, but sparely granular laterally. In six systems of three cycles, with occasionally an additional order in one half of a system. Pali very small. Columella lax, papillated, and small. Fossa moderately deep. Costæ well developed, subequal, and marked by three or four dentate projections; they are evidently covered with a fine epitheca, which is not granular; where the epitheca is worn the costæ are seen to be smaller, the tertiary being much smaller than the others; all project, however. Exotheca moderately developed, and often becoming indurated. Endothecal dissepiments fragile, but horizontal and frequent. Height some inches; diameter of branches 1 inch, more or less; diameter of the corallites $\frac{4}{30}$ inch; distance between the corallites about $\frac{1}{10}$ inch.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

P. ramea, var.

Calices large and deep. Three cycles of septa. Pali small, but evidently arising from the bottom of the corallite, often only before the primary septa; but although the secondary do not reach the columella, still the opposing pali are attached to that structure, which, although papillose above, is seen to be well developed in longitudinal sections. Exotheca generally indurated. Endothecal dissepiments stout and horizontal.

From the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

This fossil is worn, but is intensely hard; and another in the collection, which belongs to the typical specific form, and is from the same locality, is nearly silicified, and has attached to it the common Foraminifera of the Nivajè deposit.

26. Solenastræa Verhelsti (Milne-Edwards & Jules Haime, Hist. Nat. des Corall. p. 496), variety.

Corallum massive, short, flat, with a plane surface. Calices circular, close, almost equal in size. Wall very thin. Septa in three cycles and unequal in size; the primary are the largest, and the secondary, which are a little smaller, extend to the rudimentary columella, whilst the tertiary are small and reach but a little way inwards. All are sharply granular or subspinous laterally, and the free inner edges of the third order are bluntly but regularly dentate. Costæ rudimentary, attached to each septum, rounded and blunt. Exothecal cells large, and about $\frac{1}{20}$ inch in longitudinal measurement. Endothecal dissepiments delicate, a little inclined, with the spaces between them smaller than the exothecal cells. Diameter of corallites in transverse section $\frac{3}{20}$ inch; height 2 to $2\frac{1}{2}$ inches.

From the tufaceous limestone, San Domingo. Coll. Geol. Soc.

The identity of this form with the *Solenastræa Verhelsti*, Edwards & Haime, of the Eocene of Ghent, is very remarkable; for fragility and increased delicacy of septa cannot be admitted as evidences of anything more than a variation, induced probably by the comparative nutrition of the polypes. The dentate free edge of the smaller septa is very well marked, and is not noticed in Milne-Edwards's description. The San-Domingan Coral is therefore a very interesting form, and must be considered a variety of the Eocene species. It differs from the recent Antillian species *Solenastræa Bournoni*, Edwards & Haime, and all the other known recent forms, whilst the long corallites and crowded septa of the Miocene *Solenastræa Turonensis* are too prominent peculiarities to be mistaken.

27. Siderastræa grandis, nob.

A small fragment of this well-marked species, described in Part I. under the Jamaican fossil Corals, is amongst the specimens from the silt of the Sandstone plain, San Domingo. Coll. Geol. Soc.

28. Pocillopora crassoramosa, spec. nov. Pl. V. figs. 2 *a*, 2 *b*.

Pocillopora, spec. nov., Lonsdale MS.

Corallum dendroid, with large cylindrical branches, which are thick, long, and marked, on one side only, by verrucosities; these are sharp, wart-like elevations, covered with calices, and placed, more or less, in longitudinal parallel series, at all heights of the Coral. Calices numerous, small, nearly circular, and very equal in size. Columella small and often not to be seen; where it exists, some small papillæ are also seen, and ten or twelve rudimentary septa likewise. Fossa shallow. Intercalicular tissue dense and sparely granular on its free surface, where there are often seen irregular polygonal lines. Costæ none. Tabulæ vary in thickness. The centre of the branches is occupied by lax longitudinal corallites, without intercorallite tissue. Thickness of branches from $1\frac{1}{2}$ inch to $\frac{8}{10}$ inch; diameter of calice about $\frac{1}{20}$ to $\frac{1}{30}$ inch; diameter of intercorallite space $\frac{1}{12}$ to $\frac{1}{20}$ inch.

From the Nivajè shale, San Domingo. Coll. Geol. Soc.

The MS. of Mr. Lonsdale contains an elaborate examination of this form, but the above specific diagnosis is not taken from that source. All the *Pocilloporæ* yet described are from the Pacific, East Indian, and South Sea provinces, and *Pocillopora madreporacea*, from the Turin and Dax Miocene, is the only fossil form.

IV. General Observations.

It is very remarkable that simple Corals should predominate in San Domingo, whilst there are no instances of their having been found in Antigua. It would appear that something like this distribution exists at the present day, for simple Corals and pedunculated compound forms are very common around the northern Antilles, but rare in the eastern Caribbean Sea. Rich as the Chert and Marl of Antigua are in *Zoantharia*, they are surpassed, both in genera and species, by the shales and limestones of San Domingo. The extent of the San-Domingan Tertiaries will account, in some degree, for their comprehensive Coral-fauna; and the general absence of the siliceous form of mineralization, which appears to be quite as destructive as preservative in Antigua, has tended to the transmission of fossils in great perfection. The Nivajè and other deposits cover an extent of country of more than 3000 square miles, and they are simply the remains of a long and broad barrier-reef with its detritus and deep-sea Coral-mud. The mountain-range which supported the reef runs east and west for about 100 miles, at a distance of 30 miles from the sea, and the intervening area is filled up by argillaceous beds, limestones called tufaceous, but not really so, and a deep-blue sandy shale. The thickness of these sedimentary and reef deposits must be very great, for the cliffs through which the rivers rising in the mountain-range have cut their way are often 200 feet high close to the sea, whilst the altitude of San Jago, which is 20 miles inland, is 2000 feet, the strata dipping gently to the N.N.W. Remains of the reef exist along the mountain-side, and the sedimentary beds between it and the sea contain more or less perfect Corals, Testacea, Crustacean remains, Fish-teeth, and enormous deposits of Foraminifera and Coral-detritus *.

The discovery of a *Pocillopora* in the Nivajè shale is one of the many proofs of a former connexion between the East and West Indian Coral-faunæ, which has been asserted in my former communication. This is also the only Tabulate Coral which has been found in the San-Domingan Miocene. Found with *Alveoporæ*, it proves the existence of a surf-beaten reef in the Miocene period off San Domingo; and, taken in consideration with the discovery of great Astræans and huge simple Corals, it indicates a great luxuriance of Coral-growth and great variation in sea-depth.

Including the forms described in the first part of this communication, there are no less than 47 species of Corals from the restricted

* See Mr. Carrick Moore on the Tertiary beds of San Domingo, Quart. Journ. Geol. Soc. vol. vi. p. 39.

area in which Colonel Heneken collected; it is a number unequalled as yet by modern observers amongst any recent reef, and I am not aware of any other group of species which possesses such wide and interesting alliances. The absence of the commonest recent West Indian Coral-genera from the Antiguan Tertiaries has been already noticed, and the remark is nearly equally true in the case of San Domingo.

V. Alliances of the West Indian Fossil Corals.

The species described, and to which a Miocene* age is given, are 76 † in number: the varieties are not included, neither are doubtful species, nor are the forms whose generic diagnosis was alone possible. The West Indian Miocene Coral-fauna may be considered, from our present knowledge, to include the following groups of species and their subdivisions:—

1.	Species found in the present West Indian seas	4	recent...... 7
2.	„ „ „ East Indian and Pacific oceans	2	
3.	„ „ both the Pacific and West Indian seas	1	
4.	„ „ the European Miocene	9	 14
5.	„ „ the Asiatic Miocene	2	
6.	„ „ the European Eocene	1	
7.	„ „ the European Cretaceous strata	2	

8. West Indian Miocene Species:—

a.	Species more or less allied to the West Indian recent Coral-fauna	2	55
b.	„ „ „ the Pacific & East Indian „	18	
c.	„ „ „ both the above „	5	
d.	„ „ „ the European Miocene „	6	
e.	„ „ „ the Asiatic Miocene „	5	
f.	„ „ „ the European Cretaceous „	5	
g.	„ „ „ the Oolitic „	2	
h.	Species with a facies peculiar to the West Indian Miocene Coral-fauna, and having no close affinity with any other	12	
			76

The species belonging to each group are as follows:—

1‡. Astræa radiata; Mæandrina sinuosissima; Agaricia agaricites; A. undata.

2. Alveopora Dædalæa; A. fenestrata.

3. Stephanocœnia intersepta.

4. Solenastræa Turonensis; S. Ellisii; Astrocœnia ornata§; Trocho-

* Since the first part of this communication was read, I have had the opportunity of discovering that Prof. Heer refers to the Miocene flora of the Southern States of North America, and not to that of San Domingo; the application of his theory is not, however, the less interesting. The affinity between the Miocene and Recent North American floras with those of Oceania and Japan is worthy of consideration when the Coral-affinities are studied.

† There are 33 varieties, and a few forms which could not be specifically determined.

‡ The numbers refer to the groups just noticed.

§ The great masses of this Coral resemble the Miocene form called *Astræa microstella* by Michelin.

cyathus cornucopia *; T. laterospinosus; Siderastræa crenulata; Porites Collegniana; Ceratotrochus duodecimcostatus; Stylophora raristella.

5. Antillia ponderosa †; Astræa endothecata †.
6. Solenastræa Verhelsti.
7. Phyllocœnia sculpta; Astrocœnia decaphylla.
8. *a*. Mæandrina filograna; Caryophyllia affinis.
   b. Astræa Barbadensis; A. Pleiades; Rhodaræa irregularis; Alveopora microscopica; A. megalaxona; Cœloria dens-elephantis; Astroria polygonalis; A. affinis; A. Antiguensis; Placocyathus Barretti; P. variabilis; P. costatus; Placotrochus Lonsdalei; P. alveolus; Flabellum dubium; Dichocœnia tuberosa †; Stylophora affinis †; Pocillopora crassoramosa.
   c. Plesiastræa distans †; P. globosa; P. spongiformis; P. ramea; Cyphastræa costata.
   d. Astræa crassolamellata ‡; A. Antiguensis †; A. costata; A. cellulosa; Siderastræa grandis; Cyathina Guadalupensis.
   e. Antillia dentata †; A. Lonsdaleia †; A. bilobata †; Astræa Antillarum † ‡; A. cylindrica † ‡.
   f. Stephanocœnia tenuis; Brachycyathus Henekeni; Barysmilia intermedia; Phyllocœnia limbata; Parasmilia nutans.
   g. Isastræa turbinata; I. conferta.
   h. Astræa tenuis; A. brevis; Thysanus corbicula; T. excentricus; Stephanocœnia dendroidea; Paterocyathus Guadalupensis; Trochosmilia Laurenti; T. gracilis; Trochocyathus abnormalis; T. profundus; Teleiophyllia grandis; T. navicula.

Summary.

Species already described	28
New varieties of known species	7
New species	48
New varieties of new species	20
Doubtful	3
	106

EXPLANATION OF PLATES II.–V.

Illustrative of the Fossil Corals of the West Indian Islands.

Plate II.

Fig. 1. *Placocyathus variabilis*: *a*, corallum; *b*, part of a calice, both natural size; *c*, costæ and epitheca, magnified 4 diameters; *d*, lateral view of the pedicel, natural size.

2. —— ——, var. 1: *a*, corallum; *b*, columella seen from above, both natural size; *c*, lateral view of columella, magnified 2 diameters.

3. —— *costatus*: *a*, front view of corallum, natural size; *b*, costæ and epitheca, magnified 4 diameters.

* Doubtful: very probably it is a variety of *Trochocyathus abnormalis*, nob.

† There is a remote affinity with the present West Indian Coral-fauna, but not so close as with that under the head of which the species are ranged.

‡ These last Astræans have European Miocene affinities also.

Fig. 4. *Trochocyathus abnormalis*: *a*, lateral view of corallum, natural size; *b*, obliquely transverse section of corallum, showing the endotheca, magnified 2 diameters; *c*, longitudinal section of part of corallum, showing the endotheca, magnified 2 diameters.

PLATE III.

Fig. 1. *Caryophyllia affinis*; front view of corallum, two-thirds the natural size.
2. *Antillia dentata*: *a*, lateral view of corallum; *b*, calice, both two-thirds the natural size; *c*, lateral view of one of the septa, natural size.
3. —— *bilobata*; lateral view of corallum, one-half the natural size.
4. —— *Lonsdaleia*: *a*, lateral view of corallum; *b*, calice of another specimen, both one-half the natural size; *c*, part of the longitudinal section of part of a corallum showing the structural details, natural size; *d*, front view of a costa, magnified 4 diameters; *e*, lateral view of a costa, magnified 4 diameters.
5. *Teleiophyllia grandis*: *a*, front view of corallum, three-fourths the natural size; *b*, section at right angles to the columella, natural size.

PLATE IV.

Fig. 1. *Teleiophyllia navicula*: *a*, front view of corallum, natural size; *b*, section at right angles to the columella, magnified 2 diameters.
2. *Astræa Antillarum*, var.; transverse section of a corallite, magnified 4 diameters.
3. —— *brevis*: *a*, surface of corallum, natural size; *b*, calice, magnified 6 diameters.
4. *Plesiastræa distans*: *a*, surface of corallum, natural size; *b*, calice, magnified 10 diameters.
5. —— *globosa*; calice, magnified 10 diameters.
6. —— *spongiformis*: *a*, lateral view of corallum, one-half the natural size; *b*, calice, magnified 10 diameters.

PLATE V.

Fig. 1. *Plesiastræa ramea*: *a*, part of surface of corallum, natural size; *b*, calice, magnified 10 diameters.
2. *Pocillopora crassoramosa*: *a*, part of surface of corallum; *b*, longitudinal section of corallum; both magnified 2 diameters.
3. *Trochocyathus profundus*: *a*, lateral view of corallum, natural size; *b*, diagram of part of a calice; *c*, longitudinal view of two septa and the columella, magnified 2 diameters.
4. *Cœnocyathus anthophyllites*; endothecal tissue, magnified 4 diameters.
5. *Antillia ponderosa*; calice, natural size.

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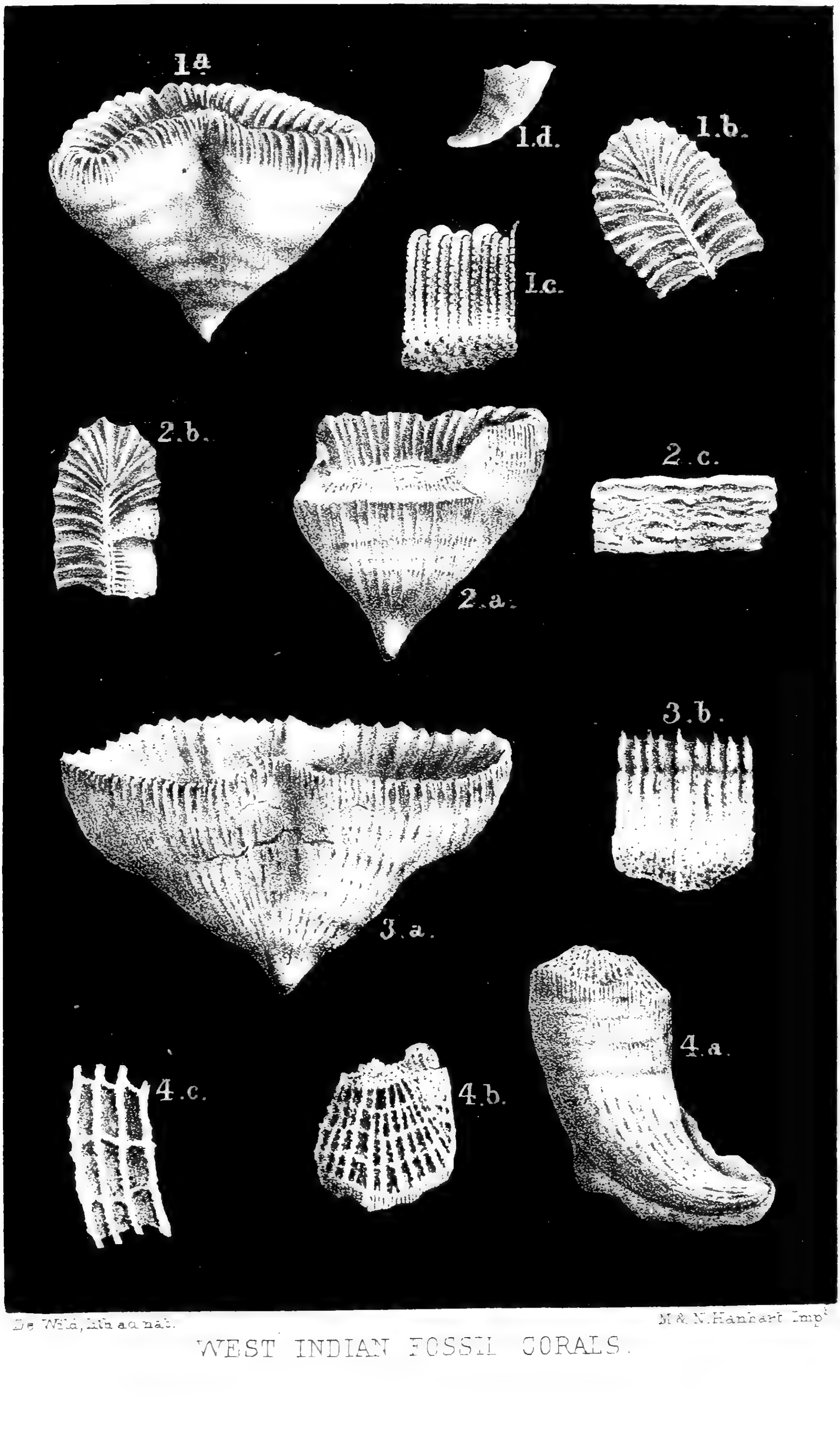
2. *Notes to accompany some* Fossils *from* Japan. By Captain Bullock, R.N.

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

(Abstract.)

No naturalist having been attached to the late Surveying Expedition of H.M.S. 'Dove,' the Commander of that vessel, Captain Bullock, endeavoured to repair the consequent loss to science, so far as his professional duties would permit, by collecting and preserving such geological specimens as he could obtain; this he was enabled to do with the aid of Mr. George Muir, Assistant-Surgeon of H.M.S.



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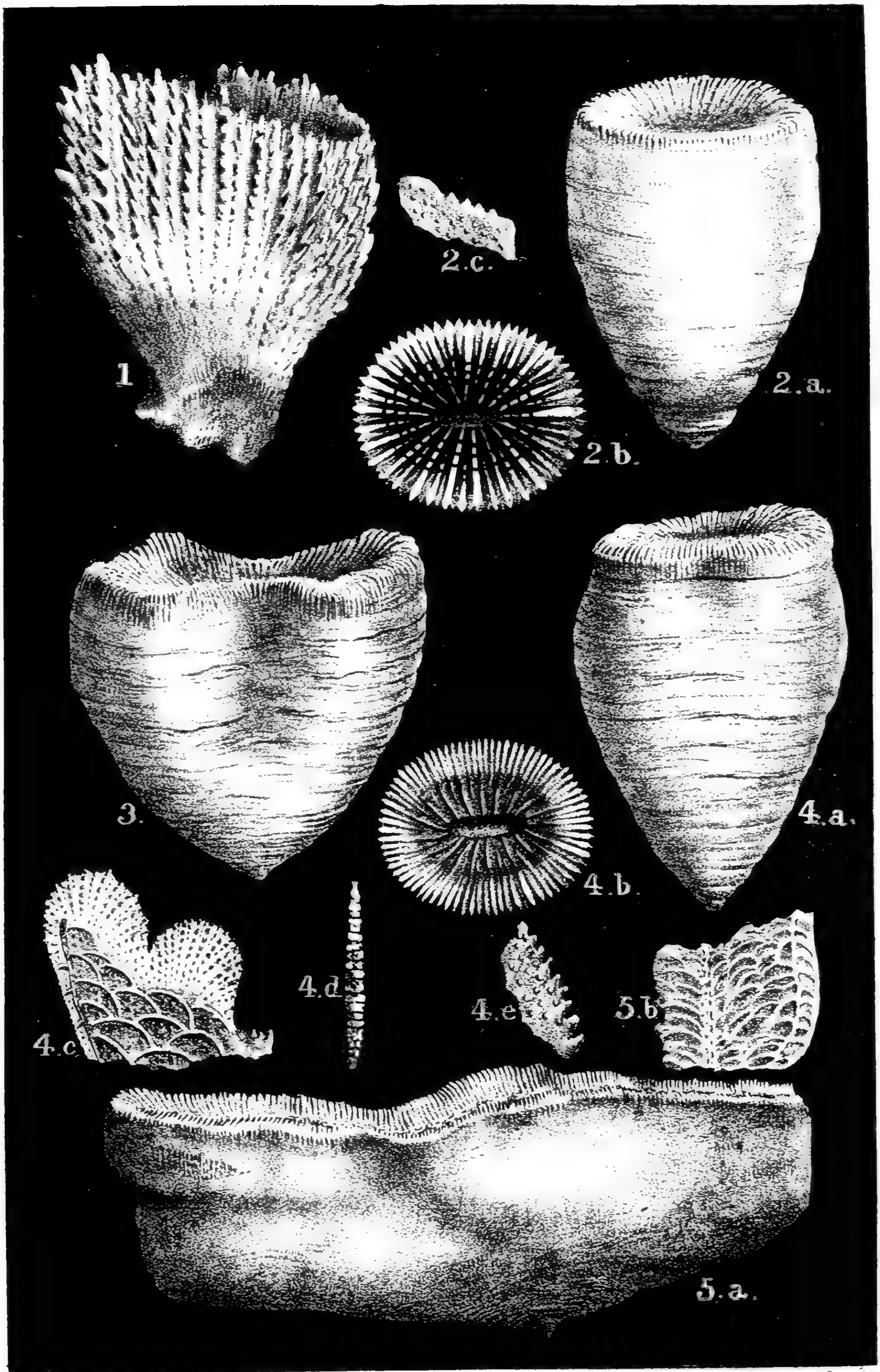
WEST INDIAN FOSSIL CORALS.



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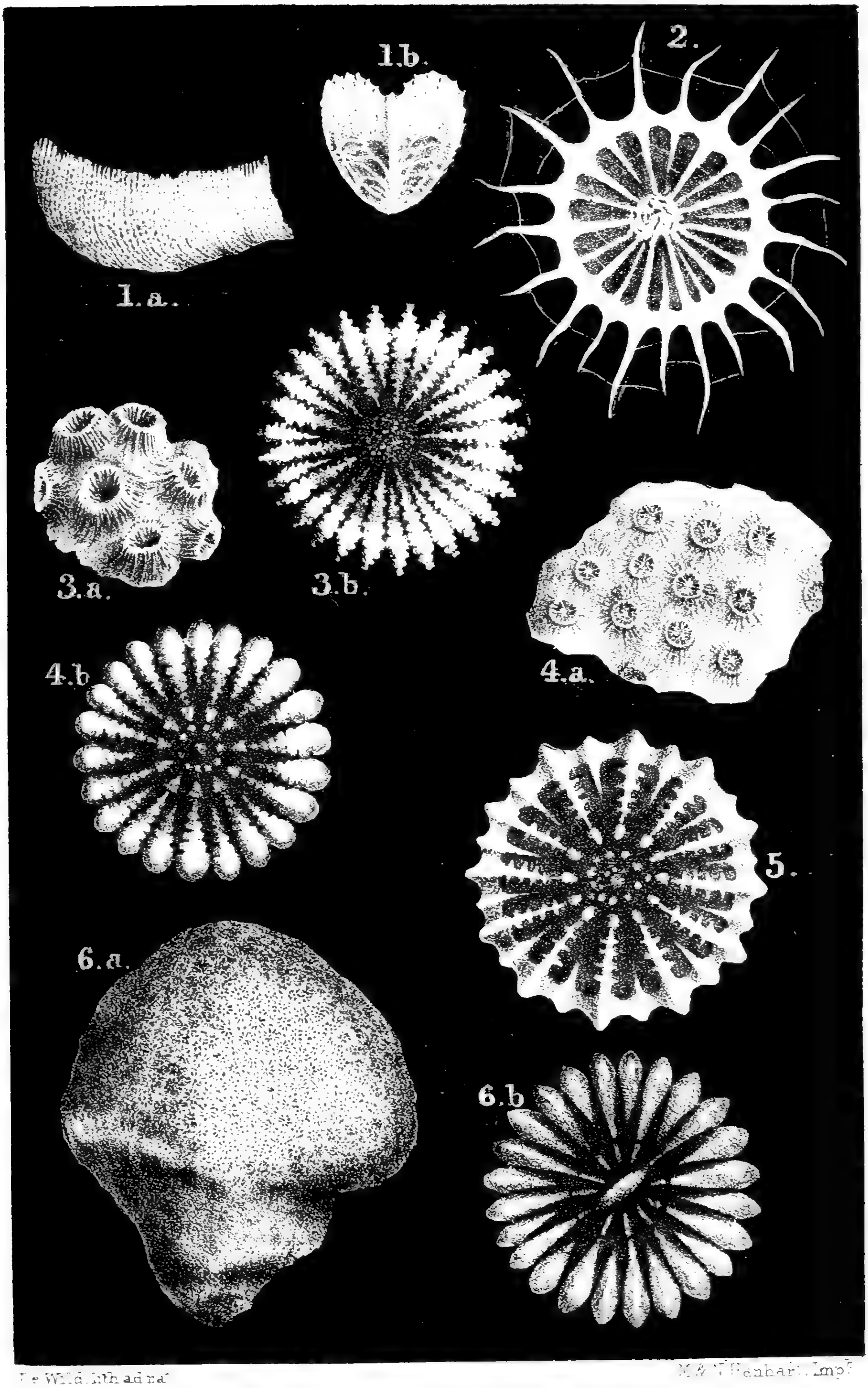

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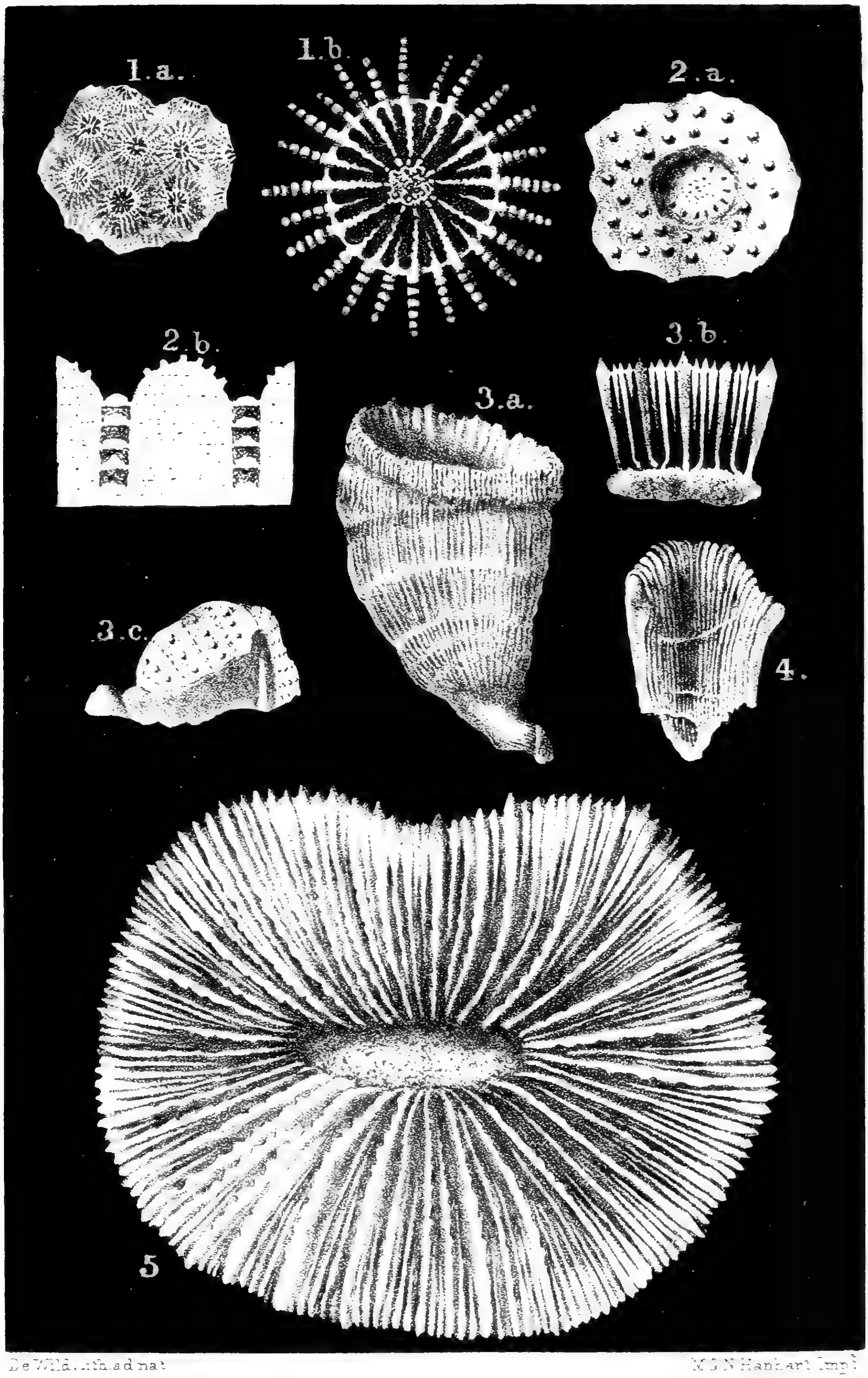

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WEST INDIAN FOSSIL CORALS

'Algerine,' and of Mr. James H. Kerr, of H.M.S. 'Actæon,' and the useful assistance of his friend Tskahara, a Japanese officer attached to the 'Dove.' The specimens obtained* were collected in Japan during the year 1861, and were forwarded, with a few notes on, and sketches of, the localities, to the Geological Society through Sir R. I. Murchison.

The chief locality is Fossil Point, Tanabe, which district the author designates the "Italy of Japan"; he remarks that the cape of Tanabe is formed by a range of hills rising in ridges to a height of 590 feet, and intersected by deep ravines. On the sea-coast the rock is everywhere sandstone, and the reefs abounding in the bay are composed of the same rock; but he mentions a particular cave, at an altitude of 350 feet, which was in a hard, black, and lichen-covered limestone. Wherever the stratification was observed it was horizontal.

The cape is further described as bordered by a plain, but a few miles inland the mountains rise to a height of from 2000 to 4000 feet; the hills on the coast are low and undulating, and the sea-shores are formed chiefly of iron-bound cliffs.

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3. *On some* Tertiary Mollusca *from* Mount Séla, *in the* Island *of* Java. By H. M. Jenkins, Esq., F.G.S., Assistant-Secretary of the Geological Society. *With a* Description *of a new* Coral *from the same locality, and a* Note *on the* Scindian Fossil Corals; by P. Martin Duncan, M.B., F.G.S.

[Plates VI. & VII.]

Contents.

§ I. Introduction.

1. *Bibliography of Javan Geology.*—Until very recently the Island of Java, notwithstanding its having been a Dutch colony for more than a century and a half, was almost a *terra incognita* to the geologist, the only familiar fact relating to its geology being that it

* The specimens are in the Society's Museum; they consist of pieces of sandstone, containing a few species of the genera *Turritella, Cancellaria, Murex, Arca, Cytherea, Cardium,* &c., the shelly matter of which has been in every case replaced by gypsum. As regards their probable age see p. 63, footnote.—Edit.

possessed a large number of volcanos, some of very great size. Even now, very little has been published concerning its geology and palæontology, although several collections of rocks and fossils have been brought or sent from thence to Europe, so that this paucity of information is to be attributed more to the absence of published descriptions than to the want of materials.

Mijnheer Junghuhn, whose admirable work on the Physical Features, Botany, and Geology of Java* is most elaborate, sent to Leijden a large collection of rocks and fossils in illustration of the volume devoted to geology. The description of the fossils (except the Plants) was entrusted to Mijnheer Herklots, who published, in 1854, under the auspices of the Dutch Government, the "Fourth Part" (although really the first, being the only one as yet published) of a large work†, which promises to be, when completed, a most valuable addition to our knowledge of the palæontology of the Eastern Archipelago. The same author is at present engaged upon the Gasteropods contained in M. Junghuhn's collection, and this second instalment will probably appear in the course of next year. The description of the fossil Plants, by Dr. H. R. Goeppert‡, was also published in 1854, with the aid of the Dutch Government.

The conclusions arrived at by Dr. Goeppert will be considered presently; but we must be content to wait for those of M. Herklots until after he has finished the laborious investigation in which he has been engaged for so many years.

In M. Junghuhn's volume on the Geology of Java, the stratigraphical characters of the rocks, in each locality treated of, are given in great detail; and copious lists of fossils, with references to the specimens, are attached to the descriptions of the principal localities. Unfortunately, however, implicit confidence cannot be placed in the determinations. M. Junghuhn did not, apparently, endeavour to trace any order of succession between the strata of the different portions of the Island, nor has he recorded the beds from which the fossils were obtained, but merely the localities. It is to be hoped that the publication of this paper will induce M. de Groot, to whom the Society is indebted for the collection about to be described, to endeavour to trace an order of superposition, and also to record the stratum from which each fossil is obtained.

At least two collections of Javan fossils exist in Germany, namely, one at Vienna, which was sent there by Dr. Hochstetter, and forms one of the numerous results of the scientific voyage of the Austrian frigate 'Novara,' and the other at Berlin, having been forwarded by Herr von Richthofen.

In 1854 Dr. Hochstetter wrote from Batavia to Director Hai-

* Java, seine Gestalt, Pflanzendecke, und innere Bauart. Von Franz Junghuhn.

† Fossiles de Java : Description des restes fossiles d'animaux des terrains tertiaires de l'île de Java, recueillis sur les lieux par M. Fr. Junghuhn. Par J. A. Herklots. 4[me] Partie, Echinodermes. Leyde, 1854.

‡ Die Tertiärflora auf der Insel Java, nach den Entdeckungen des Herrn Fr. Junghuhn. Von H. R. Goeppert. 'S Gravenhage, 1854.

dinger * stating that he had despatched two cases of fossils to Vienna, and recommending them to the notice of Dr. Hörnes; but, until after the completion of that palæontologist's great work on the fossils of the Vienna Basin, we can scarcely hope to see a description by him of these Eastern specimens. Later in the same year Dr. Hochstetter communicated to the Geological Institute of Vienna a paper on the explorations of the Mining Engineers of the Dutch East Indies †, in which he makes some interesting remarks on the geology of Java and the other Islands of the Eastern Archipelago.

The fourteenth volume of the 'Zeitschrift der Deutschen geologischen Gesellschaft' contains four contributions from Herr von Richthofen, two of which ‡ refer to the Tertiary rocks of Java and other Eastern Islands, and the others § to the geology of neighbouring districts. Herr von Richthofen comes to nearly the same conclusion, from personal observation, as that arrived at by me from a consideration of the fossils about to be described; but these conclusions and the remarks of Dr. Hochstetter will be referred to at the end of this paper.

In London there are at least three collections of specimens from Java:—one in the British Museum, collected by Madame Pfeiffer, and consisting principally of fossil Shells; one of rocks and fossils collected by Jonathan Rigg, Esq., and presented to this Society more than twenty years ago; and, lastly, the collection of fossils recently sent over by M. Corn. de Groot, also in the Museum of the Geological Society, and which has given rise to this communication.

The fossils contained in Madame Pfeiffer's collection are so entirely different from those sent by M. de Groot, that it is, perhaps, better, in order to prevent confusion, to reserve the consideration of them for another paper. Mr. Rigg's collection was evidently intended to illustrate a short paper by him "On the Geology of Jasinga," published at Batavia in 1838, and it consequently refers to an entirely different part of the Island, besides being a very heterogeneous assemblage of boulders, volcanic rocks, and fossils of more than one age; it also contains little or nothing in common with the fossils under consideration. Still, a more careful examination of this collection than has yet been made will probably result in our obtaining some further information respecting the Tertiary Formation of Java.

A very interesting paper by M. J. Hardie, referring more particularly to the Jasinga district, is contained in the fourth volume of the 'Bulletin de la Société Géologique de France' (pp. 218 *et seq.*); it was accompanied by an illustrative collection, which was presented to that Society, and would, doubtless, materially assist in elucidating the geological structure of that part of the Island.

* Jahrbuch der k.-k. geol. Reichsanstalt, 9 Jahrgang. 1858, Verhandl. p. 102.

† "Nachrichten über die Wirksamkeit der Ingenieure für das Bergwesen in Nederländsch-Indien," *ibid.* 9 Jahrgang. p. 277.

‡ "Bericht über einen Ausflug in Java," *op. cit.* p. 327; and "Ueber das Vorkommen von Nummulitenformation auf Japan und den Philippinen," *ibid.* p. 357.

§ Letter to Herrn G. Rose, *ibid.* p. 247; and "Bemerkungen über Siam und die hinterindische Halbinsel," *ibid.* p. 361.

Two geological maps of Java have been published,—one by M. Junghuhn, which I have not seen; and a much older one, printed on the same sheet as Sir Stamford Raffles's map of the Island, by Dr. Horsfield, of which it need only be observed that the locality whence M. de Groot's fossils were obtained, like the greater portion of the Island, is coloured as purely volcanic.

From Mr. Jukes's book on the 'Voyage of H.M.S. Fly,' it appears that he visited only the more eastern portion of Java, and that he was not able to make any very extended geological observations.

In the first volume of the 'Palæontographica'*, Herr Dunker gave a diagnosis and a figure of a single species of *Turritella* from Java; and, with this solitary exception, no fossil Mollusca from the Island have yet been described.

2. *Geology of the Mount-Séla District.*—The last volume of the Society's Journal contains a short paper by M. Corn. de Groot†, in which it is stated‡ that he had sent to England, amongst other rocks and fossils, a collection of specimens from the clay and marly sandstone of Mount Séla (Gunung Séla), a hill about 2000 Paris feet (2130 English feet) in height. Through the kindness of Sir R. I. Murchison, to whom these fossils were sent, they were presented to the Society soon after the reading of M. de Groot's paper.

Mount Séla is situated in the Kuningan District of the Tjeribon Residence, and forms part of the Kĕndĕnggebirge; it is also situated at the southern side of the foot of the Gunung Tjerimai—a huge volcano about 10,000 English feet in height,—and assists in forming the northern boundary of a great valley of denudation, the southern margin of which is formed by the Rantja Plateau.

Respecting this and the neighbouring districts M. Junghuhn remarks§ that "the south-western part of the Plateau of Bandong (2100 feet‖ high), namely, the district of Ronga, upon the south side of the Tji-Tarumkluft, is bounded on the south by a kind of 'Subapennine Formation,' which reposes upon the flanks of a still more southern, partly volcanic, arch. The strata of this formation, extending from Lio-tjitjangkang westwards to the Gunung Séla, consists of clay and bluish-white, often marly, sandstones, and are very rich in marine Shells in an extremely good state of preservation." The sandstones appear to be the principal rocks, and are further described by this author as being bluish-grey, fine- or medium-grained, calcareous (effervescing with acids), firm but easily weathering, and in places very rich in fossil Shells and Corals; and as occurring in beds, from 1 to 2 feet thick, alternating with partings, from 3 inches to 1 foot in thickness, of similarly coloured, hard, often shining, bituminous clay.

The physical features of the district may be described in a very few words, as they so nearly resemble those of the Wealden of England, and it requires merely a glance at the accompanying section (after Junghuhn) to make any geologist acquainted with the differences in

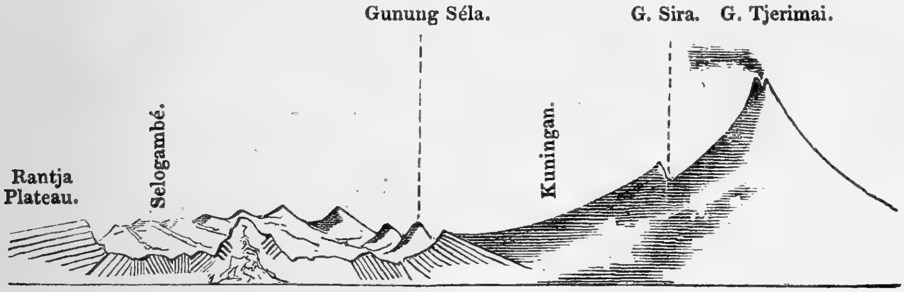
* Vol. i. Lief. 3. p. 132. pl. xviii. fig. 10.

† Vol. xix. p. 515, 1863. ‡ P. 516 (footnote).

§ *Op. cit.* vol. iii. p. 72. ‖ Paris feet, equal to nearly 2240 English feet.

the two valleys, these being differences in stratigraphical detail, caused by the volcanic axis of the Javan anticlinal, rather than differences in principle. The "form of the ground" in the two cases is also very similar; in both there are two parallel ridges, the outer and flatter sides of which form a kind of sloping plateau, while the steeper are turned towards a central valley having a minor ridge near the centre; but in Java the last-named ridge is much more evident than in the Valley of the Weald, as it is composed of an igneous and consequently less yielding rock. In the Wealden, however, the strata simply form an anticlinal more or less rolling in the centre, and much broken up by faults; but, in Java, the volcanic axis of the anticlinal has thrown the strata in its immediate neighbourhood into all sorts of positions.

Fig. 1.—*Section from the Foot of the Gunung Tjerimai to the Rantaj Plateau* (after Junghuhn).



Even allowing for repetition by faults, the thickness of the strata in this district must be very great for a Tertiary formation, Mount Séla being more than 2000 feet above the base-line of the section. M. Junghuhn considers all the beds in this district as belonging to the same formation, and after endeavouring to explain away, in some degree, the apparent thickness, he finally computes it to be at least 10,000 Paris feet *; but this estimate is probably much too great.

Herr von Richthofen speaks of the beds in this district as regularly superposed upon one another, and having a slight dip. He estimates the total thickness of the formation at 2000 German feet †, and describes it as a series of fine-grained marly sandstones and sandy marls, passing into and alternating with more or less trachytic conglomerates and micaceous marls, the predominating rock being, however, the fine-grained sandstone; he also observes that the whole formation is very rich in fossils.

3. *Remarks on the new Species.*—Before describing the fossils it may be as well to follow the example of MM. d'Archiac and Haime ‡, by stating the course adopted in this paper respecting new species, especially as the distance of Java from any well-known deposit similar to that from which these fossils were derived rendered the task somewhat difficult.

Of the twenty-two species of Shells contained in the collection, seven are in the state of casts; of the latter I have attempted to identify but one, that being a *Cardium* represented by many specimens,

* 1 Paris foot is equal to 1·0654 English foot.
† 1 German foot is equal to 1·0284 English foot.
‡ Fossiles du Groupe Nummulitique de l'Inde, p. 231.

which exhibit all, or nearly all, the characters used as specific distinctions almost as well as the shells themselves would have done. The remaining six are compared with species which appear to resemble them, but have not been given other than generic names. This course is in direct opposition to that pursued by the above-mentioned authors, who, avowedly, did not attempt, in many cases, to make their "forms" of the same value as natural-history species *, but nevertheless used them, for the purpose of supporting their conclusions, as if they had that value.

As, however, in treating of Tertiary fossils, a comparison with recent species is inevitable, it is, perhaps, better to confine specific determinations, so far as the foundation of new species is concerned, to well-characterized specimens, especially as it is very probable that the species of the palæontologist, particularly when the opposite course is adopted, are not always of the same value as those of the conchologist, who has, in many cases, all the extra advantages of knowledge of the animal, colour, and other characters, of which the palæontologist cannot take cognizance. But it should not be forgotten that the percentage of recent species in a formation may be considerably altered in consequence of these differences in the methods of, and facilities for, specific determination.

The following Table contains a list of the species, whether determined or undetermined, and a description of their matrices; the latter being taken from an examination of the substances contained in or composing the specimens.

Descriptive Number.	Genera and Species.	Material contained in, or composing, the Specimens.
1.	Murex Grooti, spec. nov.	Light-grey marl.
2.	—— ? paradoxicus, spec. nov.	Greyish sand.
3.	—— ? sp.	Dark-grey mud.
4.	Pyrula cochlidium, *Linn.*	Same as No. 1.
5.	—— Javanis, spec. nov.	Greenish sandy marl.
6.	Purpura umbilicata, spec. nov.	Same as Nos. 1 and 2.
7.	Oliva utriculus (juv. ?), *Gm.*	Greyish sand and greyish marl.
8.	Conus striatellus, spec. nov.	Greyish marly sand.
9.	Natica Duncani, spec. nov.	Greenish-grey marl.
10.	—— rostalina, spec. nov.	Reddish calcareous sand.
11.	—— Flemingiana ?, *Récluz*	Reddish marl.
12.	Vicarya (?) callosa, spec. nov.	Sandy marl.
13.	Turritella acuticingulata, spec. nov.	Greenish and grey sand.
14.	—— simplex, spec. nov.	Grey argillaceous marl.
15.	Phasianella ? sp., or Paludina ? sp.	Reddish sandy marl.
16.	Turbo obliquus, spec. nov.	White limestone.
17.	Bulla, sp.	Greenish-grey marly sandstone.
18.	Cardium subalternatum, spec. nov.	Reddish marly sandstone and greenish sandstone.
19.	Pythina Semperi, spec. nov.	Same as No. 5.
20.	Cytherea, sp.	Reddish marl.
21.	Tellina, sp.	Reddish sandy clay.
22.	Cultellus ? sp.	Similar to No. 21, but more sandy.
23.	Amphistegina vulgaris	Same as No. 10.
24.	Astræa Herklotsi, spec. nov.	?

* *Op. et loc. cit.*

§ II. Description of the Species.

1. Murex Grooti, spec. nov. Pl. VI. figs. 1 *a*, 1 *b*.

Shell thick, subfusiform, transversely ridged. Whorls convex, almost flat near the suture, six-varicose, crowned with an angular tubercle on each varix, and having a tubercle or longitudinal fold between some of the varices, especially on the upper whorls. Varices rounded, solid, those of each whorl alternating with those of the next, produced down the caudal prolongation almost parallel to one another, two of them thus meeting the oblique canal at acute angles. Transverse ridges equidistant, sharp, alternately larger and smaller, and having a number of raised lines between them, both ridges and lines becoming more evident on the varices. Aperture obovate, somewhat oblique, nearly flat above; outer lip dentate at the margin; inner lip distinct; canal short, oblique, contracted above, and rapidly widening downwards.

The tubercles on the varices are so worn as to be distinguishable only on the last two or three; they give a peculiarly angular appearance to the whole shell, which is also remarkable for its solidity and the downward parallel prolongation of the varices.

M. de Groot's collection contains but one specimen of this species, which appears to resemble a species from Bordeaux represented in the Society's collection by three specimens presented by Sir C. Lyell, and marked "*Murex*, nov. spec." by M. Deshayes. These Bordeaux shells are lighter and less solid than the Javan specimen, and their varices, which are less thick, are not prolonged downwards as in this species, but gradually die away. The two species are otherwise very similar, especially in the general form, the obliquity of the aperture and the canal, the ornamentation, and the size. There is also a general resemblance between this fossil and *Murex despectus*, Michelotti, an Italian species, the varices in both having the same kind of prolongation downwards; but they are much more numerous in the latter species, which also differs in its details from *M. Grooti*.

Dimensions.—Length $1\frac{19}{24}$ inch; breadth $1\frac{1}{4}$ inch; length of aperture $\frac{7}{12}$ inch, breadth $\frac{5}{12}$ inch; length of canal $\frac{1}{2}$ inch.

Matrix.—This shell is filled with a light-grey marl; but there are spots of dark-green marl on its surface.

2. Murex? paradoxicus, spec. nov. Pl. VI. figs. 2 *a*, 2 *b*.

Shell elongately ovate, umbilicate, transversely ridged. Whorls convex, depressed above, indistinctly varicose, crowned with a series of short, acute, ascending spines, which spring from the numerous indistinct varices. The body-whorl has two rows of spines, those of the lower row being much the smaller; they form the lower limit of the varices, and become ultimately hidden through the growth of the shell. Transverse ridges very pronounced, alternately larger and smaller, of very regular width, and curving towards the nearest spine where they cross the varices. Upper whorls more distinctly varicose and less spiny. Suture distinct, flexuous in consequence of its being just above the lower row of spines. Aperture narrowly and obliquely oval; inner lip distinct; canal very short, oblique, very wide, and abruptly truncated.

This shell is clearly related to *M. minax*, Lam., a well-known Paris-Basin species; but the alliance is not remarkably close. It would perhaps be advisable to collect such species as the one under consideration, with *M. minax*, &c., into a distinct genus or subgenus. They appear to be really spiniferous whelks.

Dimensions (largest specimen).—Length $1\frac{5}{24}$ inch, breadth $\frac{19}{24}$ inch; length of aperture $\frac{1}{3}$ inch, breadth $\frac{1}{4}$ inch; length of canal $\frac{5}{24}$ inch.

Matrix.—Greyish sand.

3. Murex? sp.

One badly preserved and mutilated specimen of a shell apparently similar in form to *Pyrula rusticula*, Bast., but probably a *Murex*, is contained in M. de Groot's collection. It differs from the above-mentioned *Pyrula* in having several rows of tubercles, on the last whorl, collected into indistinct varices; it appears to have had a slightly oblique canal, which is broken off just below the aperture. The outer lip is very defective, and the surface of the shell is so corroded and bored into that it is impossible to make out any of its characters. The thinner portions of the shell are translucent, and the interior is somewhat nacreous; these circumstances, together with the fresh-looking appearance of the corroded surface, and the almost total absence of any matrix, induced me to suspect that it was not a fossil. It is very unlikely, however, that M. de Groot would have made such a mistake; and, moreover, Mount Séla is a considerable distance from the sea. Possibly this may be the shell referred to by M. Junghuhn as *Murex minax*, to which it bears some degree of resemblance.

Matrix.—The small portions of matrix found in the fragment of the canal, and in the cavities made by boring-shells, appear to consist of a dark-grey mud.

4. Pyrula cochlidium, Linn. Pl. VI. fig. 4.

Shell fusiformly pear-shaped, with an elevated spire, and an excavated, slightly sinuous suture. Whorls angular, longitudinally ribbed, transversely lirate, flat above, the flat portion being marked by three parallel raised ridges; ribs (9) broad, flatly convex, dying away towards the base, and each crowned at the angle with a strong, compressed, slightly ascending tubercle. Transverse ridges most evident near the base, where they are alternately larger and smaller, and somewhat sinuous; nearer the angle the alternate smaller ridges are wanting, and the others are broader, less prominent, and scarcely sinuous. Aperture narrowly spathulate; outer lip dentate at the margin, and marked interiorly by a number of parallel ridges; inner lip indistinct.

This species, well known in the recent state as an inhabitant of Torres Straits, is represented in the Javan collection by a single specimen, deficient in the uppermost whorls, but agreeing with recent specimens in every particular, except that the latter do not exhibit ridges on the interior of the outer lip. This may be a variation; but it may also be due to the fact of the nacreous inner layer not being preserved in the fossil. At any rate, as the Javan specimen agrees in every other respect remarkably well with recent examples, this difference does not appear to be of specific value.

Dimensions (imperfect specimen).—Length $1\frac{11}{12}$ inch, breadth $1\frac{1}{4}$ inch; length of aperture $1\frac{1}{4}$ inch, greatest breadth $\frac{1}{12}$ inch.

Matrix.—The same as that of *Murex Grooti*.

Although a well-known species, I have given a complete description of it because it has never before been described as a fossil, and the diagnoses given of recent Shells are rarely of much value to the palæontologist, who is obliged to determine species by means of more lasting but less evident characters than those commonly appealed to by the conchologist.

5. Pyrula Javanis, spec. nov. Pl. VI. figs. 3 *a*, 3 *b*.

Shell thick, fusiformly pear-shaped, with a slightly elevated spire. Whorls convex, longitudinally ribbed, transversely ridged, nearly flat above, the flat upper portion being marked by three rather distant ridges; ribs thick, broad, convex, dying away towards the base; suture distinct, slightly sinuous, on an elevated rim or band which is separated from the rest of the whorl by a deep groove. Aperture narrowly spathulate; outer lip marked interiorly by about twelve distinct ridges; inner lip indistinct.

This fossil is allied to *Pyrula lactea*, Reeve, a species now inhabiting the coasts of the Philippine Islands; the latter, however, has the whorls crowned with indistinct tubercles (the bases of which extend downwards), rather than having distinct ribs; and these tubercles or ribs are nearly twice as numerous as in *Pyrula Javanis*. There are also other differences of detail, especially as regards the character of the suture, which is rather peculiar in this fossil; but the general resemblance is very great.

Pyrula Javanis is also allied to *P. cochlidium*, but the resemblance between them is not sufficiently close to render probable the chance of their being mistaken for one another.

Dimensions.—Length $1\frac{2}{3}$ inch, breadth $1\frac{1}{12}$ inch; length of aperture $1\frac{1}{24}$ inch, greatest breadth $\frac{1}{3}$ inch.

Matrix.—Greenish sandy marl.

6. Purpura umbilicata, spec. nov. Pl. VI. figs. 5 *a*, 5 *b*.

Shell ovate, thick, largely umbilicate, transversely striated, with a conical, rather long, acuminate spire, equalling or exceeding in length the rest of the shell; striæ with a binary arrangement, very numerous, deeply impressed. Whorls convex, declining next the suture, then subangular, and crowned with one row of short, acute, slightly recurved spines. Umbilicus expanded, with a thick, angular, slightly ascending marginal rim; aperture obovate-oblong; inner lip thick; canal curved outwards and backwards.

The nearest ally to this species is the recent *Purpura carinifera*, Lam.; but the former is easily distinguished from that and all other species of the genus by its extremely large umbilicus, single row of spines, closely set and biserially arranged impressed striæ, and absence of keels and rows of granules.

In some parts of the shell, in certain specimens, the interspaces have more the appearance of raised lines, and consequently the impressed striæ appear to be the interspaces; but usually the description given above is most applicable.

Dimensions.—Figured specimen: length $1\frac{1}{4}$ inch, breadth $\frac{5}{6}$ inch; length of aperture $\frac{2}{3}$ inch, breadth $\frac{1}{4}$ inch.

Matrix.—Some of the specimens have the same matrix as *Murex Grooti*, the others the same as *Murex? paradoxicus*.

7. Oliva utriculus (juv.?), Gm. Pl. VII. fig. 4.

Shell fusiformly ovate, broad, thick, with two well-defined, broad, spiral, coloured bands at the base, and with an acuminate spire. Columella very callous, the callosity extending upwards so as to cover the greater portion of the spire, and becoming much less thick towards the base, being indistinct where the columellar plaits commence—that portion of the columella appearing to be somewhat worn; columellar plaits 7 or 8 in number, separated by grooves, the lowest of which is by far the deepest and the most distinct, the others and the plaits becoming gradually fainter upwards. Aperture not very wide, gaping below; inner lip well defined, the edge of the callosity being very distinct, and, where it dies away towards the base, the area of the columellar plaits being marked off from the rest of the shell by its margin forming a more or less elevated ridge.

There are several specimens of this species in the collection, but they are all of small size, and none of them are so broad as, or have the extremely callous appearance of, adult specimens; so that it is most likely they all belonged to young individuals. There can be scarcely a doubt as to their identity with this species.

Dimensions.—Figured specimen (rather a small one): length $1\frac{1}{12}$ inch, breadth $\frac{1}{2}$ inch; length of aperture $\frac{3}{4}$ inch, breadth $\frac{3}{24}$ inch.

Matrix.—A greyish or reddish sand in some specimens, and a greyish marl in others.

8. Conus striatellus, spec. nov. Pl. VII. figs. 3 *a*, 3 *b*.

Shell conical, somewhat elongated at the base, and flatly convex above, with a very short mucronate spire. Whorls of a brown colour (varying in depth in different specimens and in different parts of the same specimen), scarcely overlapping, flat and slightly grooved next the suture, then conoidly convex, becoming somewhat drawn-out towards the base, and ornamented laterally with a number of blackish slightly raised stripes. Suture impressed. Aperture narrow, slightly dilated at the base. Columella slightly twisted and grooved at the base.

On the upper third of the sides of the whorls the coloured stripes are not more than half as far apart as on the middle third; and on the lower third they are accompanied, first alternately and then entirely, by slightly sinuous shallow grooves, like sutures, just above them. Between the coloured stripes in the central part of the shell there are indications of a row of coloured dots, or of another stripe; and this ornament is rendered more complex by the presence of subordinate raised bands (probably the remains of thin light-coloured stripes), to the number of two or three, between each coloured band, and of very fine, impressed hair-lines not quite coinciding in direction with the coloured stripes. All these bands are crossed more or less at right angles by the lines of growth.

This species is closely related to *Conus fuscocingulatus*, Bronn, differing from it, somewhat, in the characters of the coloured rings, and essentially in those of the suture and the upper portion of the shell.

Of the specimens of *Conus* sent by M. de Groot, there are two (one a very imperfect specimen, three times as large as any of the others, and one about the same size as the remainder) which may belong to a distinct but related species. This cannot be decided properly without more perfect specimens; and as it is better to omit a species than to make one unnecessarily, I prefer leaving the matter in abeyance for the present, although the absence of the mucronate spire, and the much narrower aperture, in the two specimens referred to, render it very probable that they are really distinct.

Dimensions.—Length 1 inch, breadth $\frac{2}{3}$ inch; length of aperture $\frac{21}{24}$ inch, breadth $\frac{1}{12}$ inch. The dimensions of the two specimens which I suppose to belong to a distinct species are as follows:—large specimen, length $2\frac{1}{3}$ inches, breadth $1\frac{2}{3}$ inch; small specimen: length $\frac{11}{12}$ inch, breadth $\frac{13}{24}$ inch; length of aperture $\frac{10}{12}$ inch, breadth $\frac{1}{24}$ inch.

Matrix.—Greyish marly sand in the specimens referred to this species. The large specimen alluded to above is filled with a greenish-grey sandstone containing large flakes of a black substance resembling charred wood.

9. Natica Duncani, spec. nov. Pl. VI. fig. 6.

Shell thick, ovate, rather narrowly umbilicate, with a produced spire. Whorls almost flat and obtusely grooved next the suture, then abruptly and somewhat convexly declining. Aperture ovate, almost flat at the base. Columella angular, thick, especially near the apex of the aperture, flat in front, and with a rather broad columnar callosity entering the umbilicus. Lines of growth very distinct. Operculum broadly half-heart-shaped, thick, especially near the columellar margin, broad at the base; convex margin reflexed outwardly, with a narrow groove on the outer side close to the edge, and a deeper parallel groove at a distance of $\frac{1}{20}$ inch inside it.

The two specimens which I refer to this species differ from *Natica maculosa*, Lam., to which they bear some resemblance, in having the whorls flatter near the suture, in being more truncate at the base of the mouth, and in the columella and the whole shell being much thicker. The thickness of the upper portion of the columella and the truncated base of the mouth give the aperture an almost triangular shape, and the whole shell a somewhat remarkable appearance.

I have named this species after my friend Dr. Duncan, who first detected the operculum in its interior, and who has assisted me in arriving at a definite conclusion respecting the age of these fossils by furnishing me with concurrent testimony drawn from an examination of the East Indian Tertiary Corals.

Dimensions.—Large specimen: length $1\frac{1}{12}$ inch, breadth $\frac{11}{12}$ inch; length of aperture $\frac{7}{12}$ inch, breadth $\frac{9}{12}$ inch. Small specimen: length $\frac{7}{12}$ inch, breadth $\frac{6}{12}$ inch; length of aperture $\frac{1}{3}$ inch, breadth $\frac{5}{24}$ inch.

Matrix.—A coarse greenish-grey marl, with black cinder-like grains.

10. Natica rostalina, spec. nov. Pl. VI. fig. 8.

Shell subglobose, largely and perspectively umbilicate, with a short but protruding spire and a distinctly impressed suture. Whorls rounded, smooth, somewhat flattened near the suture, and then convexly descending, produced downwards, and rapidly increasing in size. Aperture narrow, not quite a semicircle, equally tapering above and below; basal portion of the peristome produced so as to form an almost horizontal, but slightly descending, obtuse spout. Umbilicus with a distinct raised margin, which descends below the mouth and beyond the columella, and then curves upwards so as to include the spout. Columella thin, enamelled above, and with a small, flat, rather broad, striated callosity entering the umbilicus.

Operculum half-heart-shaped; convex margin turned outwards, unevenly serrated outwardly, and succeeded by a narrow platform projecting beyond the rest of the outer surface of the operculum, and separated from it, first by an obliquely descending rim, and below this by a groove cut horizontally into the side of the platform. The rest of the outer surface of the operculum is flat, with the exception of a nearly semicircular tumidity, which begins at the nucleus, and extends, with the growth of the operculum, almost parallel to the convex margin, but at a gradually increasing distance, and becoming gradually less prominent. The inner or columellar margin of the operculum, like that of the preceding species, is thick in the middle and becomes thinner at each end.

This species, of which there are two specimens (one nearly perfect contained the operculum just described) in M. de Groot's collection, is allied to *Natica pellis-tigrina*, Chemn., a Swan-River species. Were other evidence wanting, the differences in their opercula would alone be sufficient to establish their specific distinctness; but these differences are also associated, as would be expected, with differences in the shells. Thus, the aperture of *N. pellis-tigrina* is much more dilated, the umbilicus smaller, and the spire longer than the corresponding structures in the Javan fossil. There is, however, a very great general resemblance in form between the two species.

Dimensions.—Length $\frac{23}{24}$ inch, breadth $\frac{21}{24}$ inch; length of aperture $\frac{2}{3}$ inch, breadth $\frac{1}{3}$ inch.

Matrix.—A reddish calcareous sand, partly composed of fragments of shell, and containing a Foraminifer, referred to below (p. 62) as *Amphistegina vulgaris*.

11. Natica Flemingiana?, Récluz. Pl. VI. fig. 7.

Shell pyriformly ovate, smooth and shining, very thick, with a rather small umbilicus almost covered by a thick, tumid callosity. Whorls very rapidly declining, shallowly concave in the upper portion next the suture, especially in the case of the body-whorl. Spire somewhat exserted, having a mammillary aspect in consequence of the concavity of the upper portion of the body-whorl. Aperture semilunar, small; columella thick and densely callous, especially in the upper part.

I doubtfully refer to this species three specimens which agree generally with the figure of it in Reeve's 'Conchologia Iconica'*, but which have a more tumid callosity, a slightly smaller aperture, and a rather more obtuse apex, besides being much smaller specimens than the one there figured. But as these are all slight differences of degree and not of kind, there does not appear any necessity, for the present at least, for referring the Javan specimens to a new species. *Natica Flemingiana* occurs recent on the shores of the Isle of Luzon, in the Philippines.

Dimensions.—Length $\frac{11}{12}$ inch, breadth $\frac{9}{12}$ inch; length of aperture $\frac{13}{24}$ inch, breadth $\frac{7}{24}$ inch.

Matrix.—A reddish marl, containing many grains of white quartzose sand, and minute black particles probably of volcanic origin.

12. Vicarya (?) callosa, spec. nov. Pl. VII. fig. 5.

Shell thick, turreted, elongately conical. Whorls almost cylindrical, but somewhat wider at the base than at the upper portion; with a raised nodiferous band just below the suture, becoming gradually obsolete in the upper whorls; and also ornamented by one or two parallel ridges, closely accompanied above by a minor groove, between their lower margin and the nodiferous band. Suture linear, indistinct, occasionally manifested by the base of the upper whorl being produced so as to form a ridge. Aperture small, obliquely oval; inner lip distinct, furnished with a very large and very thick callosity, which extends forwards as a semicircle, and upwards, in the shape of a tongue, as far as the row of tubercles of the whorl above. Columella thickened at a distance of about one-third from the base. Outer lip and canal broken away.

The nodiferous band carries about ten inequidistant, unequal, obtuse, compressed tubercles, or short spines; and also a distinct groove running along the centre and over the apices of the tubercles. The last whorl is flat at the base and rounded-off towards the sides.

M. de Groot's collection contains two specimens of this species, but, as both of them have lost their epidermis and much of the outer shelly layer, and are moreover in a condition very much resembling chalk, and consequently very friable, they do not exhibit the ornamentation so well as could be wished; it is, therefore, very probable

* "Monograph of the Genus *Natica*," pl. 18. figs. 80 *a*, 80 *b*.

that better-preserved specimens would render necessary some alteration in the above description.

As regards the affinities of this species, it requires but a glance at pl. 28. fig. 4. of d'Archiac and Haime's 'Description des Animaux fossiles du Groupe Nummulitique de l'Inde' to render manifest the very close affinity existing between *Vicarya Verneuilii*, d'Arch., and this species; the differences being merely those of detail in the ornamentation, and of form and size in the callosity. This affinity is so unquestionable that I have adopted provisionally the genus doubtfully proposed by the above-mentioned authors for the reception of the Scindian fossil, but, at the same time, reserve any opinion as to the claims of *Vicarya* to be considered as a distinct genus. It may be observed, in passing, that the Indian shell referred by Mr. Hislop to the genus *Vicarya** appears to be of an altogether different nature, and is probably allied to one of the subgenera of *Melania*.

Dimensions.—Large specimen: length $3\frac{1}{3}$ inches, breadth (including callosity and tubercle) $1\frac{5}{6}$ inch; breadth of last whorl $1\frac{1}{3}$ inch; length of aperture $\frac{1}{2}$ inch, breadth $\frac{5}{12}$ inch. Small specimen: length (imperfect) $2\frac{5}{12}$ inches; breadth of last whorl $\frac{11}{12}$ inch.

Matrix.—The matrix of the large specimen cannot well be made out; that of the small one is a greenish-grey sandy marl.

13. TURRITELLA ACUTICINGULATA, spec. nov. Pl. VII. fig. 1.

Shell turreted, obtuse. Whorls very finely striated, with two sharp prominent keels in the central region, the lower one being the more prominent; one less prominent ridge beneath, and occasionally a still lower one masking the line of suture; and about four still smaller ridges on the upper part. Interspaces between the central portions of the adjacent whorls deeply and semicylindrically excavated, as also is the space between the median keels, both the grooves being very finely and spirally striated between, and parallel to, the ridges. Aperture small, ovate.

In the uppermost portion of the shell the suture is often unaccompanied by the ridge which marks its position in the lower portion; it is then neatly impressed.

The nearest ally to this species is, perhaps, *Turritella Archimedis*, Bronn, a well-known European Miocene shell: but it is also closely related to *T. duplicata*, L., an equally well-known recent species. All these Shells belong to the same type of *Turritella* as *T. angulata*, Sow., which MM. d'Archiac and Haime refer, with the other Soomrow fossils, to the Nummulitic formation, though Mr. Sowerby figured and described them as "Tertiary" in contradistinction to "Nummulitic." The beds, also, whence they were obtained were described under the same title by Captain Grant†.

In the Society's Museum is a small collection of fossils from Bengal, presented and described (as regards their locality, &c.) by H. J. Colebrooke, Esq.‡, which contains a few very imperfect specimens of a

* Quart. Journ. Geol. Soc. vol. xvi. p. 177, pl. 8. figs. 36 *a*, 36 *c*.

† Geol. Trans. 2nd ser. vol. v. pp. 289 *et seq.*

‡ *Ibid.* vol. i. pp. 132 *et seq.*

species of *Turritella*, scarcely, if at all, distinguishable from that under consideration. The only fossil Shell from Java hitherto described* is also allied to this species.

Dimensions.—Figured specimen: length (imperfect) $1\frac{2}{3}$ inch, breadth $\frac{2}{3}$ inch; length of aperture $\frac{1}{4}$ inch, breadth $\frac{1}{4}$ inch.

Matrix.—A greenish and grey sand.

14. Turritella simplex, spec. nov.

Shell thick, turreted, obtuse. Whorls with a single acute keel, at a distance of about one-third of their length from the base; marked above by two coarse, indistinct ridges equidistant from one another, the keel, and the suture. Aperture nearly round, slightly pentagonal, and flat at the base.

The epidermis is preserved in places, and exhibits striæ in the direction of the lines of growth. The upper whorls appear to be somewhat rounded, and not keeled; but as that portion of the shell, in the only specimen sent to England by M. de Groot, is rather badly preserved, this may be accidental, or, rather, due to attrition or weathering.

Turritella simplex approaches very closely to *T. subangulata*, Brocc.; but it differs from that species in its much more obtuse form, in being much more solid, and in the absence of the fine transverse striæ characteristic of the latter, and which are replaced in this species by two obtuse, indistinct ridges. *Turritella subangulata* occurs in the Miocene beds of several European localities, including Antwerp, Angers, Baden, &c., several places in Italy, Switzerland, &c.; and, according to M. Abich, it also occurs in the Caucasus.

Dimensions.—Length $2\frac{1}{12}$ inches; breadth of last whorl at the keel 1 inch; length of aperture $\frac{5}{12}$ inch, breadth $\frac{5}{12}$ inch.

Matrix.—A light-grey argillaceous marl.

15. Phasianella ? or Paludina ?

A flattened internal cast, ovate in longitudinal section, with about six ventricose whorls, a rather elongated spire, and an oval aperture produced above almost to a point, appears to belong either to the genus *Phasianella* or to *Paludina*. As the cast consists of a reddish sandy marl, similar to the material composing some bivalve-casts (*Cytherea*, *Tellina*) in the same collection, the probability is that the specimen belongs to the marine genus. On the other hand, it is more ventricose and, relatively, much shorter than any known species of *Phasianella*, being, perhaps, most nearly allied to the Australian *P. ventricosa*; but it is so flattened, that it would be unsafe to refer it positively to either genus.

16. Turbo obliquus, spec. nov. Pl. VII. fig. 6.

Shell conoid, imperforate, smooth, with a produced spire. Whorls obliquely convex, very much depressed above, slightly concave near the suture, flattened at the base. Aperture suborbicular, produced above to a sharp point; columella slightly callous.

* Palæontographica, vol. i. Lief. 3. p. 132. pl. 18. fig. 10.

This species is allied to *Turbo variabilis* and *T. petholatus*, both recent species inhabiting the shores of the Philippine Islands. It differs from them in being very much smaller (none of the Javan specimens being more than one-half the size of even small examples of those species), in the obliquity of its growth, and in its flattened base. The lines of growth are discernible, but are not so regular as in the allied species just mentioned.

Dimensions.—Figured specimen: length $\frac{19}{24}$ inch, breadth $\frac{19}{24}$ inch; length of aperture $\frac{5}{24}$ inch, breadth $\frac{5}{12}$ inch.

Matrix.—White limestone.

17. Bulla, sp.

Several casts of a species allied to the recent *Bulla australis* are contained in M. de Groot's collection; it is probably distinct, but I have not given it a specific name in the hope that more perfect specimens may be obtained with the shell still preserved, so as to determine whether it had any ornament. The rock composing these casts is a greenish-grey marly sandstone, apparently very rich in Shells and Corals, as most of the specimens contain fragments of one or the other.

18. Cardium subalternatum, spec. nov. Pl. VII. figs. 7 *a*, 7 *b*.

Casts broadly and obliquely ovate, cordiform in section, compressed posteriorly, inflated anteriorly, somewhat attenuated towards the umbones, and very inequilateral; anterior side rounded; posterior side produced, subangularly rounded, and closed. Surface ornamented with from 27 to 29 radiating curved ribs, which become slightly expanded close to the margin; between these ribs, especially in the anterior region, are smaller, less elevated ridges, which die away towards the umbones, and probably correspond to minute alternate ribs on the shell.

The ribs are not very evident in the extreme posterior region, but become inconspicuous behind a broad and rather shallow channel or groove, which runs between the two hindermost, well-marked costæ, and gives that portion of the cast a compressed character; they also become indistinct anteriorly, but there the casts are inflated instead of being compressed.

This species appears to be most nearly related to *Cardium alternatum*, Sow., from the Philippine Islands; but they differ in the former being somewhat more produced and much more compressed posteriorly, and not more than one-third the size of the latter. There is also no evidence of this being a gaping species (the posterior compression leading to an opposite conclusion), whilst *C. alternatum* is slightly so.

Dimensions.—Figured specimen: length $1\frac{1}{6}$ inch, breadth 1 inch, thickness $\frac{3}{4}$ inch.

Matrix.—Some of the casts are composed of a reddish marly sandstone, and some of a greenish sandstone.

19. Pythina Semperi, spec. nov. Pl. VII. figs. 8 *a*, 8 *b*.

Shell small, transversely elongated, equilateral, ovato-triangular; flexuous, having a deep triangular depression in the middle of the left valve, whilst the right valve is scarcely depressed in that region; the shell is also twisted laterally towards the left in the anterior region. Anterior margin of the valves rounded, posterior more tapering; dorsal margin descending posteriorly: ventral edge of the left valve rather sinuous; that of the right valve concave, as if a lenticular piece had been cut out of the longer side of a semi-oval dish. Umbones very small. Surface of the shell concentrically striated, especially on the right valve. In consequence of the left valve being so much more twisted than the right, the anterior margin of the latter appears to be produced downwards to some extent; and when the valves are closed, there is a narrowly lanceolate gape in the middle of the ventral region.

This little shell approaches most nearly to *Pythina peculiaris*, A. Adams, a species inhabiting the coasts of Ceylon, and remarkable for its lateral twist and deeply sinuous ventral margin. I have named it after my friend Dr. Otto Semper, of Altona, to whom I am indebted for assistance in comparing this and other shells with specimens in Mr. Cuming's collection.

Dimensions.—Length $\frac{4}{24}$ inch, breadth $\frac{7}{24}$ inch.

Matrix.—This species was obtained from the interior of the single specimen of *Pyrula Javanis.*

20. Cytherea, sp.

A single mutilated cast of a species of this genus, with a small portion of the shell still adhering to the dorsal region, exists in M. de Groot's collection. It is broadly oval, almost flat at the sides, and very inequilateral; the anterior margin is broken away, but was probably almost semicircular; and the posterior margin, though quite as defective, appears to have been more or less pointed. There is just enough of the shell left to show that the ligamental area was narrowly lanceolate in form; but the lunule has disappeared.

Many species of *Cytherea* approach one another very closely in general form, so that it is difficult to arrive at a satisfactory conclusion as to the affinities of a mutilated cast. The nearest in form to this species is, perhaps, *Cytherea erycina*, Lam.; but that shell is concentrically sulcated, while this appears to be smooth.

Matrix.—The cast is composed of a reddish marl containing grains of sand.

21. Tellina, sp.

Three internal casts referable to this genus are orbicular, slightly ventricose, and almost equilateral; anterior margins rounded; posterior slightly angular, in consequence of two ridges extending radiately from near the umbones to the margin: the stronger ridge is the more anterior one; it is slightly curved, and is preceded in the left valve by a wedge-shaped depression. The surfaces of the casts are marked by concentric striæ, which are crossed by fine longitudinal radiating lines. The muscular scars are scarcely distinguishable.

The recent *Tellina plicata* appears to be closely related to this fossil, which is very well marked in consequence of the two posterior ribs being not merely plications in the shell, as is the case in so many species of the genus.

Matrix.—The casts are composed of a reddish sandy clay.

22. Cultellus (?), sp.

Three portions of internal casts, each representing something less than half of a very elongated shell, probably belong to the genus *Cultellus*, or to one of its subgenera. The casts are elongated and compressed, rounded and slightly gaping at the ends, and concentrically wrinkled towards the extremities. Pallial sinus probably short, acutely angular, and not very wide. The shell was nearly equilateral.

One of the specimens represents the posterior portion of the shell, the remaining two the anterior region; the former is marked by a very oblique channel, extending from near the umbo almost to the end. This may possibly represent an umbonal rib, but it may only correspond to a plication in the shell. The only species having such an oblique groove is, I believe, *Solen uniradiatus*, Bellardi *, in which, however, it is much more oblique, and appears to be caused merely by a plication on the shell, and not to be a definite structure like the umbonal rib of *Machæra*.

Matrix.—Similar to that of the *Tellina*, but more sandy.

23. Amphistegina vulgaris, d'Orb.

Two specimens of this Foraminifer occurred in the matrix of *Natica rostalina*. For their identification I am indebted to Prof. T. Rupert Jones, F.G.S., who considers that this form and the Miocene *A. Haueri*, as well as *A. Lessonii* and *A. gibbosa*, are merely varieties of one species.

III. Conclusion.

1. *Emigration Eastwards of the European Miocene Fauna and its influence on the Contemporaneity of Tertiary Formations.*—Before discussing the probable age of the Mount Séla deposit, the question of the contemporaneity of Tertiary strata in different parts of the world requires a little consideration.

It will be admitted that if two Tertiary formations, geographically distant from one another, contained the same proportion of recent species, that one would be the newer whose species bore the greatest resemblance to the fauna of the neighbouring seas, unless it could be proved that great physical changes had recently occurred in the one area and not in the other. Consequently, if two Tertiary formations contain about the same proportion of recent forms, and an emigration of species to, or continued existence of them in, one area can be shown to have occurred, that formation is *certainly* the newer

* "Catalogo ragionato dei Fossili Nummulitici d'Egitto," di L. Bellardi, Mem. Reale Accad. delle Scienze di Torino, ser. 2, vol. xv. p. 184. pl. 2. fig. 5.

towards which the ancient fauna has emigrated, and that one is *probably* the newer near which it has continued to exist.

The old Miocene sea or ocean was only, it seems to me, a later and smaller edition of the great Nummulitic sea or gulf which extended from south-western Europe to Japan *, and perhaps further. This belief is chiefly founded on the following facts: namely, the intimate relation of the southern- and middle-European older and middle Tertiary to the East Indian recent Mollusca (especially univalves); the close relationship, according to Dr. Duncan †, of the European Miocene corals to those at present inhabiting the East Indian Ocean; the number of recent species of Mollusca now common to the Mediterranean and the Red Sea; the affinity of the fauna of the latter to that of the Indian Ocean ‡; and the existence of the Eocene and Miocene formations at several localities *en route*.

The last three facts only prove a former connexion between the seas on the west of the Isthmus of Suez and those on the east of that barrier, the last fact rendering it probable that this connexion existed during the Miocene period, as it certainly did during the Eocene. The first two facts also show either that a tide of emigration of, at any rate, a part of the fauna has set from west to east, or that the ancient fauna continued to exist in the Indian Ocean (more or less altered, it may be) after it had died out further westward §.

One fact, discovered by Philippi and mentioned by Mr. Woodward, shows that an emigration from west to east has occurred; he remarks that, of the species common to the Red Sea and the Mediterranean, "40 are Atlantic shells which have migrated into the Red Sea by way of the Mediterranean, probably during the newer Pliocene period; the others are Indo-Pacific shells which extended their range to the Mediterranean at an earlier age." The facts already stated, however, appear to prove, as regards the latter portion of the quotation, that it was the Mediterranean species which extended their range to the Indian Ocean, and not the converse, and that the tide of emigration continued in activity in the same direction during the newer Pliocene period (as inferred by Mr. Woodward), until it was arrested by the formation of the Isthmus of Suez.

It is therefore probable that the Javan fossils are somewhat more recent than the percentage of existing forms amongst them would appear to indicate ||.

* The Nummulitic formation has recently been discovered in Japan by Herr von Richthofen; and another Tertiary formation, probably the Miocene, by Captain Bullock.

† Quart. Journ. Geol. Soc. vol. xix. p. 456.

‡ See Woodward's 'Manual of the Mollusca,' pp. 368, 369.

§ The close relation between the European Miocene and the East Indian Recent Molluscous faunæ is proved by the fact of ten or twelve genera of Shells being confined in the fossil state to the former, and in the recent state (with the exception of three, which occur also in the Mediterranean) to the Indo-Pacific region; also by a large number of *species* being common to the European Miocene and the East Indian Ocean. These facts alone appear to me sufficient to prove that an emigration eastwards of at least a part of the European Miocene fauna has taken place since and, perhaps, partly during that period.

|| Prof. Edward Forbes was, perhaps, the first to assert that similarity in the

Starting with this principle, it remains to be seen what is the percentage of existing species in the Javan deposit.

2. *Percentage of Recent Species.*—From the foregoing descriptions and Table it will be seen that Mijnheer de Groot's collection contains 22 species of Mollusca, of which six have not been determined, for the reasons already stated; and that, of the remainder, three are still living, and 13 are new species.

When it is remembered that only one fossil Shell from Java has hitherto been described, and when the distance of the Island from any locality where the Tertiary rocks have been well worked out, and their fossils properly determined, is taken into consideration, this large proportion of new species will not be thought so remarkable as might at first sight appear.

As they seem to be unknown forms, it may, perhaps, be assumed that all the new species are extinct—although it is probable that some of them may eventually be found to exist on the coasts of Java or of other islands of the Indian Ocean. If it be granted, then, that 13 out of 16 species are extinct, the existing species do not constitute more than 19 per cent. of the whole; so that, if the percentage test can be applied to so small a number of species, these fossils must be considered, according to that method, to be approximately of the age of the Miocene deposits of Bordeaux and of the Vienna Basin.

3. *Affinities of the New Species.*—The number of species having recent alliances is seven; and the following Table will show that these allies all inhabit the Indian Ocean, which is also the habitat of the existing species contained in the collection. The extreme range of habitat on either side (east and west) occurs in the case of known species—namely, Torres Straits, on the east, which is the habitat of *Pyrula cochlidium*, and Africa, on the west, the coasts of that continent being the habitat of *Oliva utriculus*.

Analysis of the Species contained in M. de Groot's Collection.

A. Recent Species.

Descriptive Number.	Species.	Habitat.
5.	Pyrula cochlidium, *Linn.*	Torres Straits.
7.	Oliva utriculus (juv. ?), *Gm.*	Africa.
11.	Natica Flemingiana ?, *Récluz*	Philippines.

organic contents of two formations, as shown by the presence of either identical or representative species, was a proof of difference in the age of the deposits; more recently, Prof. Huxley has endeavoured to show that faunas and floras having distinct facies may be contemporaneous; but I am not aware that any one has yet attempted to prove which of two apparently contemporaneous deposits is the older or the newer. The particular conclusion here arrived at may or may not be correct, but I am convinced of the truth of the principles employed, and of the importance of the mode of reasoning followed in the above argument.

B. New Species.

Descr. No.	New Species.	Allied Species.		
		Name.	Age.	Locality.
1.	Murex Grooti	Murex, sp.	Miocene.	Bordeaux.
2.	—— ? paradoxicus	—— minax, *Lam.*	Eocene.	Paris Basin.
5.	Pyrula Javanis ...	Pyrula lactea, *Reeve*	Recent.	Philippines.
6.	Purpura umbilicata	—— carinifera, *Lam.*	Recent.	?
8.	Conus striatellus...	Conus fusco-cingulatus, *Bronn*	Miocene.	Touraine, Vienna, Italy.
9.	Natica Duncani ...	Natica maculosa, *Lam.*	Recent.	Philippines.
10.	—— rostalina......	—— pellis-tigrina, *Chemn.* ...	Recent.	Swan River.
12.	Vicarya (?) callosa	Vicarya (?) Verneuilii, *D'Arch.*	Eocene?	Scinde.
13.	Turritella acuti-cingulata	Turritella Archimedis, *Brong.*	Miocene.	Vienna, Bordeaux.
14.	—— simplex	—— subangulata, *Brocc.*	Miocene.	Touraine, Vienna, Bordeaux.
16.	Turbo obliquus ...	Turbo petholatus, *Linn.*	Recent.	Philippines.
18.	Cardium subalter-natum.	Cardium alternatum, *Sow.* ...	Recent.	Philippines.
19.	Pythina Semperi...	Pythina peculiaris, *A. Ad.*	Recent.	Ceylon.

The existing fauna to which these Javan Shells are related is, therefore, that of the neighbouring East Indian Ocean; and this is also the case with the Coral described by Dr. Duncan in a note to this paper. The fact of the recent alliances being remarkably close strengthens the probability of the beds being somewhat newer than is indicated by the percentage phase of the question alone. It will be seen from the Table, also, that only four species are allied to European Miocene Shells, that is to say, rather more than half as many are allied to Miocene fossils as have affinities with recent Shells, and these Miocene species, two of which occur in the Touraine beds, may have emigrated eastwards and become altered on the way. One species is related to *Murex minax* of the Paris Basin.

4. *Nummulitic Formation of India.*—But one other species remains to be noticed, namely, a species of *Vicarya*, remarkably like *V. Verneuilii* from the Nummulitic formation of Scinde. This solitary instance of an affinity in that direction, and one so unmistakeable, induced me to investigate the question of the age of the so-called Nummulitic formation of India, and it appears to me that the uniform date of all the Scindian and neighbouring deposits usually referred to that formation is by no means satisfactorily proved; and the occurrence of a *Vicarya* in Scinde augurs more favourably for the newer age of some of the Scindian beds than for the greater antiquity of the Javan deposit.

It is possible, however, that the fossils from Java may have come from two or more beds having different ages; but, notwithstanding that all the fossils were evidently not obtained from the same bed, it is very improbable that the *Vicarya* belongs to a more ancient deposit than the rest, because its mineral condition (resembling chalk) is exactly like that of *Turritella simplex*, which is closely allied to *T. subangulata*, a well-known Miocene species.

Knowing that Dr. Duncan had been recently studying the Tertiary Corals, I asked him to look at those from Scinde in the Society's collection, with a view of ascertaining whether any of them were known Miocene species, and, as a result, he has favoured me with the following note, which is inserted here with his permission :—

Note on the SCINDIAN FOSSIL CORALS. By P. MARTIN DUNCAN, M.B., F.G.S.

The Nummulitic Coral-fauna of Scinde will always be associated with the name of the late M. Jules Haime, who described the species published in the 'Animaux Fossiles de l'Inde.' It was with some surprise that I found, on examining the collection of Corals which had passed through the hands of MM. d'Archiac and Haime, many species undescribed; and also that, had all the specimens been named, a very different aspect would have been given to the whole. The Coral-fauna, as represented by the whole of the specimens given to the Society by Lieutenant Blagrove, consists (1) of the species which are common to it and the European Nummulitic formation of the maritime Alps,—the fossils of these distant localities being often barely distinguishable, on account of their mineralization being identical, and the species found at La Palarea being very well represented in Scinde ; (2) of the single species which is common to the Eocene of north-western Europe and to the Nummulitic of La Palarea—the *Stylocœnia emarciata* ; (3) of species peculiar to Scinde.

The Corals of the first and second divisions and of part of the third have been described by M. Haime, and, with one exception, they belong to well-known Eocene genera or are Eocene species ; but nearly all the forms remaining in the third division, and the exceptional instance just mentioned, pertain to the Miocene, Pliocene, and Recent Coral-faunæ.

Either these specimens came from the same strata as the rest, or they are from a later Tertiary formation. If they are Nummulitic (and certainly the appearance and mineralization of some of them is like that of the species described as such), some new genera and some new species of old genera must be admitted into the Eocene period. In this case the Scindian Nummulitic Coral-fauna will, without any known Oligocene affinities, be closely allied to that of the Mid-tertiary.

If, however, the specimens came from later Tertiary formations, there must be an unrecognized Miocene and probably a Subapennine formation in Scinde.

I recognize amongst the undescribed Corals the following genera, which may be classified thus :—

1. Genera, some species of which have been found in the Eocene, namely, *Hydnophora*, *Montlivaltia*, *Siderastræa*, *Astræa*, and *Oculina*; but the species of these genera, from the results of my observations, are more closely allied to known Miocene and Recent forms than to those of the Eocene, except in the case of the genus *Montlivaltia*.

2. Genera, some species of which have been described from the Miocene, but not from the Eocene, namely, *Dasyphyllia, Antillia, Isastræa, Cladocora.*

3. Genera, some species of which have been described as Pliocene and Recent, namely, *Agaricia, Mycedium, Cladocora, Corallium.*

The single species which I have mentioned as having been described by M. Haime, and which I do not think belongs to a well-known Eocene genus, has so great a resemblance to an *Antillia* of the Miocene, that I have little doubt that better specimens will determine it not to be a *Montlivaltia.*

The genus *Mycedium* is now noticed for the first time as fossil. The *Cladocoræ*, the *Oculina*, and the *Corallium*, I believe, from their affinities and mineralization, not to belong to either a Mid-tertiary or Nummulitic age.

There are no precedents for admitting the genera of the second division into the Eocene, and there are abundant evidences of a Miocene formation in Asia. Milne-Edwards and Abich have described Miocene species of Corals from the Taurus and Upper Asia; Dr. Carter notices a Miliolitic limestone of Miocene age over the Lower Tertiary formation in eastern Arabia; and I have identified Miocene species in the Loftus Collection, which came from Persia, and also amongst some fossils from Travancore.

In conclusion, I arrange the undescribed forms as follows:—

Nummulitic—*Montlivaltia.*

Miocene — *Hydnophora, Siderastræa, Astræa, Dasyphyllia, Antillia, Isastræa, Agaricia, Mycedium.*

Pliocene—*Cladocora, Oculina, Corallium.*—[P. M. D.]

But it will probably be remarked that the range in time of the different genera and species of Corals is by no means well determined; and that other evidence is necessary before any of the fossils described by MM. d'Archiac and Haime can be referred to the Miocene period. In the first place, it may be observed that there is, amongst palæontologists and geologists, a prejudice against Corals as evidences of the age of strata; but, from what has lately been done by Dr. Duncan and others, it seems to me that this prejudice is by no means well founded. Moreover, the facts just stated in Dr. Duncan's note are too many and too weighty to be explained away in that manner.

In the next place, although it is not now my intention to attempt to *prove* that any of the beds in question are Miocene, I think a very good *primâ facie* case, suggesting the probability of some of them being of that age, can be made out without very much labour.

The matrix of *Vicarya Verneuilii* is stated by MM. d'Archiac and Haime to be a "Calcaire grisâtre avec des grains de fer oxydé hydraté." Now, very few fossils are stated by them to have a ferruginous matrix; and it is appended to the description of the matrix of some of these, that it is very different from that of the greater number of the fossils from the same locality. Of the four known species of Mollusca from this rock, noticed by the above-mentioned authors, three, namely, *Pholadomya Puschi*, Goldf., *Lucina mutabilis*, Lam., and *Siliquaria Granti*, Sow., occur also in the Miocene of Europe; the fourth known species is *Natica sigaretina*?, Desh., about which they are doubtful, besides its being a species the limits of which are uncertain, and consequently its range in time. There are but three other species from this rock, including *Vicarya Verneuilii*, all of which are new, and, with the exception of the species mentioned, come, I suppose, into the category of "forms."

Amongst the fossils from the same locality having the more usual matrix are *Cardium anomale*, Math., *Nucula margaritacea*, Lam., *Mytilus lithophagus*, Linn., *Trochus cumulans*, Brongn., and *T. agglutinans*, Lam. Nearly all of these have marks of doubt attached to them, and their occurrence in the Nummulitic rocks of India appeared somewhat remarkable to the authors of the great work on the fossils of that formation.

An investigation into the claims of MM. d'Archiac and Haime's "forms" to rank as true species would furnish more than sufficient material for a special paper by an experienced palæontologist; but, adopting their views for the present, it may be remarked that some of the new species of Mollusca described by them, the majority of which are merely casts, are stated to be most nearly allied to Miocene species; and, as regards the Nummulites, two species, according to those authors, are identical with forms occurring in the Miocene Basin of the Adour, namely, *Nummulina intermedia* and *N. Garansensis*. From a consideration of these facts, MM. d'Archiac and Haime conclude that the Nummulitic formation of India consists of three series of beds of slightly different ages; but they do not consider either of them to belong to the Miocene period.

Dr. H. J. Carter, F.R.S., of Bombay, at one time considered the Soomrow (Cutch) fossils, which were figured by Mr. Sowerby as "Tertiary" in contradistinction to "Nummulitic"*, to belong to the Miocene period†; and M. d'Orbigny, in his "Prodrome de Paléontologie," referred many of the Indian Nummulitic fossils to his "Étage Falunien," a determination somewhat severely criticized by MM. d'Archiac and Haime. More recently, Prof. H. B. Medlicott, F.G.S., one of the most experienced of Indian geologists, has argued‡ that the so-called Nummulitic rocks of Subathoo, referred by MM. d'Archiac and Haime to one formation, belong to two horizons. If this be true of one region (and Prof. Medlicott's reputation as an Indian geologist renders it very probable), it is most likely to be true of another, especially as one of the new species with a ferruginous matrix has been found also at Subathoo.

It will be seen, therefore, that the uniformly Eocene date of all the beds belonging to the Nummulitic formation of India is still uncertain, and it remains for future researches to elucidate this really important problem.

5. *Evidences of Physical Conditions.*—Returning to the Javan fos-

* Trans. Geol. Soc. Lond. 2nd ser. vol. v. part 2. pls. 25 & 26.

† Compare Journ. Bombay Roy. Asiat. Soc. vol. v. pp. 179 *et seq.* with "Geological Papers on Western India," p. 743 (footnote).

‡ Journ. Beng. Asiat. Soc. vol. xxx. pp. 22 *et seq.*

sils, the small size of many of the species when compared with their nearest allies or, in the case of known species, with recent specimens, is somewhat remarkable. Thus, all the examples of *Oliva utriculus* are small, and have the appearance of young specimens; the single specimen of *Pyrula cochlidium* is not more than one-half the size usually attained by that species, but it also may be a young specimen; the same may be said of the three examples of *Natica Flemingiana*?, which are also very diminutive, their small size being the chief cause of my placing a note of interrogation after the name of the species.

The new species are still more diminutive; for *Conus striatellus, Turbo obliquus,* and *Cardium subalternatum* are less than one-half the size of their nearest allies. Moreover, Dr. Duncan has observed the same relation between the new species of Coral (*Astræa Herklotsi*), which he has described in a note to this paper, and its recent representative *A. quadrangularis.* On the other hand, some of the species allied to fossil forms are somewhat larger than their related representatives; for instance, *Vicarya* (?) *callosa* is a little larger than *V. Verneuilii*; and *Turritella simplex* is very much larger than *T. subangulata.* Still, the balance of evidence appears to show that there was some influence in operation in the East Indian Seas, at the time when these animals lived, more adverse to their growth than there is at present; but what that influence was the evidence is not sufficient to prove. It may be observed, however, that the present Japanese fauna is said to have a peculiarly Northern aspect on account of a current of cold water from the north washing the shores of those Islands.

All the genera represented have a bathymetric range as high up as low-water mark; and many of them, namely, *Murex, Purpura, Pyrula, Oliva, Conus,* &c., do not range lower than from 25 to 40 fathoms. It may, therefore, be reasonably inferred that the deposit in question was formed in comparatively shallow water, especially as the matrix of the fossils is not contrary to such a conclusion.

6. *Age of the Tertiary Formation of Java.*—M. Hardie commences his interesting paper*, already noticed, by remarking that only two kinds of rocks exist in the Island of Java; namely, volcanic deposits, and a very recent Tertiary formation.

He gives the following succession of the strata in the western part of Java, proceeding from below upwards.

1. Shelly limestone; associated with clay containing marine fossils and sometimes fragments of the limestone.
2. Trachytic conglomerate, or tufa with large blocks of trachyte.
3. Saponaceous clay.
4. Volcanic clay.

The last three groups are without marine fossils, and are considered by the author to be of volcanic origin.

The first group is very fossiliferous; but the fossils, with the exception of Shells of the genera *Ostrea, Venus* (supposed to be *Venus pullastra* by M. Hardie), *Arca, Pecten, Cardium, Pinna, Lucina, Trochus,*

* Bull. Soc. Géol. de France, vol. iv. 1834, pp. 182 *et seq.*

Natica, *Conus*, and *Pyrula*, were too much calcined for preservation. This author also found microscopic organisms supposed to be allied to *Rotalia* and *Miliolites*; and Mr. Sowerby believed that he could identify some *Cyprides*. The limestones often contain Corals, and M. Hardie considered them to approach mineralogically to the limestones of the Vicentin; and the calcareous sandstones, both in mineralogical characters and in fossils, to the Molasse of the Bellunois (N. Italy).

Dr. Hochstetter concludes his paper on the Dutch East Indies, already noticed (p. 47, footnote), with some general remarks upon the coal-formation of Borneo, Sumatra, and Java. He remarks that, according to the researches of Dr. Herklots and Dr. Goeppert, there is scarcely a doubt that the greatly developed Tertiary beds of the East Indian Archipelago are of Eocene age; and he states that Mijnheer P. van Dijk, one of the Mining Engineers of the Dutch East Indies, has arrived at the same conclusion, and has published a paper on the subject in a number of the 'Natuurkundig Tijdschrift voor Nederländsch Indie,' of which I have not been able to find a copy in London.

Dr. Hochstetter himself appears to coincide in this opinion; and he divides the whole (so-called) Eocene formation of these Islands into three groups, namely—

1. *Lower Group*: coal-bearing; containing silicified Wood, but few or no marine Shells.
2. *Middle Group*: a calcareous formation, represented in Borneo by a Nummulite-limestone, and in Java by a Coral-limestone with marine Shells; it is partly contemporaneous, perhaps, with the next group.
3. *Upper Group*: a shale- and sandstone-formation, very rich in marine Shells, in fossil Plants (described by Goeppert), and in fossil Resin.

Mijnheer Herklots does not attempt to give the probable age of the Echinoderms from Java which he has described; but, respecting the age of the fossil Plants, Dr. Goeppert, after enumerating the different localities in Europe in which Eocene Plants occur, makes the following remark:—"Beyond Europe I refer to this period the Tertiary flora of Java discovered by Herr Junghuhn, and which I have just investigated, less on account of its tropical character * * * * * * than on account of its stratigraphical position beneath a marine formation."*

Mijnheer Junghuhn obtained fossil Plants from three localities, as stated by him and quoted by Dr. Goeppert, and one of these localities, namely, Sélogambé, is in the same district as Mount Séla.

Continuing the comparison of this district with the Valley of the Weald, Mount Séla is situated close to the northern escarpment, answering to our North Downs, while Sélogambé is situated south of the central axis, about midway between that point and the southern escarpment, and almost due south of Mount Séla (see woodcut, p. 49). It is probable, therefore, that the strata at Sélogambé

* Die Tertiärflora auf der Insel Java, &c. p. 65.

are older than those of Mount Séla; consequently, the former may be of Eocene date without affecting the Miocene age of the latter; though I cannot find, in Mijnheer Junghuhn's work, any notice of fossil Mollusca occurring in the southern portion of this district.

It is somewhat remarkable, however, that the Plants described by Dr. Goeppert occur in the uppermost of Dr. Hochstetter's subdivisions, which, from its lithological character and richness in marine Shells, appears also to be the one whence the fossils just described were obtained. In this case, the Shells referred to by Dr. Goeppert, and which he supposed to be of Eocene date, may be those of Mount Séla; and it then becomes extremely probable that the Plants described by him may belong to a more recent period than the Eocene, especially as Dr. Goeppert expressly states that his chief reason for considering them Eocene is their position under a marine formation*.

This view is supported by the remarks of Herr von Richthofen in his papers already alluded to. He characterizes the Tertiary formation of Java as extremely simple, both as regards mineral constitution and stratigraphical succession; and he observes that Nummulitic and other Eocene formations, which have been supposed to be so well developed in Java, appear to him entirely absent both from that and the neighbouring Islands, the uniform age of the strata being either Middle or Younger Tertiary. In explanation of this difference of opinion between himself and others, he remarks that the Orbitolites have probably been mistaken for Nummulites†; he also notices the analogy of the other fossils to those now living on the coasts of the Island. Fortunately, he refers more especially to the district in which Mijnheer de Groot's fossils occurred, and, so far as that area is concerned, there need be no hesitation in endorsing his opinion as to the probable age of the beds, as they appear to be of late Miocene date.

The affinity of one of the fossils to a Paris-Basin species, and the fact of another being a species of *Vicarya*, would alone be scarcely sufficient grounds for considering them older than the Pliocene, supposing that fossils of that period could be identified in the Tropics‡;

* Dr. Heer, on the other hand, considers the Javan Plants, together with the Brown-coal of Borneo and Sumatra, to be either "Diluvial" or Pliocene (contemporaneous with the Norwich Crag): see Flora Tertiaria Helvetiæ, vol. iii. pp. 323 & 324, also Table, p. 324. When two distinguished botanists draw, from the same materials, such widely different conclusions, it is, perhaps, allowable not to place much faith in Plants as diagnostic of the age of strata, nor to permit either conclusion to have any weight in the scale of evidence.

† Prof. T. Rupert Jones, F.G.S., suggested that they were probably *Orbitoides*, and informed me that Prof. Ehrenberg has described several Javan species of Foraminifera of the genera *Nodosaria*, *Amphistegina*, *Orbitoides*, &c.; the two last-mentioned include the characteristic forms. They were obtained from a white limestone labelled "Gua Linggo manik." See Abhandl. Akad. Berlin, 1855–56, p. 132; also Ehrenberg's 'Mikrogeologie,' pp. 157 & 160.

‡ The "Pliocene" of Europe being, as I conceive, merely the more or less arctic termination of a great period (to which is given the name "Miocene"), the tropical representative of that era could not be distinguished (especially in the East) from a late Miocene formation,—the Miocene fauna having a tropical and, to a great extent, an "Eastern" facies. This question, however, requires further discussion and illustration.

nevertheless Mijnheer Junghuhn's title of "Subapennine," though wonderfully near, considering the errors in his determinations of the fossils, is in all probability somewhat too recent.

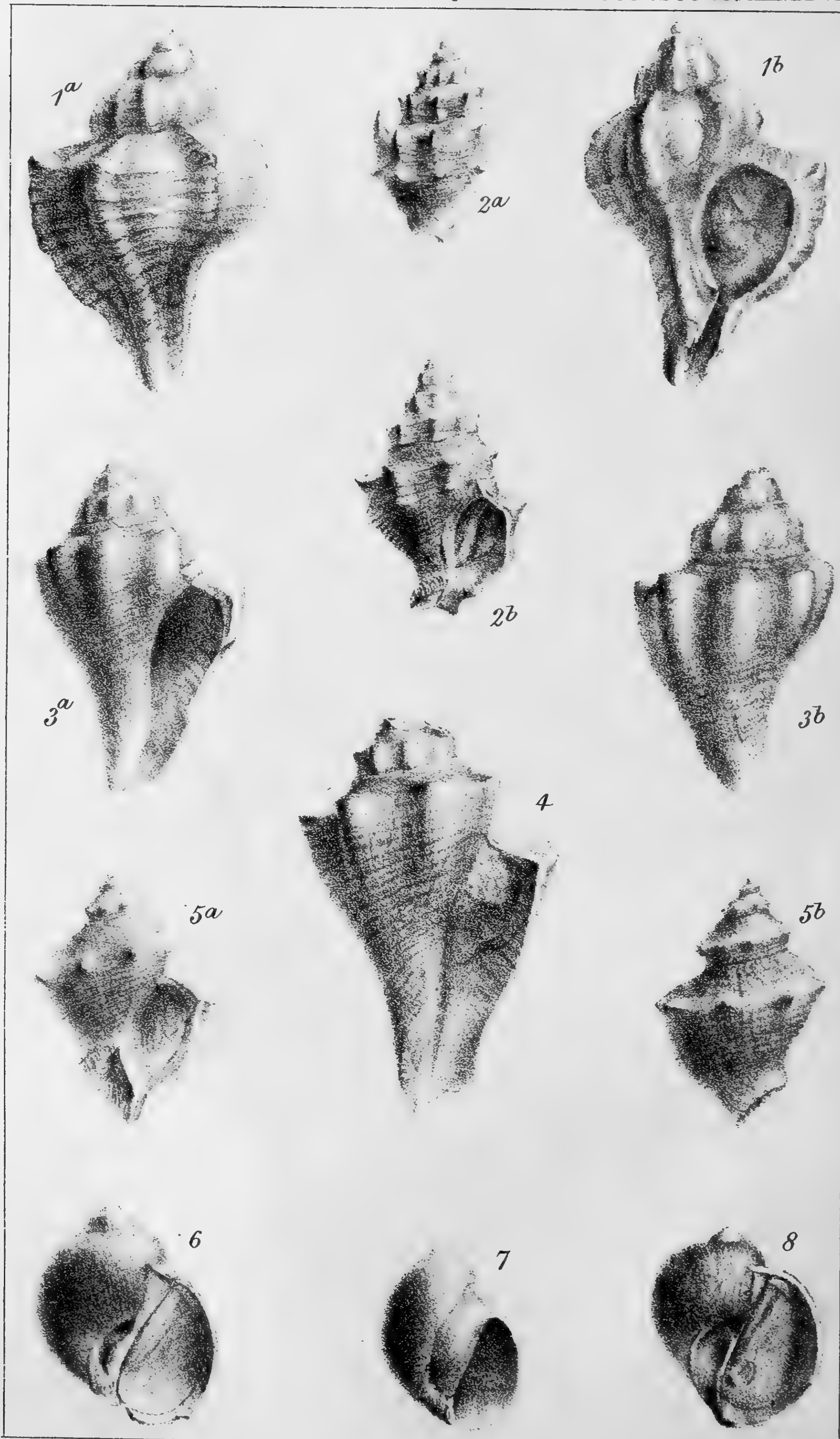
The question whether Herr von Richthofen's generalization—that the Eocene formation is entirely unrepresented in Java—and M. Hardie's assertion that there are but two kinds of rock-formation in Java—a volcanic and a recent Tertiary—be well founded or not will require further discussion, and the cooperation of M. de Groot and his coadjutors, before they can be considered as more than conjectural.

Note on a New Coral *from* Mount Séla *in the Island of* Java.

By P. Martin Duncan, M.B., F.G.S.

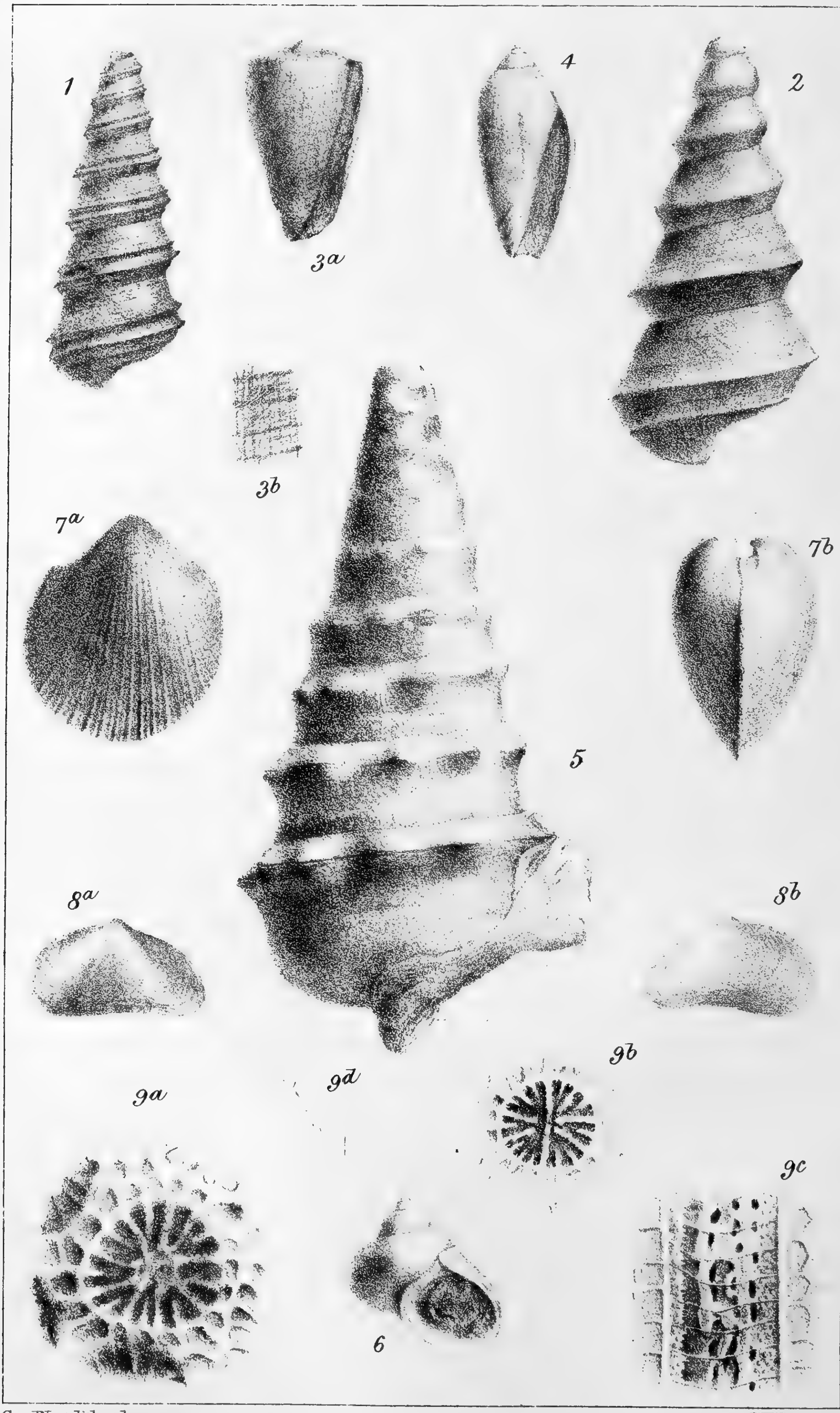
Astræa (Heliastræa, Edwards & Haime) Herklotsi, spec. nov. Pl. VII. figs. 9 *a*–9 *d*.

Corallum large and compound; base smaller than the calicular surface, which is slightly convex generally, but subplane here and there. Corallites crowded but distinct, slender, tall, very variable in shape, and radiating from the base; circular in transverse section at the base, but becoming polygonal, oval, or elliptical at the surface. Walls thin, imperforate, and delicate throughout; they appear to unite with others at the calicular margin, but such is not really the case, as costæ intervene. Calices often deformed, crowded, variable in outline, and hardly projecting. Costæ well developed, wedge-shaped, rather prominent (laterally), straight, and equal; they equal the septa in number, and spaces between their upper margins, at the surface, are very distinct and characteristic. Septa variable in number and size, barely exsert and slightly incised above; in six systems. There are three cycles in three systems generally, and two in the rest; but a rudimentary septum is often noticed between the more fully developed septa. Primary septa the largest, either four of them being very marked or two greatly thickened; they are often curved above, and are generally thicker towards the columella at the base, and they carry a stout paliform tooth at their inner end. Laminæ granular, and perforated close to their inner margin by large foramina. Secondary septa smaller than the primary, but larger than the tertiary. Both the secondary and tertiary septa are inclined to curve towards each other and to the primary; their laminæ are very areolar, with the free edges serrated, and with granules on the lateral surfaces near the wall. Columella very rudimentary, and formed by small cylindrical dissepiments, which are attached to the inner margin of the septa by stout processes, and which look like pali. The septal fossa is tolerably deep. There are no pali. Endotheca well developed; dissepiments either horizontal or inclined, but not vesicular; the first kind extend close to the calicular edge, and, by being on the same plane, nearly close-in the corallite—like tabulæ, whilst the latter are regular and well marked also. Exotheca well developed; dissepiments stouter than those of the endotheca,



Geo. West. lith. ad nat. W. West imp.

FOSSILS FROM JAVA.



Geo. West lith. ad nat.

W. West imp.

FOSSILS FROM JAVA.

and horizontal; they form large and small cells, the first being broad, and the last high. Reproduction by extracalicular gemmation and by fissiparity. Breadth of the corallites at the base from 1 line to 2 lines, and at the calicular surface from $\frac{1}{5}$ to $\frac{1}{4}$ inch. Height of the corallites 3 inches, and depth of the fossa about $1\frac{1}{2}$ line. There are three dissepiments to a line.

This species is characterized by the polygonal and irregular shape of the calices, the rudimentary columella, the incomplete third cycle, the transverse and horizontal epitheca reaching very high up, the presence of corallites undergoing fissiparous growth, and the intercostal pits. The perforated state of the smaller laminæ is the only Cyphastræan peculiarity; and the species is closely allied to, but is smaller than, *Astræa* (*Heliastræa*) *quadrangularis*, Edwards and Haime, the habitat of which is unfortunately unknown. The amount of endotheca approximates the form to those of the Miocene; but there are none other than generic resemblances to the only known Eocene Astræan.

The perforated laminæ of *Astræa Defranci* (Miocene) resemble those of this species, but the abundant endothecal tissue of the latter forms a specific distinction.—[P. M. D.]

EXPLANATION OF PLATES VI. & VII.

Illustrative of Tertiary Shells from Java.

[The figures are of the natural size, unless it is otherwise stated.]

Plate VI.

Fig. 1. *Murex Grooti*: *a*, back view; *b*, front view.
2. ——? *paradoxicus*: *a*, spinous variety, back view; *b*, ordinary form, front view.
3. *Pyrula Javanis*: *a*, front view; *b*, back view.
4. —— *cochlidium*; front view.
5. *Purpura umbilicata*: *a*, front view; *b*, back view.
6. *Natica Duncani*; front view.
7. —— *Flemingiana*?; front view.
8. —— *rostalina*; front view.

Plate VII.

Fig. 1. *Turritella acuticingulata.*
2. —— *simplex.*
3. *Conus striatellus*: *a*, front view; *b*, portion of the side, magnified 4 diameters.
4. *Oliva utriculus* (juv.?); front view.
5. *Vicarya* (?) *callosa*; front view.
6. *Turbo obliquus*; front view.
7. *Cardium subalternatum*: *a*, lateral view of right valve; *b*, view of anterior extremity.
8. *Pythina Semperi*: *a*, exterior of left valve; *b*, exterior of right valve; both magnified 3 diameters.
9. *Astræa Herklotsi*: *a*, calice, magnified 4 diameters; *b*, transverse section of a corallite, magnified 3 diameters; *c*, longitudinal section of a corallite, magnified 4 diameters, showing the walls, the laminæ, the endothecal dissepiments across the laminæ, the central columellar false pali, and the exotheca; *d*, diagram of the superior margin of a septum showing the paliform tooth.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the Sandstones *and* Shales *of the* Oolites *of* Scarborough, *with* Descriptions *of some* New Species *of* Fossil Plants. By John Leckenby, Esq., F.G.S.

(Read June 17, 1863*.)

[Plates VIII.–XI.]

I. Description of the Beds.

The "Grey Limestone" of Scarborough, and its associated and alternating beds of sandstone and shale, have lately attracted the attention of geologists from other parts of England, who, aided by their knowledge of the Oolites of their own districts, and of France and Germany, have done much to establish more accurate views of the correlations of the Yorkshire beds.

I do not, therefore, hope to add much to the general information which is now possessed as to the true position of the fossil plant-yielding beds at Gristhorpe Bay, Cloughton Wyke, and the neighbourhood of Whitby; my chief intention being to describe and figure some new or imperfectly known species, and to point out certain affinities and differences that have hitherto escaped detection.

Prof. Williamson, in a paper communicated to the Geological Society in 1839†, first pointed out the true position of the famous plant-bed at Gristhorpe Bay, below the Grey Limestone; and, in 1859, his views were confirmed by Dr. Wright, the subject being considerably amplified in a paper read by the latter author before the Geological Society in April of that year‡. I have only to add, in confirmation of these opinions, a fact which is not made sufficiently prominent in Dr. Wright's paper, that from the first appearance of the "Grey Limestone" in the north corner of Gristhorpe Bay, through-

* For the other communications read at this Evening-meeting, see Quart. Journ. Geol. Soc. vol. xix. p. 506.
† Trans. Geol. Soc. 2nd ser. vol. vi. part 1. p. 143, 1841.
‡ Quart. Journ. Geol. Soc. vol. xvi. p. 1, 1860.

out its entire course, both on the south and to the north of Scarborough, on the coast, and in the interior, it is uniformly based upon a bed of freestone (No. 11, Dr. Wright's memoir, p. 30). Wherever the "Grey Limestone" is found in Yorkshire, this bed, well known to local geologists, will be found in immediate underlying contact, and all the fossil Plants of Gristhorpe are found in a bed many feet below it.

Thus it follows that all the Plants hitherto referred to the "Upper Sandstone, Shale, and Coal," and figured in plates 7 & 8 of the 'Illustrations of the Geology of Yorkshire,' belong to the "Lower Sandstones and Shales." They occupy at Gristhorpe the same zone as at Cloughton Wyke, and the Table on p. 76 shows how little difference really exists in the respective floras of the two localities.

I believe the error to have originated in the fact of the thin, attenuated edges of the bed of Grey Limestone in Gristhorpe Bay having been for a long time overlooked, and only first detected by Prof. Williamson,—the bed No. 21 of Dr. Wright's memoir (p. 31) having been previously supposed to be the first indication of marine conditions below the Cornbrash,—the truth being that the entire series, from the Inferior Oolite upwards to the Cornbrash, is in Yorkshire a frequent succession of marine and freshwater conditions, the alternations not being fewer than ten in number.

Hitherto but few Plants have been found in the true Upper Sandstones and Shales overlying the "Grey Limestone." Traces of other species sometimes occur; but the only definite form that I am acquainted with from these beds is the *Cyclopteris digitata*, Fossil Flora, tab. 66 (*Cyclopteris Huttoni* of Sternberg and Morris). This is not the *Cyclopteris digitata* of Brongniart; the two species being distinct, as was first pointed out by Sir C. J. F. Bunbury, in his paper on the Fossil Plants of Scarborough, published in the 'Proceedings of the Geological Society,' March 1851. It is rather abundant in a white, fine-grained sandstone (bed No. 7, p. 28, Dr. Wright's memoir), showing the blackened leaves in fine contrast. Although not uncommon at White Nab, south of Scarborough, it is more frequently obtained in the same zone a little to the north of the town. Hence specimens in collections have been always referred to the "Lower Sandstone and Shale." I am not aware that it occurs in the "Lower Sandstone and Shale" at all, although referred to this stratum by Sir C. J. F. Bunbury (p. 184), he having been doubtless misled by the labels in the collections which he examined at Scarborough.

Along the course of the "Upper Sandstones and Shales," between the Spa and White Nab, the geologist may examine with interest the remains of the bed of an extensive freshwater lake, whose bottom has been a living mass of Unioniform Shells; they are all placed endwise and closely impacted, but exist only as casts, with rarely traces of their shelly exterior. In some instances, the entombing rock being harder than the mud which formed their bed, the latter has perished, and in caves by the sea-side the *Uniones* may be seen depending from the rock above.

In the following list of Plants from the beds at Gristhorpe and Cloughton, I have distinguished as follows—

a. Those hitherto found only at Gristhorpe.
b. Those found only at Cloughton.
c. Those common to both localities.

b. Thuytes expansus, *Lindley*.
c. Brachyphyllum mammillare, *Lindl*.
a. Fucoides arcuatus, *Lindley*.
c. —— erectus, *Bean, MS*.
a. Cycadites.
c. Palæozamia pecten, *Lindley*, sp.
c. Pterophyllum comptum, *Lindley*.
c. —— Nilssoni, *Lindley*.
a. —— tenuicaulis, *Phillips*.
a. —— angustifolium, *Bean, MS*.
a. —— medianum, *Bean, MS*.
c. Tæniopteris major, *Lindley*.
c. —— vittata, *Lindley*.
a. Ctenis falcata, *Lindley*.
a. —— Leckenbyi, *Bean, MS*.
a. Glossopteris Phillipsii, *Brongniart*.
c. Cyclopteris digitata, *Brongniart*, non *Lindley*.
c. Otopteris Beanii, *Lindley*.
a. Sagenopteris cuneata, *Lindley*.
a. Baiera longifolia, *Phillips*, sp.
b. —— gracilis, *Bunbury*.
c. Sphenopteris arguta, *Lindley*.
b. —— serrata, *Lindley*.
c. —— modesta, *Bean, MS*.
a. —— nephrocarpa, *Bunbury*.
a. Hymenophyllites denticulata, *Brongniart*.
a. —— Williamsonis, *Brongniart*.
c. Neuropteris lobifolia, *Phillips*.
a. —— undulata, *Lindley*.
c. —— arguta, *Lindley*.
c. —— recentior, *Lindley*.
c. —— ? ligata, *Lindley*.
c. Pecopteris insignis, *Lindley*.
c. —— dentata, *Lindley*.
a. —— exilis, *Phillips*.
a. —— acutifolia, *Lindley*.
c. —— ? Murrayana, *Brongniart*.
c. Acrostichites Williamsonis, *Lindley*, sp.
a. Polypodites polypodioides, *Lindley*, sp.
a. —— undans, *Lindley*, sp.
a. Phlebopteris propinqua, *Brongn*.
a. —— contigua, *Lindley*.
b. —— Woodwardii, *Leckenby*.
c. Dictyophyllum rugosum, *Lindley*.
a. Sphæreda paradoxa, *Lindley*.
c. —— parvula, *Bean, MS*.
c. Solenites Murrayana, *Lindley*.
c. Lycopodites Williamsonis, *Lindley*.

Of the species quoted above, all the moderately plentiful ones occur both at Gristhorpe and Cloughton. It is only in the case of such as are of really rare occurrence that I can quote but one locality. Further researches will probably increase the number of species common to both.

The Millepore-bed referred by Prof. Phillips (at page 51, 'Geology of Yorkshire') to the Inferior Oolite, and described by Dr. Wright (No. 26, page 31) in the memoir already referred to, is the lowest marine bed of the series, but there are at least 250 feet of sandstones and shales between it and the true Inferior Oolite or Dogger. It derives its name from the abundance of *Cricopora straminea* (*Millepora straminea*, Phillips) which is displayed upon its weathered lateral surfaces. It is the hardest rock of the series, and its superior resistance to the action of the waves is shown in rugged reefs along the shore.

Below this bed the flora is characterized by the greater preponderance of the genera *Zamia* and *Otopteris*; as we ascend these genera become, on the contrary, rarer, their place being occupied by an abundance of *Pterophyllum*. In the following list of species below the Millepore-bed, those marked *b* have not hitherto been found above it.

Thuytes expansus, *Lindley*.
Brachyphyllum mammillare, *Lindl.*
b. Zamites gigas, *Lindley*.
b. —— lanceolatus, *Lindley*.
b. Palæozamia hastula, *Bean, MS.*
(*Cycadites pectinoides*, Phillips.)
Pterophyllum minus, *Lindley*.
b. Otopteris obtusa, *Lindley*.
b. —— acuminata, *Lindley*.
b. —— lanceolata, *Bean, MS.*
b. —— graphica, *Bean, MS.*
b. —— tenuata, *Bean, MS.*
b. Equisetites columnaris, *Brongniart*.
—— lateralis, *Phillips*.
b. Sphenopteris crenulata, *Brongniart*.
—— hymenophylloides, *Brongn.*
Neuropteris lobifolia, *Phillips*.
—— ligata, *Lindley*.
b. Pecopteris Whitbiensis, *Brongniart*.
b. —— Haiburnensis, *Lindley*.
—— dentata, *Lindley*.
b. —— polydactyla, *Goeppert*.
Acrostichites Williamsonis, *Lindley*, sp.
b. Sphæreda parvula, *Bean, MS.*
b. Lycopodites falcatus, *Lindley*.
b. Cryptomerites ? divaricatus, *Bunb.*

II. Notes, and Descriptions of New Species.

1. Cycadites zamioides, nobis. Pl. VIII. fig. 1.

Cycadites gramineus, Bean, MS., non Phillips.

Frond broad, abruptly contracted near the apex; pinnæ slender, of nearly equal thickness, contracted upon the midrib at the junction with the rachis.

This species is considered by Mr. Bean to be a true Cycad, and has been named by him, in MS., *Cycadites gramineus*. The strong central midrib of the leaflet favours Mr. Bean's opinion; but more perfect specimens show that it is not attached, as he once thought, by its entire base. It seems to be intermediate between *Zamia* and *Cycadites*. I have therefore named it *Cycadites zamioides*.

2. Palæozamia pecten, Lindley, sp. Pl. IX. fig. 4.

To illustrate the affinities of this species with *Zamia*, I have figured a specimen showing the fronds, stems, and a flower on the same slab of shale.

3. Pterophyllum comptum, Lindley. Pl. IX. fig. 3.

The species here figured is a young plant, perfect at the point of attachment to the root.

4. Pterophyllum medianum, Bean, MS. Pl. VIII. fig. 2.

Frond gradually contracted towards the base, abruptly so at the apex; pinnæ long, oblique, irregularly attenuate, breadth nearly uniform, length from four to six times their breadth; apices rounded inferiorly, acutely pointed superiorly.

This species approaches *P. tenuicaulis*; but the leaflets are always more slender and delicate, and more elongated. It is found only at Gristhorpe, where it is not common.

5. Pterophyllum angustifolium, Bean, MS. Pl. VIII. fig. 3.

Frond equally attenuated above and below; pinnæ very long and tapering, perpendicular to the rachis, irregularly alternate, length from six to eight times their breadth; apices acute.

This species is well distinguished by its straight and sharply pointed leaflets, and was named, in MS., by Mr. Bean many years ago. Like *P. medianum* it is found only at Gristhorpe, where also it is rare.

6. Pterophyllum minus, Lindley. Pl. IX. fig. 2.

This species I suspect to be a mere variety or condition of *Tæniopteris vittata*, in which the leaf is split more or less frequently, and with great irregularity, so as to resemble leaflets. The figures will illustrate my meaning.

7. Ctenis Leckenbyi, Bean, MS. Pl. X. figs. 1 *a*, 1 *b*.

Frond bipinnate, spreading; principal stem very thick and deeply grooved; secondary stems slender; leaflets attached by their entire base; veins much forked, parallel, or nearly so, to the upper margin, running out at the under margin.

Mr. Bean has kindly given my name to a Plant which, rather than create a new genus, I have referred to the convenient one *Ctenis*, provided by the authors of the 'Fossil Flora' for "the reception of leaves having the general character of *Cycadeæ*, but with the veins connected by forks or transverse bars." But the species now described is bipinnate, which perhaps invalidates its claim to be classed with the *Cycadeæ*.

8. Otopteris mediana, nobis. Pl. X. fig. 2.
Pachypteris maxima, Bean, MS.

Frond elongated; leaflets oblong-ovate, crowded towards the base, more distant towards the apex.

Some fronds of this very distinct *Otopteris*, in a coarse dark-brown sandstone in which the bases of the leaflets and their mode of attachment were obscure, have been referred by Mr. Bean to Brongniart's genus *Pachypteris*. It is, however, a true *Otopteris*, and the specific name of "*maxima*" being inappropriate, I have named it *O. mediana*.

9. Otopteris lanceolata, Bean, MS. Pl. VIII. fig. 4.

Frond tapering, contracting abruptly at the apex; leaflets long and slender, patent, slightly deflected, their apices acute.

The long and slender leaflets of this species are not unlike those of the upper portion of the fronds of *Zamia gigas*. They are patent, and slightly curving downwards. It is probably the species figured (pl. 2. fig. 4) in Young and Bird's 'Geology of Yorkshire.'

10. Otopteris graphica, Bean, MS. Pl. VIII. fig. 5.

Frond very long; leaflets cuneiform, oblique, their bases expanded; apices subacute.

A very fine example of this species, two feet in length, was obtained by me some years ago, and placed in Mr. Bean's museum. It is now in the British Museum.

This example, and the specimen of which a portion is now figured, are all that I have seen. The leaflets are shorter, much broader, and more erect than in *O. lanceolata*; they also spread more at the base, and curve upwards.

11. Otopteris tenuata, Bean, MS. Pl. IX. fig. 1.

Frond long and slender; leaflets nearly circular, of uniform size, except a few at the apex, erect, much crowded, and imbricated, with three or four stronger veins interspersed amongst the ordinary ones.

This very distinct species cannot well be confounded with any other. The small, angularly rounded, and almost erect leaflets diminish but little from the base of the frond until the apex is nearly attained. The veins are not uniform, but consist of three or four principal and numerous intermediate ones. It occurs in a hard sandy shale 200 feet below the Millepore-bed.

12. Tympanophora simplex *et* racemosa, Lindley. Pl. XI. fig. 2.

In confirmation of the opinion that *Tympanophora racemosa* is *Pecopteris* ? *Murrayana* in fructification, I have figured a specimen showing fertile and infertile leaflets on the same frond. *Tympanophora simplex* is, I suspect, the fertile condition of *Neuropteris lobifolia*, but on this subject my evidence is not yet quite conclusive. *Sphenopteris nephrocarpa*, Bunbury, is also, I think, *Sphenopteris stipata*, Phillips, in the same condition.

13. Sphenopteris modesta, Bean, MS. Pl. X. figs. 3 *a*, 3 *b*.

Frond pinnate; pinnæ elongated, equal, patent; pinnules obtuse, very oblique to the rachis, alternate, attached by their entire base; lobes obtuse, often confluent, obscurely crenulated at the apex; nerves bi- or tri-furcate, widely spreading.

This very distinct species is remarkable for its straight elongated pinnæ, the pinnules of which are not in the least attenuated for three-fourths of the entire length of the pinnæ. The frond appears to have tapered gradually to a long, slender, and delicate apex. It is very abundant in a seam below the Millepore-bed, and occurs, although sparingly, at Gristhorpe.

14. Sphenopteris Jugleri, Ettingshausen. Abhandlungen der k. k. geologischen Reichsanstalt, tab. 4. fig. 5.

Notwithstanding its occurrence in a stratum so much older than the "Wealden Periode" to which the above author refers this species, I cannot distinguish any Yorkshire examples from the specimen figured and described in the work quoted. It and *Pecopteris polydactyla* (mentioned below) appear to be associated in Germany with *Cyclopteris digitata*, Brongn., and other well-known Yorkshire Oolitic species.

15. Neuropteris arguta, Lindley. Pl. X. fig. 4.

The drawing represents this Plant, as I have lately found it, partly in fructification, the fertile and infertile leaflets being on the same frond. Specimens entirely in the former condition have been long considered a distinct species, or genus, and as such Mr. Bean informs me he sent examples in 1838 to M. Adolphe Brongniart, who remarked on them as follows:—

"A very remarkable Fern, which ought to constitute a new genus among forest ferns, but approaches near to the recent ferns of the tribe *Cyathea*."

16. Pecopteris polydactyla, Goepp. Pl. XI. figs. 1 *a*, 1 *b*.

Pecopteris polydactyla, Dunker, Monogr.
Alethopteris Goeppertii, Ettingshausen. Abhandlungen der k.-k. geologischen Reichsanstalt, tab. 5. figs. 1–7.

Yorkshire examples of this elegant species agree so well with the figures and description of German authors, that I cannot, notwithstanding (as in the case of *Sphenopteris Jugleri*) their occurrence in a stratum so much older, refer them to any other species. The example figured (the first I obtained) is finer than any which have subsequently occurred, although it is now by no means rare. Its mode of fructification allies it with *Polypodites* rather than with *Pecopteris*.

17. Phlebopteris propinqua, Lindley & Hutton, sp.

Pecopteris propinqua, Lindley & Hutton.
Pecopteris crenifolia, Phillips.
Phlebopteris polypodioides, Brongniart.
Phlebopteris propinqua, Brongniart.
Phlebopteris contigua, Lindley & Hutton.
Hemitilites polypodioides, Goeppert.

An examination of the original specimen of *Pecopteris propinqua*, Lindley & Hutton (Fossil Flora, p. 119), now in the Scarborough Museum, under an ordinary pocket-lens, at once shows that the undulations of the edges of the leaflets, relied upon as a specific character, are merely the worn jagged edges of a depauperated Plant. Precisely the same appearance is given to the figure of *Pecopteris crenifolia* in Phillips's 'Geology of Yorkshire' (pl. 8. fig. 11), and from the same cause, as an examination of this type also shows. But Lindley and Hutton incorrectly refer it to their *Pecopteris polypodioides*, the venation of which is quite distinct from that of the species under consideration, there being in *P. polypodioides* no distinct areola, and the sori being placed at the tip of a short nerve, as is shown with tolerable accuracy in their figure of the magnified portion (pl. 60. fig. 2). Much confusion has been created by Lindley and Hutton having adopted the specific name "*polypodioides*" of Brongniart's 'Prodrome' for a species which his 'Histoire' proved to be quite different from their species, and which the evidence of many specimens proves to have been the same as their *Phlebopteris contigua*, as they rightly conjecture. Notwithstanding the differences to which they refer, *Phlebopteris contigua* again is only the robust condition of *Pecopteris propinqua* or *P. crenifolia*.

As the venation and fructification of *Pecopteris undans* and *P. polypodioides* resemble each other, I propose to refer these species to *Polypodites*, and to reserve the genus *Phlebopteris* for those species having a distinct areola, although the genus is again capable of subdivision into two sections—one containing those species in which, as in *P. contigua*, the sori are placed externally to the areola; and the other for species, like the following, in which the sori are placed in the centre of the areola and close to the midrib.

18. Phlebopteris Woodwardii, nobis. Pl. VIII. fig. 6.

Frond unknown; leaflets long and narrow, with a thickened midrib, grooved on each side, and from which spring rows of veins forming pentagonal areolæ, which bi- or tri-furcate towards the edges. Fructification—stellate sori, in the centre of the areolæ.

The magnified portion figured represents a species in which, as before stated, the sori are placed within an areola, which in the one before us is pentagonal. It has hitherto been found only in fragments, although tolerably plentiful. The arrangement of the nerves and the disposition of the sori are so remarkable as to leave no doubt of its being a distinct species. Their connexion with a feeding-vein is obscure.

19. Fucoides erectus, Bean, MS. Pl. XI. figs. 3 *a*, 3 *b*.

Frond expanding, somewhat fan-shaped, erect, dichotomously branched; branches cleft irregularly and longitudinally at their summits, forming lobes which are obtusely pointed, sometimes truncate, a cluster of veins forming a midrib from which spread numerous secondary ones. Fructification in one or more rows of ovate vesicles, immersed in the frond.

The fronds of this species are broader than those of *Fucoides arcuatus*, and are not incurved. It is only in finely-preserved specimens that the venation and fructification can be observed. The example figured is from the beds at Cloughton Wyke. It occurs also at Gristhorpe.

EXPLANATION OF PLATES VIII.-XI.

Illustrative of the Oolitic Plants of Scarborough.

Plate VIII.

Fig. 1. *Cycadites zamioides*; portion of a frond, natural size.
2. *Pterophyllum medianum*; portion of a frond, natural size.
3. —— *angustifolium*; portion of a frond, natural size.
4. *Otopteris lanceolata*; portion of a frond, natural size.
5. —— *graphica*; portion of a frond, natural size.
6. *Phlebopteris Woodwardii*; portion of a leaflet, magnified 3 diameters.

Plate IX.

Fig. 1. *Otopteris tenuata*; portion of a frond, natural size.
2. *Pterophyllum minus*; two fronds, showing variation in their division, three-fourths the natural size.
3. —— *comptum*; portion of a young frond, two-thirds the natural size.
4. *Palæozamia pecten*: *a*, portions of fronds, stems, and a flower, one-half the natural size; *b*, portion of a frond, magnified 2 diameters.

Plate X.

Fig. 1. *Ctenis Leckenbyi*: *a*, portions of fronds, three-fourths the natural size; *b*, leaflet, magnified $1\frac{1}{2}$ diameter.
2. *Otopteris mediana*; portion of a frond, natural size.
3. *Sphenopteris modesta*: *a*, portions of two fronds, natural size; *b*, leaflet, magnified 4 diameters.
4. *Neuropteris arguta*; portion of a frond in fructification, natural size.

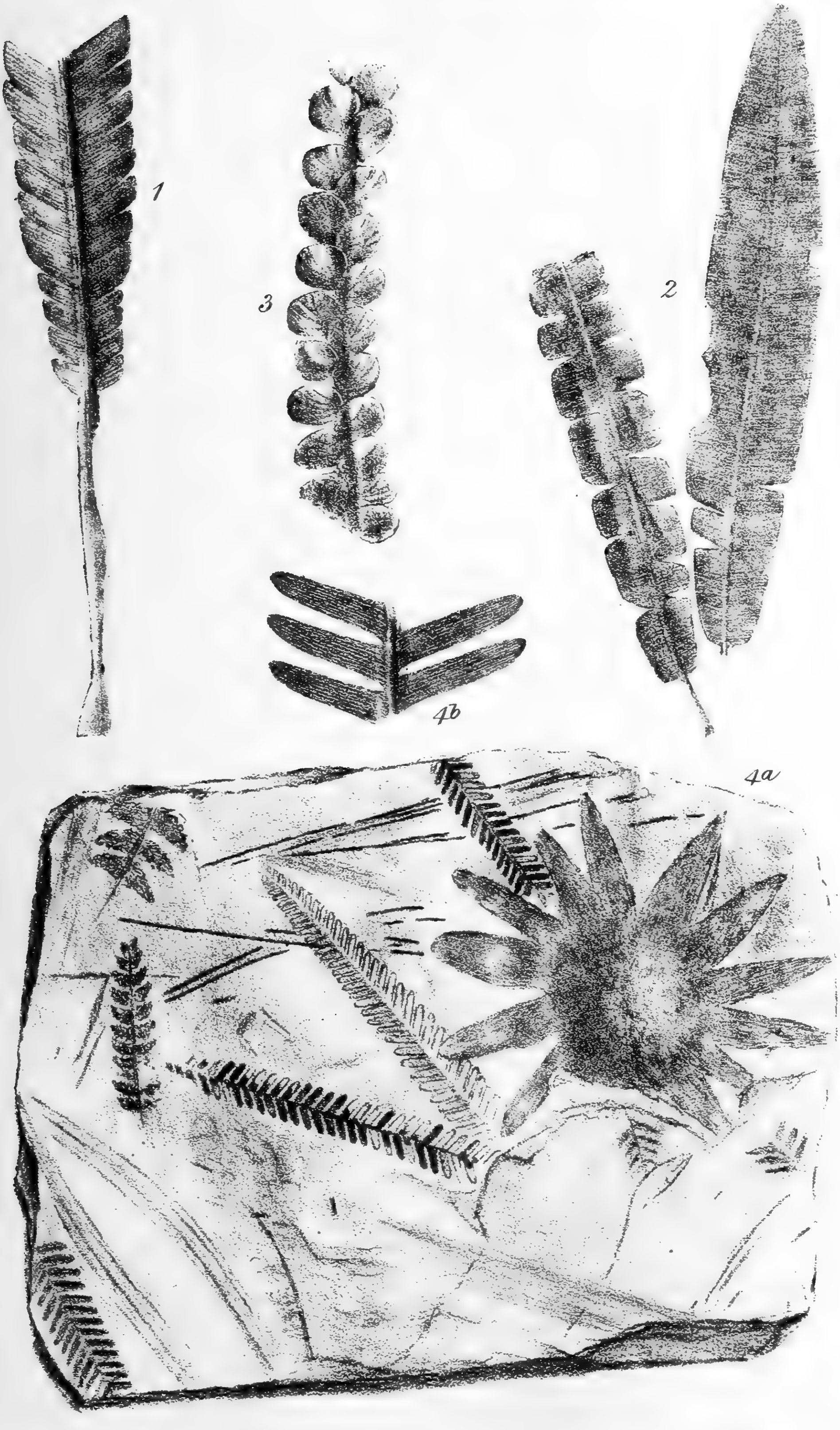
Plate XI.

Fig. 1. *Pecopteris polydactyla*: *a*, frond and rachis, natural size; *b*, leaflet, magnified 3 diameters.
2. *Tympanophora simplex*; portion of a frond, natural size.
3. *Fucoides erectus*: *a*, thallus, natural size; *b*, portion of a thallus in fruit, natural size.

G. West lith. ad nat.

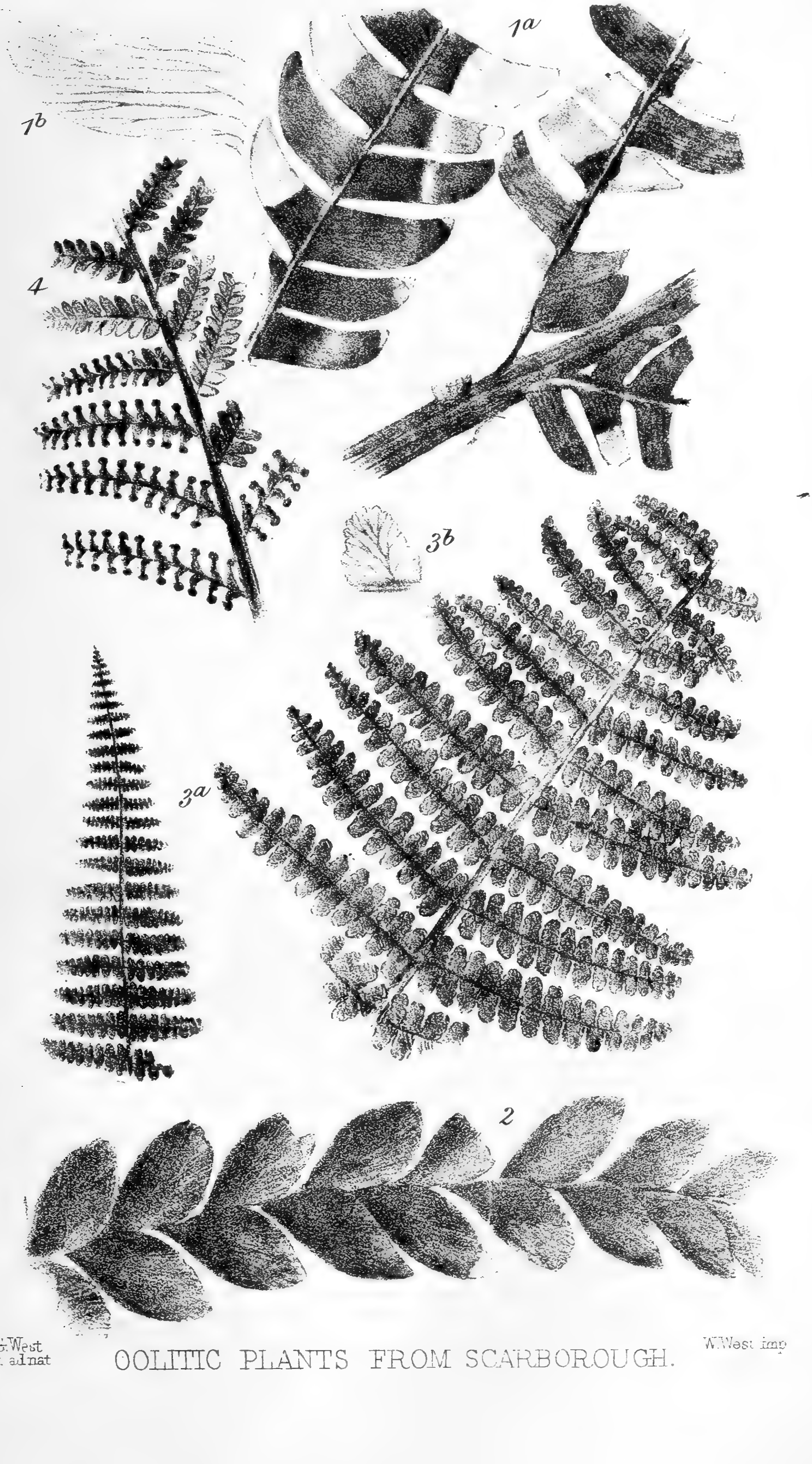
OOLITIC PLANTS FROM SCARBOROUGH.

W. West imp.



G. West lith. ad nat. W. West imp.

OOLITIC PLANTS FROM SCARBOROUGH.



G. West Lith. ad nat.

OOLITIC PLANTS FROM SCARBOROUGH.

W. West imp.

G. West lith. ad nat. OOLITIC PLANTS FROM SCARBOROUGH. W. West imp.

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Whitney, J. D. Notice of the Progress of the Geological Survey of California, up to May 1863. 1863.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 2, 1863.

Arthur Bott, Esq., 5 Hanover Terrace, Peckham; Alexander Bryson, Esq., F.R.S.E., Hawk Hill, near Edinburgh; George Cheetham Churchill, Esq., 13 Craven Hill, Bayswater, W.; James Fergusson, Esq., F.R.S., 20 Langham Place, London, W.; The Rev. Norman Glass, 39 Richmond Terrace, Clapham Road, S.; Harrison Hayter, Esq., M. Inst. C. E., 33 Great George Street, Westminster; Edward Ball Knobel, Esq., 138 High Street, Burton-on-Trent, Staffordshire; George Lyall, Esq., 38 East Winchester Street, South Shields; Arthur Lennox, Esq., Assistant Geologist, West Indian Survey, Jamaica; William James Nevill, Esq., Hatton House, Cheshunt, Herts; The Hon. William Owen Stanley, M.P., Penrhos, N. Wales; Arnold Thomas, Esq., Mining Engineer, Winnall's Hill, Coleford, Gloucester; William Vicary, Esq., 7 Albert Terrace, St. Leonard's, Exeter; and Edwin Brown, Esq., Burton-on-Trent, were elected Fellows.

The following communications were read:—

1. *On the* Correlation *of the* Oligocene Deposits *of* Belgium, Northern Germany, *and the* South *of* England. By Herr Adolf von Kœnen, Member of the German Geological Society.

[Communicated by F. E. Edwards, Esq., F.G.S.]

English geologists have lately become very much interested in certain Tertiary deposits which contain marine fossils hitherto unknown in England, and which were discovered first in a railway-cutting about one mile north of Brockenhurst, and afterwards at Lyndhurst and Roydon in the New Forest. The fossils from these localities were chiefly collected, and some of them described, by Mr. Frederick E. Edwards, to whom we are so much indebted for our knowledge of the fossils of the English Lower Tertiaries. By his extreme kindness in allowing me the use of his cabinet, and in giving me all the information in his power, I have been enabled to judge for myself of the age of the Brockenhurst beds.

As these beds were seen in superposition to the Lower Headon-hill (freshwater) series*, there is no doubt that they are of the same age as the Middle Headon beds of Colwell Bay and White-cliff Bay, which, moreover, contain some of the most characteristic fossils of the Brockenhurst beds (*Cancellaria scabricula*, Edw., *Fusus labiatus*, Sow., &c.); but as they have a richer and true marine fauna, they are of the greatest importance in comparing the Headon beds with foreign (Belgian and Northern German) Tertiary strata.

Sir Charles Lyell and other geologists compared the Headon series with the Tongrien inférieur of M. Dumont, because both were seen in superposition to the Barton clay; Professor Sandberger compared the Headon series and the Bembridge series with the Tongrien inférieur, principally because he found many fossils from the Hempstead beds identical with those from the Lower Mayence beds (Système Rupélien of M. Dumont). The Belgian Upper Tongrien beds were placed by Sir Charles Lyell at the top of the Headon series, and the Système Rupélien was supposed by him to be the equivalent of all the beds above the Headon series. All these beds were grouped together to form the Upper Eocene of Sir Charles Lyell, the Upper Hempstead beds being the uppermost member of that series. Now in this case there would really have been a considerable interval between the Eocene and the Miocene periods, very few species passing over from the former to the latter. But, in fact, there exist intermediate beds between them, to which Sir Charles Lyell did not attach sufficient importance when he proposed that, his first, classification of the Tertiary strata, though the fossils from these beds had been described and figured long ago by Goldfuss (Petrefacta Germaniæ), and afterwards by R. A. Philippi†; and his later classification is even less conformable to their evidence. These beds are to be found over a very large area in Northern Germany:—in the east, as the "Sternberger Gestein," in Mecklenburg, near Magdeburg and Leipzig, round Cassel (in Hesse)‡, and near Osnabrück (Westphalia); in the west near Düsseldorf and near Crefeld; and I have found, very recently, that they also exist near Maestricht.

* In working at Brockenhurst with the assistance of Mr. Keeping, of Freshwater, I only saw crushed, indeterminable freshwater Shells; but Mr. Keeping and afterwards Mr. Edwards assured me that *the same species* were to be found at this locality as in the Lower Headon beds.

† "Ueber die Tertiär-Versteinerungen der Wilhelmshöhe bei Cassel." Programm der höheren Gewerb-Schule in Cassel für 1841–42.

‡ See Hamilton "On the Tertiary Formations of the North of Germany," Quart. Journ. Geol. Soc. vol. xi. p. 126.

Although there is no order of superposition to be seen, they must be divided into two parts, on account of the difference in the fauna of the different beds. The lower part contains a large number of species from the Système Tongrien and Système Rupélien, together with a number of new and very characteristic fossils—large Spatangides (*Echinolampas Kleinii* and others), *Pecten, Cythereæ*, &c., which pass over to the superior part, where small *Nassæ* make their first appearance, generally in large numbers. This genus does not exist in the older beds, but occurs generally in the rocks of the Miocene and Pliocene periods, and exists in the recent seas.

It is impossible at present to give comparative lists of fossils, because many of the species have not yet been described, or, if described, have been incorrectly determined; but no geologist who has studied these beds, as well as the underlying and overlying strata, can deny that they form, with the Systèmes Rupélien and Tongrien, a particular group, as different from the older as from the younger deposits. This fact has been fully recognized by Professor Beyrich, of Berlin, who proposed, many years ago, in a paper communicated to the Royal Academy of Berlin*, to establish for this group the name of Oligocene; and this name has been accepted wherever its upper member (Cassel, Osnabrück, &c.) is known. The London Clay and Lower London Tertiaries now form the Lower Eocene, the Bracklesham series the Middle, and the Barton Clay the Upper Eocene†. The Système Tongrien inférieur represents the Lower Oligocene, and the Système Rupélien the Middle Oligocene, to which it will be necessary, I suppose, to join the Belgian freshwater beds of the Système Tongrien supérieur.

The Lower Oligocene is well developed, with a true marine fauna, in Belgium, near Tongres (north of Liége), and in the North of Germany between Magdeburg, Bernburg, Aschersleben, Egeln, and Helmstädt (near Brunswick‡), and it contains above 700 species of Mollusca, besides a large number of Corals, Bryozoa, and Foraminifera, and several species of Fish-teeth and Echinodermata; and the most characteristic of these fossils have also been found at Brockenhurst. The fossils from this locality contained in Mr. Edwards's cabinet are the following (the asterisks in the different columns signify the presence of the different species in the respective beds):—

* "Ueber den Zusammenhang der norddeutschen Tertiärbildungen, zur Erlaüterung einer geologische Uebersichtskarte." Abhandl. der K. Akad. der Wissenschaften zu Berlin. Aus dem Jahre 1855, p. 1.

† The White Glasshouse-sand also belongs to this last division, because, at Hordwell, it contains many characteristic Barton fossils—*Oliva Branderi*, &c.

‡ As these fossiliferous beds (about 10 feet in thickness) are covered with beds of gravel and sand, sometimes more than 200 feet thick, and containing much water, it is impossible to dig pits for the mere purpose of obtaining the fossils. But below these beds there are seams of fossil wood, upwards of 150 feet in thickness, which are worked by numerous mines, and to this circumstance we are indebted for obtaining the fossils, which are found in a tolerable state of preservation only at the different mining-works which pass through the fossiliferous beds.

No.	Univalves.	Barton Clay.	Oligocene of Germany.	
			Lower.	Middle.
1.	Ancillaria buccinoides, *Lam.*	*	*	
2.	Aporrhaïs speciosa, *Schloth.*	....	*	*
3.	Cassis ambigua, *Sol.* (C. affinis, *Phil.*)	*	*	
4.	Cancellaria elongata, *Nyst*	....	*	
5.	C. evulsa, *Sol.*	*	*	*
6.	C. scabricula, *Edw. MS.*			
7.	Conus dormitor, *Sol.*, var. seminudus, *Edw.*			
8.	C. procerus, *Beyr.* (C. alatus, *Edw.*, var. hemibyssus)	....	*	
9.	Fusus labiatus, *Sow.*			
10.	F. longævus, *Lam.*	*		
	F. longævus, var. egregius, *Beyr.*	....	*	
11.	F. Sandbergeri, *Beyr.*	....	*	
12.	Infundibulum obliquum ?, *Sow.*	....	*	
13.	Leiostoma ovatum, *Beyr.*	....	*	
14.	Murex, n. sp.	....	*	
15.	Natica Hantoniensis, *Sow.*	*	*	
	N. Hantoniensis, var. obovata, *Sow.*	....	*	
16.	N. labellata, *Lam.*	*	*	*
17.	Pleurotoma bellula, *Phil.* (P. pyrgota, *Edw.*, pars)	....	*	
18.	P. cymæa, *Edw.*			
19.	P. denticula, *Bast.*	*	*	
20.	P. læviuscula, *Edw.*	....	*	
21.	P. subdenticulata, *Goldf.* (P. Hantoniensis, *Edw.*)	....	....	*
22.	P. transversaria, *Lam.* (*Edw.*)			
23.	Rostellaria ampla, *Sol.*	*	*	
24.	R. rimosa, *Sow.*	*		
25.	Strepsidura deserta, *Sol.* (Buccinum excavatum, *Beyr.*)	*	*	
	S. deserta, var. armata, *Sow.* (Buccinum bullatum, *Phil.*)	....	*	
26.	Voluta decora, *Beyr.* (V. maja, *Edw.*)	*	*	
27.	V. suturalis, *Nyst* (V. contabulata, *Edw.*)	....	*	
28.	V. spinosa, *Linn.*			
29.	Xenophora, n. sp. ?	....	*	
	Bivalves.			
30.	Anomia Alcestiana, *Nyst* (A. tenuistriata, *S. Wood*, pars, non *Desh.*)	....	*	
31.	Arca biangula, *Lam.*	*	*	
32.	A. duplicata, *Sow.* (A. sulcicostata, *Nyst*)	*	*	
33.	Cardita deltoidea, *Sow.*			
34.	C. orbicularis ?, *Goldf.*	....	*	
35.	Cardium Edwardsii ?, *Desh.*	....	*	
36.	C. porulosum, *Sol.*	*	*	
37.	Corbula cuspidata, *Sow.*	*	*	
38.	Cypricardia pectinifera, *Sow.*	*	*	
39.	Cyprina scutellaria, *Desh.* (*Nyst*)	....	*	
40.	Cytherea incrassata, *Sow.*	....	*	
41.	C. elegans ?, *Lam.*	*		
42.	C. Solandri, *Sow.*	*	*	
43.	Clavagella Goldfussii ?, *Phil.*	....	*	

No.	Bivalves—(*continued*).	Barton Clay.	Oligocene of Germany.	
			Lower.	Middle.
44.	Diplodonta dilatata?, *Sow*	*	*	
45.	Fistulana Heyseana?, *Phil.*	....	*	
46.	Isocardia transversa?, *Nyst*, var.	....	*	
47.	Lucina Menardii?, *Desh.*, var.	*		
48.	Modiola Nystii, *Kickx*	....	*	
49.	Nucula similis?, *Sow.*, var.	*	*	
50.	Ostrea ventilabrum, *Goldf.* (O. prona, *S. Wood*)	....	*	
51.	Panopæa corrugata?, *Sow.*	....	*	
52.	Pecten bellicostatus, *S. Wood*	....	*	
53.	Pholas, n. sp.			
54.	Psammobia compressa, *Sow.*	....	*	
55.	Tellina	?	*	
56.	Teredo antenautæ?, *Sow.*	?	*	

Of these 56 species, 43 exist in the Lower Oligocene of Germany, and 6 are peculiar to the English Brockenhurst and Headon beds; 21 of them are found also in the Upper Eocene, and 4 pass over to the Middle Oligocene of Germany; 23 of these species are characteristic Lower Oligocene species, which have been met with neither in the older nor in the younger beds, therefore there can be no doubt that the Brockenhurst beds, and with them the Headon series at Colwell Bay and Whitecliff Bay, belong to the Lower Oligocene.

The Middle Oligocene occupies a very great surface of the Continent: in France the "Sables de Fontainebleau" are well known; and the Mayence Basin is equally so, through the excellent work of Professor Sandberger. M. de Koninck many years ago, and M. Nyst more recently, have described the fossils of the Rupelmonde Clay of Belgium. The Rupelmonde Clay, or Clay with Septaria as it is called in Germany, is covered by the Upper Oligocene strata (yellow and green marls) round Cassel in Hesse, as Professor Beyrich has described in another paper read before the Royal Academy of Berlin*.

Proceeding eastward, we find numerous localities where Middle-Oligocene beds occur, sometimes superposed to the Lower Oligocene, as in the neighbourhood of Brunswick, Magdeburg, Cöthen, Berlin, and Freienwalde in Mecklenburg, and, last of all, north of Stettin, where they consist of several hundred feet of yellow ferruginous sands, with occasional layers of dark "Septarien-Thon." Generally the Middle Oligocene is developed as a dark bluish clay, possessing then a true marine fauna identical with that of Rupelmonde (south of Antwerp), and containing *Leda Deshayesii, Fusus multisulcatus*, Nyst, and *Pleurotomæ* as the most common fossils; this clay has always been considered as being the upper part of the Middle Oligocene, and is so in reality in Belgium, and generally in Germany.

In the Mayence Basin, the Rupelmonde Clay was discovered only a

* "Ueber die Stellung der Hessischen Tertiärbildungen." Bericht der K. Preuss. Akad. der Wissenschaften zu Berlin. Aus dem Jahre 1854, p. 640.

few years since by Mr. Weinkauff *; and Professor Sandberger considers the marine sand of Weinheim, &c., as the lower part, and the "clay with Septaria" as the upper part, of the Middle Oligocene, including all the freshwater beds in the Upper Oligocene. The marine sand of Weinheim he identifies with the "Sables de Fontainebleau" and some sandy beds at Neustadt-Magdeburg, and also with the upper (marine) beds of the Hempstead series. Now the fauna of the Neustadt-Magdeburg and Weinheim beds is somewhat different from that of the real "clay with Septaria" described by several authors, but in certain localities in the North of Germany, for instance near Söllingen (near Brunswick), beds with the same fauna as those near Magdeburg are seen in superposition to the clay with *Leda Deshayesii*. We are obliged, therefore, to consider the difference of these two faunas as caused only by a difference of conditions at the localities,—difference in the depth of the sea, &c., indicated too by the difference of the lithological structure,—and for this reason we cannot divide, generally, the Middle Oligocene into two periods.

Mr. Edwards, whose complete knowledge of the English Tertiaries abundantly qualifies him for the task, intends working out the identity of the Mayence and Belgian freshwater fossils with those of the Isle of Wight, and I have no doubt that he will find, besides the great number already considered identical, a still greater number common to the three localities. The freshwater beds of the Mayence Basin and of Belgium will therefore probably form part of the Middle Oligocene, as well as all the Hempstead series. It will be decided only then, where we are to place the Bembridge series and, with it, the Paris freshwater beds, which until now have been considered to belong to the Lower Oligocene.

One of the best reasons for accepting Professor Beyrich's "Oligocene" is, I think, that between each of his four periods there appear to have been great general changes over all Europe. The marine beds of the Eocene period in France and England are mostly succeeded by freshwater beds; sometimes the Oligocene beds do not exist at all, whereas they are the lowest Tertiary strata over all Germany, from Brunswick to Königsberg †. Miocene formations do not exist in England and in the North of France; in Belgium ‡ and in Northern Germany they occur very near the coast; but, on the other hand, beds of this age are very much developed in Poland, Hungary, Southern Germany, and the South of France, where the Oligocene is wanting. The Pliocene, again, is wanting in the last-named countries and in the North of Germany, while it skirts the coast in Belgium and France, and occurs also in England.

* See his paper "Septarien-Thon im Mainzer Becken." Neues Jahrb. 1860, p. 177; also "Ueber die tertiären Ablagerungen im Kreise Kreuznach." Zeitschrift der nat.-hist. Vereins der Preuss. Rheinlande und Westphalens. Jahrg. xvi., p. 65.

† Prof. Beyrich considers certain beds near Königsberg to be Lower Oligocene.

‡ About a twelvemonth ago I identified the Système Diestien of M. Dumont with the Miocene of the North of Germany. Typical species from the Superga near Turin, as *Oliva Dufresnei*, Bast., *Nassa flexuosa*, Brocchi, &c., exist there. The Système Bolderien is also identical with the Système Diestien.

2. *On the* Liassic Strata *of the* Neighbourhood *of* Belfast. By Ralph Tate, Esq., F.G.S. *With* Descriptions *of* New Species *of* Mollusca, &c.; *by* R. Etheridge, Esq., F.G.S., F.R.S.E.

Contents.

1. *Introduction.*—General Portlock, in his Geological Report on Londonderry, Tyrone, and Fermanagh (1843), was the first to direct attention to certain beds linking the Triassic and Liassic formations. In that Report he refers to the occurrence of beds at Colin Glen, Belfast, characterized by the same Shell (*Cardium striatulum*) as that which occurs in the Lisnagrib section (pp. 49, 56, 107).

It is now my purpose to describe in detail the strata thus referred to, and their extension to neighbouring localities.

Within the last few years the stratigraphical relations and the fauna of the Lower Liassic and *Avicula-contorta* series, as developed in England, have been made known by the labours of Dr. Wright* and Mr. Charles Moore†.

I trust the value of the present communication is enhanced by the attention I have given to the correlation of the Belfast beds with the members of the same epoch, as detailed in papers read before this Society, and referred to above.

The following members of the Liassic period are developed in the neighbourhood of Belfast, namely, the zone of *Ammonites Bucklandi*, the zone of the White Lias, and the zone of *Avicula contorta*; but before proceeding to the details of these formations, I shall give a short description of the geological features of the locality, rendered somewhat necessary by the peculiarities that here occur.

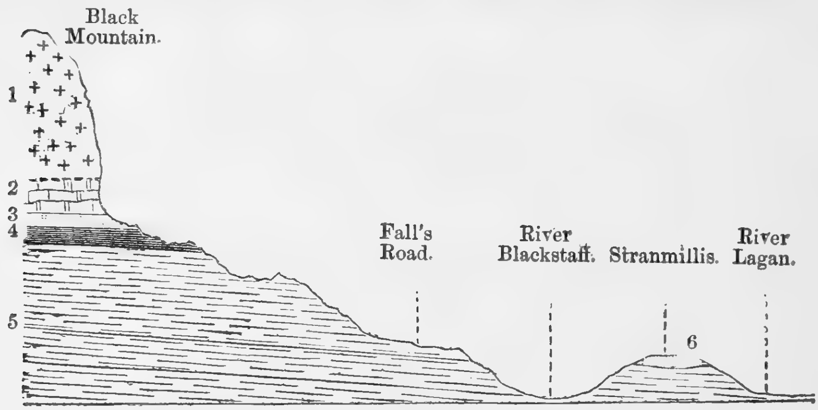
2. *General Geological Description.*—The neighbourhood of Belfast is divided by the Belfast Lough and the River Lagan into two naturally well-marked sections, both as regards the geological formations and its geographical relations:—the Northern Section is part of the county of Antrim, and the geological formations are Neozoic; the Southern Section is situated in the county of Down, where the formations are Palæozoic.

The Northern Section is occupied by the Belfast Hills range, the basis of which is the Keuper formation, presenting a steep incline, rising from the shore and the River Lagan to a maximum elevation of 650 feet. The New Red is surmounted by the Lias, Gault, Upper Greensand, Hard Chalk, and Basalt; forming a bold escarpment extending from Whitehead on the north-east to Lisburn, &c., on the south-west, with an average elevation of 1000 feet. Numerous trap-dykes intersect or cut through all the sedimentary rocks, and may be carried up into the overlying Basalt. The prevailing strike of the dykes varies between N.E. and N.W.

* See Quart. Journ. Geol. Soc. vol. xvi. p. 374, &c. † *Ibid.* vol. xvii. p. 483, &c.

The accompanying section exhibits the general geological features of the Belfast Hills.

Fig. 1.—*Section from the River Lagan to Black Mountain.*



1. Basalt.
2. Hard Chalk.
3. Greensand.
4. Lias.
5. Keuper.
6. Tertiary Sands.

3. *Zone of Avicula contorta.*—Sections of this formation have been examined in the escarpment of the Belfast Hills, extending from near Lisburn to Whitehead, a distance of 24 miles.

From Moira, 15 miles from Belfast, to Kilcorig, 9 miles south-west of Belfast, the *Avicula-contorta* beds are absent, the Hard Chalk lying directly upon the Keuper Marl.

In Colin Glen, 5 miles south-west of Belfast, the greatest development of the Liassic series occurs.

This locality is referred to by General Portlock in his Report, p. 107. Treating of the section at Lisnagrib, the beds of which are now identified with the *Avicula-contorta* zone, he says, "It may be remarked that the shaly bed containing *Cardium striatulum* [*C. Rhæticum*] is again found 40 miles distant in Colin Glen, near Belfast; but as yet the calcareous grit*, with the teeth and scales, has not been there discovered." It is very gratifying to me to be able to report the presence of these forms. From the following sections it will be observed that a fish-bed is a marked feature of this zone throughout the neighbourhood. In addition to the species observed by Portlock, I have found two others.

It is interesting to note the great variety of lithological characters that occurs in the Colin Glen Section of the Rhætic series.

* "The section at Lisnagrib principally consists of alternating beds of dark shale and calcareous grit."

Section of the Avicula-contorta *Zone in Colin Glen.*

No. of Bed.	Lithology.	Thickness.	Organic Remains.
	Zone of the White Lias resting on	ft. in.	
10	Black Shales	0 11	Axinus cloacinus, Avicula, Cardium Rhæticum, Placunopsis.
11	Argillaceous Limestone	0 5	
12	Black Shales	1 7	Pecten Valoniensis, Modiola, Avicula, Placunopsis alpina.
13	Marly Shales	1 3	Axinus cloacinus, Avicula contorta.
14	Blue Argillaceous Limestone	0 7	
15	Marly Shales	0 5	
16	Brown Argillaceous Limestone	0 6	
17	Black Shales	1 2½	
18	Micaceous Sandstone	0 1	
19	Soft Shales	0 9	
20	Argillaceous Limestone	0 0½	
21	Stiff Shales	1 9	Axinus cloacinus, Cardium Rhæticum, Avicula contorta.
22	Argillaceous Limestone	0 2	
23	Shales	0 6	
24	Soft Micaceous Sandstone	0 1	
25	Stiff Shales	0 8	Axinus cloacinus.
26	Compact Calcareous Sandstone	0 1	
27	Soft Shales	0 6	
28	Stiff Shales	0 5	Pecten Valoniensis, Cardium Rhæticum, Axinus cloacinus, Avicula contorta.
29	Compact Sandstone	0 2	
30	Black Shales	0 7	
31 to 34	Shales and Micaceous Sandstones	0 4	
35	Arenaceous Shales	0 2	Fish-bed.
36	Soft Shales	0 5	
37	Thinly laminated stiff Shales	0 5	Scattered Fish-remains, NaticaOppeli, Trochus Waltoni, & Avicula contorta.
38	Arenaceous Shales	4 6	
39	Stiff Black Clay	1 3	
	Blue Marls of the Keuper below	... ...	
		19 9	

Section of the Avicula-contorta *Zone at Cave Hill, three miles north of Belfast*

No. of Bed.	Lithology.	Thickness.	Organic Remains.
	White Lias resting on	ft. in.	
5	Black Shales	12 2	Axinus cloacinus and Avicula contorta.
6	Argillaceous Limestone	0 1½	
7	Shales	2 8	
8	Three bands of Argillaceous Limestones	0 2½	
9	Black Shales	0 10	Avicula contorta and Fish.
	Blue Marls of the Keuper below	... ...	
		16 0	

Section of the Avicula-contorta *Zone at Woodburn, ten miles north-east of Belfast.*

No. of Bed.	Lithology.	Thickness.	Organic Remains.
		ft. in.	
	Basalt, about	50 0	
	Breccia of crystalline limestone	2 0	
	Unseen	8 0	
1	Black Shales	0 6	Avicula contorta.
2	Argillaceous Limestone	0 6	Axinus cloacinus.
3	Black Shales	1 10	
4	Argillaceous Limestone	0 1	
5	Black Shales, thinly laminated and highly charged with red oxide of iron	10 6	Scattered Fish-remains, Avicula contorta.
	Grey Marls of the Keuper below	... ...	
		13 5	

The *Avicula-contorta* beds are thus separated at Woodburn by 10 feet from the Basalt, and 2 feet of this is composed of a breccia of granular saccharoid marble. The thickness of the *Avicula-contorta* series cannot therefore be more than the maximum thickness of this formation, as measured in Colin Glen.

Here all the beds superior to this zone have evidently been denuded since the deposition of the Cretaceous strata, but previous to the outpouring of the Basalt. At about $\frac{1}{4}$ of a mile in the direction of the dip of the beds the Upper Greensand attains its usual thickness; but the White Limestone (Hard Chalk) is only 20 feet thick. I find again the *Avicula-contorta* beds, with Micaceous Sandstones, resting on the Keuper Marls; and in close proximity the shales of the Rhætic series are completely porcellanized by the intrusion of a trap-dyke.

4. *Section at Whitehead,* 14 *miles north-east of Belfast.*—From the base of the Hard Chalk, the escarpment at Whitehead is occupied by an undercliff of slipped Triassic, Liassic, Gault, and Greensand rocks. In the railway-cutting through this undercliff the following section is seen. Little reliance can be placed on any further measurements, from the very disturbed nature of the slip.

Section of the Avicula-contorta *Zone at Whitehead.*

	ft.	in.
1. Argillaceous Limestone	0	3
2. Black Shales	3	0
3. Compact Shales with *Axinus cloacinus* and *Avicula contorta*	1	6
4. Argillaceous Limestone	0	$1\frac{1}{2}$
5. Black Shales	6	5
6. Argillaceous Limestone	0	1

		ft.	in.
7.	Black Shales	3	2
8.	Argillaceous Limestone	0	1
9.	Stiff calcareous Clay	0	8
10.	Black Shales with *Placunopsis alpina*, &c.	1	0
11.	Fish-bed	0	1
12.	Black Shale	1	7
13.	Soft micaceous Sandstone	0	3
14.	Black Shales	1	2
	Variegated Marls	...	...
		19	4½

The zone of *Avicula contorta* is thus represented in this neighbourhood by a succession of shales of variable thickness, alternating with argillaceous limestones varying from 1 inch to 6 inches in thickness, with some soft sandstones in the lower part. The maximum thickness attained being in Colin Glen, namely, 21 feet 6 inches.

In all the sections given, the *Avicula-contorta* beds are seen resting on the Keuper Marls. There is no gradation; the change is most marked—the red and blue marls presenting a striking contrast to the Black Shales above.

Fossils of the Avicula-contorta *Zone.*

No.	Species.	Localities.			
		Colin Glen.	Cave Hill.	Wood-burn.	White-head.
1	Ichthyosaurus, femur and teeth	*	......	*	
2	Gyrolepis Albertii, *Agass.*	*	*	*	*
3	—— tenuistriatus, *Agass.*	*			
4	Acrodus minimus, *Agass.*	*	......	*	*
5	Acrodus, n. sp.	*			
6	Saurichthys apicalis, *Agass.*	*	......	*	*
7	Hybodus minor, *Agass.*	*			
8	Natica Oppeli, *Moore*	*			
9	Trochus Waltoni, *Moore*	*			
10	Pecten Valoniensis, *Defrance*	*	*		
11	Axinus cloacinus, *Quenstedt*	*	*	*	*
12	Avicula contorta, *Portlock*	*	*	*	*
13	Cardium Rhæticum, *Merian*	*		*	*
14	Modiola minima, *Sow.*	*			
15	Placunopsis alpina, *Winkler*	*	......	......	*
16	Myophoria postera, *Bronn*	*			

5. *Zone of the White Lias.*—The beds have a close resemblance to the variegated marls of the Keuper; and, but for the well-marked succession and the presence of *Cardium Rhæticum*, one would be very much disposed to refer them to that period.

Section of the White Lias in Colin Glen (above the section on p. 105).

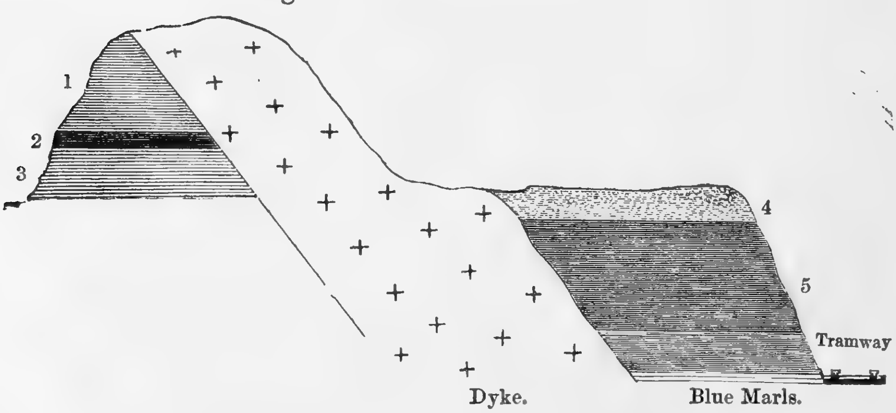
	ft.	in.
Lower Lias resting on		
5. Arenaceous Marls with *Cardium Rhæticum* ..	1	0
6. White Limestone	0	4
7. Grey Marls	6	0
8. Red Marls	9	0
9. Grey Arenaceous Shales, passing down into No. 10, with *Axinus cloacinus, Cardium Rhæticum, &c.*	10	0
	26	4

The section at Cave Hill is complicated by the intrusion of a large trap-dyke (see fig. 2). I have made out the following succession:—

Section of the White Lias at Cave Hill (above the section on p. 105).

	ft.	in.
1. Indurated Shales, fossiliferous	8	6
2. Indurated Shales, unfossiliferous	1	10
3. Indurated Marls, exhibiting an oolitic structure, which disappears 6 feet from dyke: no fossils	3	10
4. Unseen, about	(4	0)
5. Black Shales of Section, p. 105............		
	14	2

Fig. 2.—*Section at Cave Hill.*



[For the Explanation of the figures see above.]

At some distance from the above section the following beds, in descending order, appear as resting upon the same dyke:—

1. Gault.

---

	ft.	in.
2. Marly Shales with the fossils of No. 1 in the previous section	8	10
3. Micaceous Sandstone	0	2

		ft.	in.
4.	Blue marly Shales with *Cardium Rhœticum*	1	0
5.	Indurated Shales..........................	1	3
6.	Indurated Shales of brick-red colour, with *Modiola minima*	1	0
	Basaltic dyke.		
		12	3

The value of this section, imperfect as it is, is not to be underrated; for its fossil contents, as well as the relations of the beds, indicate a newer horizon than that of the *Avicula-contorta* series.

I have here to acknowledge the assistance rendered me by Mr. Charles Moore in the examination of fossils, especially from this locality, and also for some valuable suggestions that have determined me in referring the beds of this section, with their equivalents of the Colin Glen Section, detailed at p. 108, to the White Lias.

The only other locality in which I have seen the White Lias is at Waterloo, Larne. There, grey marls, with disseminated calcareous particles, presenting an oolitic structure*, appear below true Lower Lias, and surmounting black shales with *Avicula contorta.*

List of Fossils of the White Lias.

Chemnitzia (cast).
Ostrea liassica, *Strickland.*
Cardium Rhæticum, *Merian.*
Modiola minima, *Sow.*
Myacites (casts of two sp.).
Cardinia (cast).
Monotis decussata, *Goldfuss.*
Axinus concentricus ?, *Moore.*
—— cloacinus, *Quenstedt.*
Arca Lycetti ?, *Moore.*

They have all been obtained from Bed No. 1 of the Cave Hill Section. Of these, *Cardium Rhœticum, Axinus cloacinus,* and *Modiola minima* are common to the White Lias and the *Avicula-contorta* zone.

6. *Zone of the Lower Lias, with* Ammonites intermedius, *the equivalent to* A.-Bucklandi *zone.*—The Lower Lias is absent from many localities in the neighbourhood of Belfast. It occurs resting on the White Lias at Colin Glen, and consists of the following beds (underlying the Gault):—

		ft.	in.
1.	Black shales, unfossiliferous..................	16	0
2.	Highly calcareous marls with *Lima gigantea* and *Ammonites intermedius*	1	0
3.	Marls and shales with Echinus-spines and *Modiola minima* ?	17	0
	(Trap-dyke 2 feet.)		
4.	Alternations of shelly limestones with *Ostrea liassica* ? and *Modiola minima*	4	3
5.	White Lias	..	..
		38	3

* Have these beds been mistaken for true Oolite, which is said to occur in this neighbourhood ?

The Beds Nos. 3 and 4 of the above section doubtfully belong to the Lower Lias, and perhaps should be referred to the White Lias. Up to the present time only the species mentioned above have been found in them; and as these occur also in the Lower Lias, the evidence they afford is not of a positive character.

The fossils of Bed No. 2 are but few in number; they, however, occur with others on the shores of Larne Lough. There the most characteristic fossil is *Ammonites intermedius*. The species associated with it are those that characterize the zone of *Ammonites Bucklandi* of Gloucestershire. This Ammonite is here replaced by *A. intermedius* (Portlock).

List of Fossils from the Lower Lias.

[Those with the prefix *C.* occur in Colin Glen.]

Vertebræ of Ichthyosaurus.
C. Ammonites intermedius, *Portl.*
—— Turneri, *Sow.*
—— angulatus, *Schloth.*
Nautilus striatus, *Sow.*
Cerithium, sp.
Chemnitzia Blainvillei, *Münst.*
—— septemcincta, *Münst.*
——, sp.
Dentalium minimum, *Strickland.*
Pleurotomaria Anglica, *Sow.*
—— expansa, *Sow.*
Tornatella fragilis, *Dunk.*
Turbo paludinarius, *Münst.*
—— elegans, *Münst.*
C. Avicula inæquivalvis?
Astarte dentilabrum, n. sp.
Cardinia Listeri, *Stutchb.*
C. —— ovalis, *Stutchb.*
Cardium truncatum, *Sow.*
Ceromya gibbosa, n. sp.
Corbis uniformis, *Phil.*
Cucullæa psilonoti, *Quenst.*
Goniomya rhombifera, *Goldf.*
C. Gryphæa incurva, *Sow.*
C. Leda rostralis, *Goldf.*
C. Lima acuticosta, *Goldf.*
—— antiquata, *Sow.*
C. Lima gigantea, *Sow.*
C. —— Hermanni, *Voltz.*
—— pectiniformis, *Schloth.*
C. —— punctata, *Sow.*
C. Modiola cuneata, *Sow.*
C. —— minima, *Sow.*
—— Hillana, *Sow.*
Nucula variabilis (?), *Sow.*
Ostrea arietis, *Quenst.*
C. —— irregularis, *Münst.*
Pecten textorius, *Schloth.*
—— calvus, *Goldf.*
C. Pleuromya unioides, *Agass.*
Perna infraliassica, *Quenst.*
Pholadomya glabra, *Agass.*
Plicatula spinosa, *Sow.*
Unicardium cardioides, *Phil.*
Orbicula reflexa, *Sow.*
Lingula Beani, *Phil.*
Terebratula punctata, *Sow.*
Pollicipes liassicus, n. sp.
Serpula socialis, *Goldf.*
—— raricostata?, *Quenst.*
Cidaris Edwardsii, *Wr.*
C. Hemipedina, sp.
Pentacrinus tuberculatus, *Mill.*
Montlivaltia Haimei, *Chapuis et Dewalque.*

This list contains several species which are more especially characteristic of higher zones; many of these, however, are rare. The more common species are:—

Ammonites intermedius, Dentalium minimum, Chemnitzia septemcincta, Cardinia ovalis, Corbis uniformis, Gryphæa incurva, Lima gigantea, Ostrea irregularis, Cucullæa psilonoti, Unicardium cardioides, Pentacrinus tuberculatus, Cidaris Edwardsii.

7. *Distribution of the Liassic Rocks in the North of Ireland.*—The presence of the Lower Lias, and to some extent its thickness, are dependent on the amount of denudation before the deposition of the overlying Cretaceous strata, or, in some cases, to denudation subsequent to their deposition. This formation I have traced on the south

of the co. Antrim from Colin Glen to Whitehead, also on the Carrickfergus Commons, and on the shores of Lough Morne; on the east, around the shores of Larne Lough and on the east coast of Island Magee, Larne, Glenarm, and Garron Point; on the north, at Ballintoy and Portrush; and in the co. Londonderry, at Magilligan, on the N.E., Aghanloo, and Lisnagrib; so that it occupies a considerable area in the N.E. of Ireland. The last two localities are mentioned by Portlock.

The zone of the White Lias and the *Avicula-contorta* beds probably occur in all cases below the Lower Lias, or even where a limited amount of denudation has occurred, removing only the superincumbent beds. The White Lias has been observed at Colin Glen, Cave Hill, and Larne.

The *Avicula-contorta* zone I have traced from Colin Glen to Whitehead and Larne; at Lisnagrib and Derrymore it was observed by Portlock.

Notes on Species.

Dentalium minimum, Strickland.

This minute *Dentalium* was first described, but not figured, by Portlock (Geol. Report, Londonderry, 1843) as *D. tenue*, a specific name preoccupied by a *Dentalium* figured by Goldfuss, to which species Portlock's shell is not referable.

Strickland, in the 'Geology of Cheltenham' (1845, p. 101), describes, without a figure, the same species from the Lower Lias of Cracombe as *D. minimum*.

D. minimum I have found pretty frequently on the west shore of Island Magee, co. Antrim. I have also obtained it in great abundance in the Lower Lias clay-pits off the Leckhampton Road, Cheltenham. The Irish examples are less curved and elongated and more slender than the Cheltenham forms.

Montlivaltia Haimei, Chapuis et Dewalque, Mém. Cour. par l'Acad. Roy. Belg. t. xxv. p. 265, pl. 38. fig. 5, 1854.

This Coral, new to British palæontology, has been determined by Dr. P. M. Duncan.

It was called *Cyclolites granulatus* by Quenstedt, Handb. der Petref. p. 658, pl. 59. fig. 21, 1862; but it is not the *Montlivaltia granulata* of Edwards and Haime, 1851, which is from the St. Cassian Beds, and which was originally described as *Cyathophyllum granulatum* by Münster, 1841, and afterwards as *Thecophyllia granulata* by D'Orbigny in 1850.

Montlivaltia Haimei occurs at Jamoigne, in the Belgian Lower Lias.

I have found it not unfrequently on the east shore of Larne Lough, also at Waterloo, Larne; and it has also been found by my friend Mr. Gray between Larne and Ballylig, on the west shore of Larne Lough. Specimens in the Belfast Museum are labelled Ballintoy, on the north coast of Antrim. It thus appears to be a somewhat widely distributed and not uncommon Coral.

Descriptions of New Species *of* Mollusca, *&c.* By R. Etheridge, Esq., F.G.S., F.R.S.E.

Ceromya gibbosa, Etheridge.

Shell ventricose, deep, especially at the umbonal region, or above the position of the oral and anal adductors. Umbones small, nearly central or subterminal, slightly curved or involute, leaving a wide and exposed lunular region. Anterior side produced, rounded, and gaping. Posterior side, during life, apparently closed, attenuated, slightly truncate. Ventral margin much produced, giving the shell a nearly circular appearance.

The umbonal region of this shell is strongly marked by concentric ridges or lines of growth, which rapidly disappear with age, and finally pass into well-defined but fine or closely arranged concentric striæ. Beneath the outer shell, which is thin and papyraceous, are longitudinal or highly inclined slightly impressed ribs; these are shown on the exposed surface of the right valve near the ventral margin. These lines, from their direction, do not come directly from the limb, but apparently from about the middle of the posterior region of the dorsal side or surface.

Dimensions.—Height $1\frac{7}{10}$ inch, depth $1\frac{3}{10}$ inch, length $2\frac{1}{10}$ inches.

Affinities and Differences.—This shell in general outline resembles *C. latior*, Ag., from the Inferior Oolite beds of Longuy (Luxembourg); but the postero-dorsal margin being much more elevated, and the ventral margin much more produced or rounded, indeed nearly circular, quite distinguish *C. gibbosa* from *C. latior*; added to this, the finely engraved concentric lines on the ventral portion of the outer shell, which so rapidly change their character from those of the strongly marked and elevated lines of growth near the umbo, distinguish it from any known species. The deeper-seated vertical ribs on the sides (beneath the outer shell), which appear to be directed obliquely or excentrically from the umbones towards the ventral margin, although resembling certain species from the Inferior Oolite, are nevertheless quite distinct.

On the posterior side of the umbo, near the escutcheon, there is a singular growth or expansion of the shell passing from the right valve, which overlaps the edges of both valves, quite obliterating the line of union over the corselet. This does not appear to be accidental, but part of the shell-structure, and is exhibited in the two specimens known.

Locality.—Discovered by Mr. William Gray on the east shore of Larne Lough.

Astarte dentilabrum, Etheridge.*

Shell massive, ovate, and deep. Postero-dorsal surface rounded. Posterior end slightly truncate from about the position of the anal adductor to the ventral margin or border. Anterior margin acutely rounded. Umbones small, indistinct, subcentral, slightly curved anteriorly. Lunule slightly excavated, small, oval, and attenuated, occupying half the area between the umbo and the commencement of *the antero-ventral margin. Border angular; costæ concentrically arranged, and coincident with the form or contour of the shell. Ventral margin of each valve strongly denticulate, each having a row of strongly defined teeth or serrations, those upon the anterior side being most numerous. The teeth occupying the centre of the margin are more closely arranged and more deeply set than the lateral ones; the whole are inclined inwards, giving the periphery or edge of the shell a bevelled appearance—a marked feature in the shell.*

Affinities and Differences.—This remarkable shell somewhat resembles *A. subtetragona* from the Upper Lias of Luxembourg, in the "Schiste et Marne de Grand-Cour," but its form is more tumid and much deeper, the shell is more massive, and the lines of growth are not so well defined; and no mention is made in the description of that shell of the characteristic and specific character of the dentated

Figs. 3–7.—*Fossil Shells from the Lias near Belfast.*

Fig. 3.

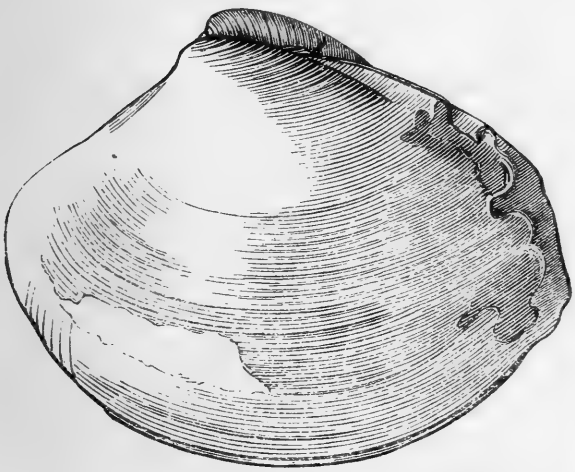


Fig. 4.

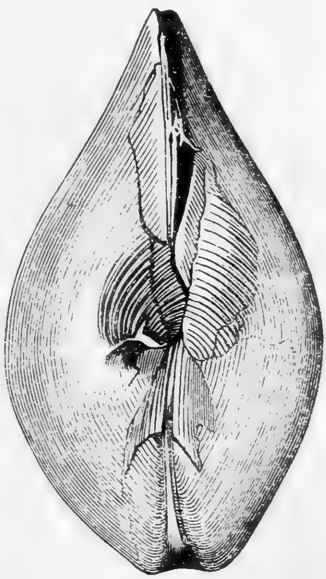


Fig. 5.

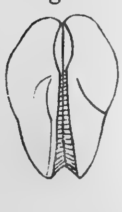
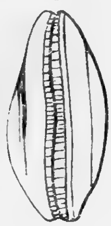


Fig. 6.

Fig. 7.



Figs. 3 & 4.—*Ceromya gibbosa.* Natural size.
Figs. 5 to 7.—*Astarte dentilabrum.* Natural size.

edges of the margin of the two valves. It differs from *A. ovata* of the Kimmeridge Clay in its more obtuse umbo and more angular lunular ridges; and although *A. ovata* is strongly dentated along the margin, still the dentations are bead-like in the Kimmeridge Clay species, and columnar and massive in *A. dentilabrum* from the Lower Lias: both are equally massive in shell-structure.

Dimensions.—Length $\frac{11}{12}$ inch, height $\frac{8}{12}$ inch, depth $\frac{5}{12}$ inch.

Locality.—Discovered by Mr. Tate in some abundance, associated with *Cardinia ovalis*, on the east shore of Larne Lough.

POLLICIPES LIASSICUS, Etheridge.

This single valve or scutum of *Pollicipes* is, I believe, the oldest known; at least, none have been described from beds older than the Great Oolite. It is an interesting form; but a specific description, or the statement of any affinities based upon a single valve, and that one of the most variable of the elements of the test of the Cirripedia, would be premature. The characters shown in this single valve (scutum) determine it to be a new species; I therefore venture to name it *P. liassicus*.

A single valve from the east shore of Larne Lough, found by Mr. Tate. [R. E.]

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3. *Notes on the* DEVONIAN ROCKS *of the* BOSPHORUS. By W. R. SWAN, Esq.

[In a letter to Sir R. I. Murchison, K.C.B., F.R.S., F.G.S.]

THE strata of the Bosphorus consist, for the most part, of grey, green, brown, and yellowish argillaceous shales, schists, and sandstones, more or less micaceous, with occasional beds of grey argillaceous limestones, in part subcrystalline and generally concretionary. The strike of the strata varies: in some parts it is about due north and south, in others about north-east and south-west; the full rise being from east varying to south-east, that is, into Asia Minor.

The eruptive rocks (not including the Trachytic rocks on both sides of the Bosphorus at the entrance into the Black Sea, and as far down as nearly to Buyukderé) are greenstones of the hornblendic character, varying from fine-grained to coarse and porphyritic, and in many parts much decomposed; they occur as dykes and large bosses, and are in such abundance that the strata are greatly broken up and disordered, and in parts so altered by heat as to become subcrystalline, with imperfect slaty cleavage. In consequence there is scarcely a good building-stone to be found around Constantinople, with the exception of the limestones, and they are, after all, none of the best, and too expensive to dress to constitute a stone for general purposes. The larger eruptions of trap, or bosses, are to be found at several of the prominent points of the Bosphorus, such as Kandili Point, Roumili Hissar Point, &c., and may possibly have had something to do with the forming of this far-famed channel.

I shall now attempt to give a description of the fossils of the Bosphorus, first premising that as the means of comparison with the fauna of other countries at my disposal have been very limited, and confined to only a few works on geology, I shall not attempt to give the name of each fossil, but simply confine myself at present to a description of the species found; the fossils also in general are in such a broken and decomposed state that it is next to impossible to recognize many of them. And, firstly, I have not been able to detect Graptolites on either side of the Bosphorus; nor any Cephalopoda, excepting some few imperfect casts not recognizable as to species, and one small shell as yet undescribed, but probably either a *Goniatites* or *Clymenia*: it occurred in grey shale to the north-west of Roumili Hissar (the furthest point west in which I have detected fossils), and was associated with several Spirifers, both broad-winged and small species, *Orthis* and other Brachiopods, together with a *Homalonotus* and other Trilobites, and Corals of the genus *Favosites*. Immediately on both sides of the Bosphorus, the beds of grey shale are replete with fossils, the most characteristic being: of Brachiopoda, several species of Spirifers, both *broad-winged* and small, with *Orthis* several species, *Strophomena* and *Leptæna* several species, *Atrypa*, &c.; of Trilobites, species of the genera *Phacops* and *Homalonotus*, and others as yet undescribed; also a small Crustacean, probably a *Beyrichia*, is highly characteristic of these strata*. Along with these are associated at least two species of the peculiar Coral, *Pleurodictyum problematicum*. Other Corals are almost wanting in these beds, but I have detected a few belonging to the genus *Favosites*. Stems of Encrinites are in abundance in some of the beds, with some stellate forms, which I was inclined at one time to consider as Star-fish. The limestones, with rare exceptions, are destitute of fossils, and likewise the brown-satiny and yellowish shales; the green and greyish shales appearing to have been most favourable to the existence of animal life.

Taking the above fossils as a criterion of the strata of the Bosphorus, imperfectly as I have described them, it is evident that they are not of Silurian age; and the absence of Graptolites and Cephalopoda, so abundant in Silurian strata, and other characteristic forms of that period, confirms this opinion in a high degree, and I should at once place these strata on a level with the Lower Devonian of the Rhine, the "Spirifer-sandstone" of Sandberger, and probably with those of Plymouth and Ogwell in the south-west of England.

I had also an opportunity lately of examining the strata along the north coast of the Sea of Marmora; and at a point about thirteen miles to the east from Scutari, I detected the broad-winged Spirifers, with *Orthis*, *Strophomena*, and a *Phacops*, in grey limestone and sandy shales, along with a fossil which I believe to be a *Calceola*; the specimen, however, is too imperfect for me to determine.

The strata in this district crop out towards the south-west to about south, and demonstrate that, by a change of the dip between these points and the Bosphorus, these strata may be in the ascending order to those in that neighbourhood. I may mention also that between these points the strata are much intercalated with quartzose rocks, and to such an extent that the large alluvial plains between Scutari and Ismidt seem to be composed entirely of quartz-conglomerate, at least wherever a section of the strata is exposed to view.

* See Rœmer's figure of *Beyrichia* and other fossils from the Bosphorus; Neues Jahrbuch, 1863, p. 521, pl. 5.—Ed.

December 16, 1863.

Andrew Leith Adams, M.D., Surgeon 22nd Regiment, Malta; J. M. Hozier, Esq., Lieutenant 2nd Life-Guards, Staff-College, Sandhurst; and J. F. Iselin, Esq., M.A., Inspector of Science-Schools, were elected Fellows.

The following communications were read:—

1. *On the* Pebble-bed *of* Budleigh Salterton. By W. Vicary, Esq., F.G.S. *With a* Note *on the* Fossils; by J. W. Salter, Esq., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

The south coast of Devonshire from Petit Tor, near Babbacombe Bay, to a little beyond Sidmouth, exhibits cliffs of New Red Sandstone, one of the beds of which, near Budleigh Salterton, is composed of pebbles of all sizes and of a flattened oval form; this bed attains a maximum thickness of about 100 feet, and some of the pebbles composing it were found by Mr. Vicary to contain peculiar fossils.

Mr. Vicary gave a description of the physical features of the area over which the pebble-bed extends, and entered into the stratigraphical details of this and the associated strata, referring to Mr. Salter's Note for information upon the affinities of the fossils.

In his Note, Mr. Salter observed that, on comparing the fossils of the Budleigh-Salterton pebbles with those from the Caen sandstone in the Society's Museum, he found that all the species contained in the latter collection were also represented in the former. The general aspect of the fossils was stated to be quite unlike that exhibited by English Lower Silurian collections; and Mr. Salter therefore suggested that the exact equivalent of the Caen sandstone does not exist in England. This difference in the two faunas appeared to him to favour the theory of the former existence of a barrier between the middle and northern European regions during the Silurian period.

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2. Experimental Researches *on the* Granites *of* Ireland.—Part IV. *On the* Granites *and* Syenites *of* Donegal, *with some remarks on those of* Scotland *and* Sweden. By the Rev. Samuel Haughton, M.D., F.R.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

The author discussed in detail the mineralogical composition of each of the fifteen Donegal granites, and described the method usually employed by him in solving lithologico-chemical problems, coming to the conclusion that nearly half of these granites are not composed altogether of the four minerals (Quartz, Orthoclase, Oligoclase, and Black Mica) which are found in them in distinct crystals, and that

the remaining varieties, even if they be composed of these minerals, must have a paste composed of the same minerals, but with a slightly different composition. Prof. Haughton then discussed the composition of the syenites of Donegal, and instituted a comparison between the granites of that district and those of Scotland and Sweden, remarking that those of the last-named region have the same stratified structure as the granites of Donegal.

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3. *On the recent* Earthquake *at* Manila. By J. W. Farren, Esq.

[Communicated by the Foreign Office.]

(Abstract.)

In two letters to Earl Russell the author described the damage done by this earthquake, observing that 289 persons were killed, and a large number more or less injured.

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4. *Extracts from* Letters *relating to the* further discovery *of* Fossil Teeth *and* Bones *of* Reptiles *in* Central India. By the late Rev. S. Hislop.

[Communicated by Prof. T. Rupert Jones, F.G.S.]

[The publication of this paper is unavoidably postponed.]

(Abstract.)

The remains alluded to consist of (1) a series of Reptilian bones, some bearing teeth, mostly Labyrinthodont, and some probably Dicynodont, from the (Triassic ?) red clay of Maledi, in which teeth of *Ceratodus* occur; and (2) several teeth similar to one from the Eocene clays of Takli, near Nagpore, and another like a conical tooth from the Eocene beds (with *Physa Prinsepii*) of Physura, from the same neighbourhood as that in which the set No. 1 was found.

At Phísdura (Tertiary) large Reptilian bones (including a femur 1 foot across at the condyles, and a vertebral centrum 7 inches across) have been found associated with large coprolites, *Physa Prinsepii*, and *Paludina Deccanensis*.

Major Gowan's discovery of a Labyrinthodont at the base of the Mahadewa Hills was also noticed by Mr. Hislop.

Mr. Hislop stated his belief that the Mangali beds, the Korhadi shales, and the red clay of Maledi should be placed above the plant-bearing beds of Nagpore instead of below them as heretofore supposed.

JANUARY 6, 1864.

Nelson Boyd, Esq., Mining Engineer, 2 Great George Street, Westminster; Henry Hakewill, Esq., C.E., 38 Harrington Square, London; John Robinson M'Clean, Esq., V.P.Inst.C.E., 23 Great George Street, Westminster; and the Rev. Frederick Silver, M.A. (Oxon), F.R.A.S., Norton-in-Hales, Salop, were elected Fellows.

M. Charles Gaudin, of Berne; Bergmeister Gümbel, of Munich; Dr. Steenstrup, of Copenhagen; M. Paul Gervais, of Montpellier; Dr. George F. Jäger, of Stuttgart; Dr. A. Oppel, of Munich; Dr. Hitchcock, Sen., of Amherst; M. E. Desor, of Neufchatel; and Dr. T. Kjerulf, of Christiania, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* RECENT GEOLOGICAL CHANGES *in* SOMERSET, *and their* DATE *relatively to the* EXISTENCE *of* MAN *and of certain of the* EXTINCT MAMMALIA. By G. S. POOLE, Esq.

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

(Abstract.)

COMMENCING with a description of the country between Clevedon and Taunton, the author stated that the district consisted of three basins, known as the "North Marsh," the "South Marsh," and the "Bridgwater Level," and drained by the River Yeo, the Rivers Axe and Brue, and the River Parrett, respectively. This district, which is composed of alluvium near the coast, with peat-mosses further inland, would be subject to occasional inundations by the sea, were it not protected by a line of embankments, composed of masonry at the most exposed points, but elsewhere of earth, slightly constructed, but of immense extent. These embankments were considered by Mr. Poole to have been made by the Romans for the purpose of a double defence—against the sea and against the natives.

In the whole of the district under consideration the surface of the land dips away from the sea and from the rivers; and as the land slopes, so the thickness of the alluvium decreases, until at last it ceases altogether, when the surface is composed of peat-moors, or "turbaries" as they are locally termed. These turbaries are of two kinds,—the peat of one kind, occurring in Bridgwater Level, being a black vegetable mould with little or no coherence, and easily convertible into good pasture or arable land; that of the other, on the contrary, making a good fuel.

In the middle of the South Marsh and in the Bridgwater Level are extensive sand-banks, in which marine Shells occur.

Mr. Poole then endeavoured to show that the district above described has been subject to considerable changes of level in recent geological periods, giving data towards the elucidation of the question of the extent of such changes; also that Man existed in the district prior to the last of these changes, and that some of the extinct Mammalia have existed there since that event.

Respecting the first-named hypothesis, the author described the submarine forests in Bridgwater Bay, referring frequently to the description of them by Mr. Horner*, and noticing especially the occurrence of trunks of trees in the sand-banks and adjoining turbary of Westhay and Burtle, stating, however, that he believed these were found in the lower beds of the turbary, which is supposed to have formed part of the surface on which these forests grew, and to be continuous with the turbaries of the basins of the Brue and the Parrett, as the peat is found throughout the district, and the upper layers aré supposed to have been formed since the trees were deposited.

An excavation made in 1826, at Huntworth, near Bridgwater, on the banks of the Parrett, exposed the following section, which was noted by the late Mr. Baker, of Bridgwater:—

	feet.
Silt	16
Peat in two strata of irregular thickness; with Shells, Bones, horns of Deer, and Wood. Upper stratum coarse, and containing freshwater and marine Shells. Lower stratum fine, containing a great number of freshwater Shells only. Compressed Alder-branches, showing the silvery bark very distinctly	1
Soft silt	9
Gravel, like that resting on the marl at Bridgwater, and containing Shells, Pottery, and bones of Horse, Ox, and Deer, all, like the gravel, of a dark colour	1
Blue clay, penetrated by roots and rootlets of Plants	2
Red marl 29 feet below the surface, which was a little below the level of the highest spring-tides	..
	29

A letter from the late Mr. Anstice to Dr. Buckland, dated November 24, 1826, was next given; it contained a description of the strata passed through in making the excavation at Huntworth, similar to that given above; but, in enumerating the bones found in the gravel, to those already mentioned are added bones of the Dog or the Fox, and of the Porpoise, together with a human femur, ilium, radius, and humerus; and it is stated that the pottery must have been made by hand without the assistance of a lathe.

About twenty years ago another excavation was made less than a mile from the one just described, when the following section was exposed:—

	ft.	in.
Soft silt	7	9
Gravel	1	0
Firm silt	6	0
Peat	1	6
Soft silt	4	0
Running sand	3	0
Red marl	..	..
	23	3

* Trans. Geol. Soc., 1st Series, vol. iii. p. 380.

In the two sections the strata are nearly the same, the peat being at the same level in each, but a little thicker in that just given.

The occurrence of roots of Plants in the blue clay of the Huntworth section, and the existence of a stratum of peat in both, were considered by the author to be good evidence of two former land-surfaces, and, therefore, to indicate two successive subsidences. If this be so, it proves the author's second conclusion, namely, that Man existed in the district prior to the last subsidence, pottery and human bones having been found, as just stated, 28 or 29 feet below the surface.

The third point which Mr. Poole endeavoured to establish was then discussed, namely, that since the last subsidence, and, consequently, long since the human bones and the pottery were deposited below the stratum of peat, some of the large Mammalia, now extinct, were inhabitants of the district.

The coast at St. Audries is bounded at high water by a Lias-cliff some 40 or 50 feet high; and, from the foot of the cliffs, there run out seaward several parallel reefs of Lias, with their northern edges tilted up, the spaces between the tilted edges being filled with a deposit of clay and gravel, and, on the top of this, with coarse pebbles or shingle. In the deposit between two of these reefs, the tusks and teeth of *Elephas primigenius* were found; but originally the whole skull was there, having been seen by Mr. Webb protruding through the shingle. The small and large end of the tusks are decayed and gone; at the smaller end they are about 4 inches in diameter, and at the larger 8. They are about 4 feet 6 inches long, but were probably much longer, and they have so considerable a curve that they form almost a semicircle. There can be no doubt that this deposit of clay, gravel, and shingle has been made since the subsidence of the submarine forest lying east and west of this spot.

Mr. Baker mentions* that the lower part of the humerus of a young Mammoth had been found at Chedzoy, one of the sand-banks in the Bridgwater Level; and the Rev. W. A. Jones, in the same Journal, narrates the finding of several bones of a young Rhinoceros in the alluvium at Taunton, considered by Professor Quekett to be *R. tichorhinus*, both of which series of bones, as well as the deposits in which they occur (the sand-bank and the alluvium), the author considered of later date than the submerged peat.

Mr. Poole concluded with certain speculations respecting the date of the last subsidence relatively to the historic period, basing his argument upon the occurrence of Roman coins at Burnham, 4 feet below the surface, and endeavouring to calculate the length of time required for the formation of that thickness of alluvium, thus coming to the conclusion that the date of the last subsidence was about 800 B.C. Finally, he alluded to the discovery of a piece of gold Phœnician ring-money at Bridgwater, 7 feet below the surface, and made some observations upon the probable extent of surface affected by the last submergence.

* Trans. Somerset. Arch. Soc. vol. i. p. 136.

2. *On the* STRUCTURE *of the* RED CRAG *in* SUFFOLK *and* ESSEX. By SEARLES V. WOOD, jun., Esq.

[Communicated by Searles V. Wood, Esq., F.G.S.]

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

(Abstract.)

BY reference to a tabulated description of about fifty sections taken from various parts of the Red-crag area, the author showed that the deposit is structurally divisible into five stages, of which the 1st, 2nd, 3rd, and 4th (counting upwards) were not deposited under water; but from their being regularly laminated, at angles varying between 25° and 35°, and possessing (with the exception of the 2nd) an unvarying direction in every stage, he regards them as the result of a process of "beaching up," by which was formed a reef extending from the river Alde on the north to the southern extremity of the deposit in Essex. Of these four stages, the 4th is the most constant and important,—the 1st, 2nd, and 3rd being frequently either concealed by the succeeding stages, or having been destroyed during their formation. At Walton-on-Naze alone do any of the four lower stages contain evidence of being a subaqueous deposit; there the 1st stage is so, but it is covered by two reef-stages, and these again by the 5th stage.

The 5th stage is invariably horizontal, and contains evidence of having been formed under water. This stage is developed in such a way as to show that it was formed in channels eroded in the older reef, and it is at its base that the coprolite-workings occur. This stage also passes up at Chillesford into the sands and gravels, termed by the author the Lower Drift, which underlie the boulder-clay; at other places a line of erosion exists between the 5th stage and the drift-sands.

JANUARY 20, 1864.

John Sidney Crossley, Esq., M.Inst.C.E., The Field, Litchurch, Derby; The Rev. Henry Housman, Northall, near Dunstable; Colin Wilson Macrae, Esq., Oriental Club, 18 Hanover Square; William Roby Barr, Esq., Norris Bank, Stockport; E. J. Routh, Esq., M.A., Fellow of St. John's College, Cambridge, St. Peter's College; George St. Clair, Esq., Holford House, Regent's Park, N.W.; John Benjamin Stone, Esq., Holly Villa, Sutton Street, Aston, near Birmingham; and Mutu Coomàra Swamy, Esq., Member of H.M. Legislative Council of Ceylon, Athenæum Club, Pall Mall, were elected Fellows.

Il Cavaliere Paolo Savi, Professor of Geology in the University of Pisa, was elected a Foreign Member.

The following communications were read:—

1. *Observations on* SUPPOSED GLACIAL DRIFT *in the* LABRADOR PENINSULA, WESTERN CANADA, *and on the* SOUTH BRANCH *of the* SASKATCHEWAN. By HENRY YOULE HIND, Esq., M.A., F.R.G.S., Professor of Geology in Trinity College, Toronto.

(Communicated by the President.)

CONTENTS.

§ 1. *The Boulders on the flanks of the Table-land of the Labrador Peninsula.*

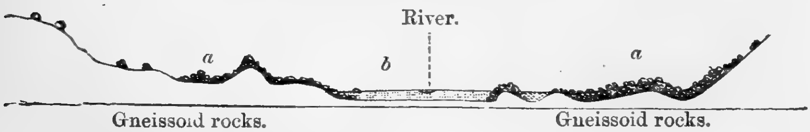
DURING an exploration of a part of the interior of the Labrador Peninsula in 1861, I had an opportunity of observing the extraordinary number, magnitude, and distribution of the erratics in the valley of the Moisie River and some of its tributaries, as far north as the south edge of the table-land of the Labrador Peninsula (lat. 51° 50′ N., long. 66° W.), and about 110 miles due north of the Gulf of St. Lawrence. Boulders of large dimensions, 10 to 20 feet in diameter, began to be numerous at the Mountain Portage, 1460 feet above the sea, and 60 miles in an air-line from the mouth of the Moisie River. They were perched upon the summits of peaks estimated to be 1500 feet above the point of view, or nearly 3000 feet above the sea-level, and were observed to occupy the edges of cliffs, to be scattered over the slopes of mountain-ranges, and to be massed in great numbers in the intervening valleys.

At the "Burnt Portage" on the north-east branch of the Moisie, nearly 100 miles in an air-line from the Gulf of St. Lawrence, and 1850 feet above the ocean, the low gneissoid hills for many miles round were seen to be strewed with erratics wherever a lodgment for them could be found. The valleys (one to two miles broad) were not only floored with them, but they lay there in tiers, three or more deep. Close to the banks of the rivers and lakes near the "Burnt Portage," where the mosses and lichens have been destroyed by fire, very coarse sand conceals the rocks beneath, but on ascending an eminence away from the immediate banks of the river the true character of the country becomes apparent. At the base of the gneissoid hills which limit the valley of the east branch (about three miles broad) at this point, they are observed to lie two or three deep, and although of large dimensions, that is from 5 to 20 feet in diameter, they are nearly all ice- or water-worn, with rounded edges, and generally polished or smoothed. These accumulations of erratics frequently form tongues, or spots, at the termination of small projecting promontories in the hill-ranges. I have several times counted three tiers of these travelled rocks where the mosses, which once covered them with a uniform mantle of green, had been burnt; and occasionally, before reaching the sandy area which is sometimes found on the banks of the river, I have been in danger of slipping through the crevices between the boulders, which were concealed by mosses, a foot and more deep, both before and after passing through the "Burnt Country," which has a length of about 30 miles where I crossed it. I extract the following note from my journal of the appearance of these travelled rocks in the "Burnt Country":—

"Huge blocks of gneiss and labradorite lie in the channel of the river, or on the gneissoid domes which here and there pierce the sandy tract through which the river flows. On the summit of the mountains, and along the crest of the hill-ranges, about a mile off on either side, they seem as if they had been dropped like hail. It is not difficult to see that many of these rock-fragments are of local origin, but others have evidently travelled far, on account of their smooth outline. From a gneissoid dome, I see that they are piled to a considerable height between hills 300 and 400 feet high; and from the comparatively sharp edges of many around me, the parent rock cannot be far distant."

On all sides of Cariboo Lake, 110 miles in an air-line from the Gulf, and 1870 feet above it, a conflagration had swept away trees, grasses, and mosses, with the exception of a point of forest which came down to the water's edge and formed the western limit of the living woods. The long lines of enormous unworn boulders, or fragments of rocks, skirting the east branch of the Moisie at this point were no doubt lateral glacial moraines. The coarse sand in the broad valley of the river was blown into low dunes, and the surrounding hills were covered with millions of erratics. No glacial striæ were observed here, but the gneissoid hills were rounded and smoothed at their summit; and the flanks were frequently seen to present a rough surface, as if they had been recently exposed by land-slides, which were frequently observed, and the cause which produced them, namely, frozen waterfalls.

Fig. 1.—*Section of the Valley of the East Branch of the Moisie,—in the Burnt Country* (3 miles).



a. Boulders of Gneiss and Labradorite. *b.* Coarse sand.

No clay or gravel was seen after passing the mouth of Cold-water River, 40 miles from the Gulf, and 320 feet above it. The soil, where trees grew, was always shallow as far as observed; and although a very luxuriant vegetation existed in secluded valleys, yet it appeared to depend upon the presence of labradorite-rock or a very coarse gneissoid rock, in which flesh-coloured felspar was the prevailing ingredient.

Observers in other parts of the Labrador Peninsula have recorded the vast profusion in which erratics are distributed over its surface. There is one observer, however, well known in another branch of science, who has left a most interesting record of his journey in the Mistassinni country, between the St. Lawrence, at the mouth of the Saguenay and Rupert's River, in Hudson's Bay. André Michaux, the distinguished botanist, traversed the country between the St. Lawrence and Hudson's Bay in 1792. He passed through Lake Mistassinni; and in his manuscript notes, which were first printed in 1861, for private circulation, at Quebec, a brief description of the journey is given. "The whole Mistassinni country," says Michaux, "is cut up by thousands of lakes, and covered with enormous rocks, piled one on the top of the other, which are often carpeted with large lichens of a black colour, and which increase the sombre aspect of these desert and almost uninhabitable regions. It is in the spaces between the rocks that one finds a few pines (*Pinus rupestris*), which attain an altitude of three feet; and even at this small height showed signs of decay."

The remarkable absence of erratics in the Moisie, until an altitude of about 1000 feet above the sea is attained, may be explained by the supposition that they may have been carried away by icebergs and coast-ice during a period of submergence, to the extent of about 1000 feet. I am not aware that any traces of marine Shells or marine drift have been recognized, north of the Labrador Peninsula, at a greater elevation than 1000 or 1100 feet. In the valley of the St. Lawrence marine drift has not been observed higher than 600 feet above the sea. Glacial striæ were seen on the "gneiss-terraces" at the "Level Portage," 700 to 1000 feet above the sea. The sloping sides of these terraces are polished and furrowed by glacial action. Grooves half an inch deep, and an inch or more broad, go down slope and over level continuously. It is on the edge of the highest terrace here that the first large boulders were observed.

The entire absence of clay, and the extraordinary profusion of both worn and rugged masses of rock piled one above the other in the valley of the east branch of the Moisie (fig. 1), as we approach the table-land, lead me to attribute their origin to local glacial action, as well as the excavation of a large part of the great valley in which the river flows. Its tributary, the Cold-water River, flows in the strike of the rocks through a gorge 2000 feet deep, excavated in the comparatively soft labradorite of the Labrador series*.

* See Sir William Logan's 'Geology of Canada' (1863), on the Division of the Laurentian Rocks into "two formations":

1st. The Labrador series.
2nd. The Laurentian.

The Labrador series, I have been recently informed by Sir William Logan, has been ascertained by him to rest unconformably upon the older Laurentian, and will be distinguished by a separate colour on his new Map of Canada. See also Mr. Sterry Hunt on the Chemistry of Metamorphic Rocks.

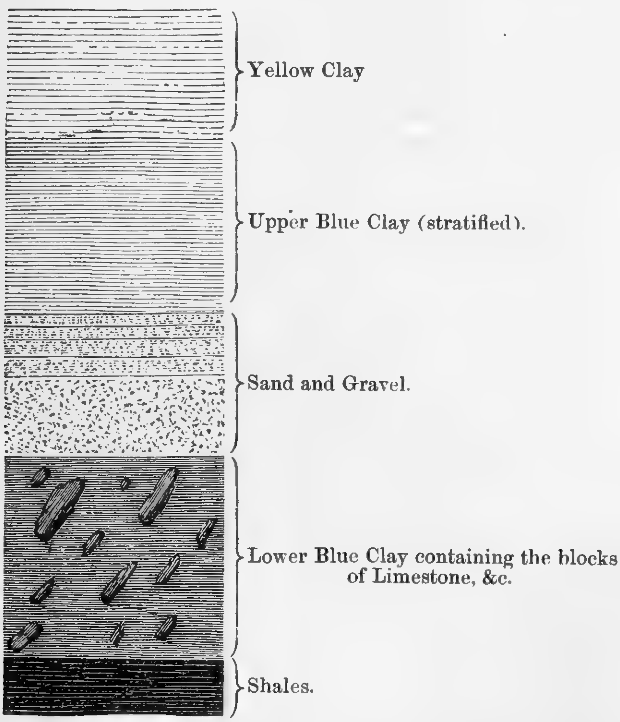
The descriptions which have recently been published* of different parts of the Labrador Peninsula not visited by me, favour the supposition that the origin of the surface-features of the areas described may be due to glacial action, similar to that observed in the valley of the Moisie River.

§ 2. *The Forced Arrangement of Blocks of Limestone, &c., in Boulder-Clay.*

The forced arrangement of blocks of limestone, slabs of shale, and boulders of the Laurentian rocks, in the Blue Clay at Toronto, formed the subject of a paper which I read before the Canadian Institute seven years ago. A minute description of this arrangement was published in my Report of the Assinniboine and Saskatchewan Exploring Expedition in 1859†, to illustrate a similar arrangement of blocks of limestone and gneissoid rocks in the clay on the south branch of the Saskatchewan observed in 1858.

I concluded the description of this remarkable arrangement with the following hint at their origin:—" May not the plastic and irre-

Fig. 2.—*Section showing the forced arrangement of Blocks of Limestone, &c., in Boulder-Clay.*



* See my 'Explorations in the Interior of the Labrador Peninsula.' Longmans, 1863.

† Report on the Assinniboine and Saskatchewan Exploring Expedition. By Henry Youle Hind, M.A. Toronto, 1859. Eyre and Spottiswoode, London, 1860 (Blue Book).

sistible agent which picked up the materials composing the Blue Clay, and then melting, left them in their present position, have been largely instrumental in excavating the basins of the great Canadian lakes?" *

And, in 1860, in a 'Narrative of the Canadian Expeditions,' I remarked, "The widespread phenomena exhibiting the greater or less action of ice, such as grooved, polished, and embossed rocks, *the excavation of the deep lakes of the St. Lawrence basin,* the forced arrangement of drift, the ploughing-up of large areas, and the extraordinary amount of denudation *at different levels,* without the evidence of beaches, all point to the action of glacial ice previous to the operations of floating ice in the grand phenomena of the Drift." †

§ 3. *The Driftless Area in Wisconsin.*

In a recent Report on the Geological Survey of the State of Wisconsin, by the distinguished American geologists, Professors James Hall and J. D. Whitney, the remarkable view is advanced by the latter, that there is an area of more than 3000 square miles in extent (long. 90° W., lat. 42° 50′ N.) which has never been overflowed since the Upper Silurian epoch. Mr. Whitney says ‡, "If we consider the magnitude and universality of the drift-deposits in the Northern United States, and especially in Northern Wisconsin, we shall be the more astonished to learn that throughout nearly the whole Lead-region, and over a considerable extent of territory to the north of it, no trace of transported materials, boulders, or drift can be found; and what is more curious, to the east, south, and west, the limit of the productive Lead-region is almost exactly the limit of the area thus marked by the absence of Drift."

The conclusions to which Mr. Whitney has been led by the study of this driftless region are briefly as follow:—

1. That since the Upper Silurian period this portion of Wisconsin has not been submerged, and that its surface has, consequently, never been covered by Drift.

2. That the denudation it has undergone has been effected by the simple agency of rain and frost.

3. That a large portion of the superficial detritus of the West must have had its origin in the subaërial destruction of the rocks, the soluble portion of them having been gradually removed by the percolating water.

4. The entire absence of terraces indicates that the region in question has not been submerged in recent times. No organic remains other than those belonging to palæozoic times, except those of land animals and plants, have been found in the Lead-region.

On the railway between Milwaukie (Lake Michigan) and Prairie du Chien on the Mississippi, there is no point which rises higher than 950 feet above the sea-level; and the towns of Galena, Menomonee, and Dunlieth, in the Lead-region, are below the level of Lake Michigan.

* *Op. cit.* (Toronto), p. 122.

† Narrative of the Canadian Expeditions of 1847 and 1858, vol. ii. p. 254. Longmans, 1860.

‡ Vol. i. p. 116.

§ 4. *Beaches and Terraces.*

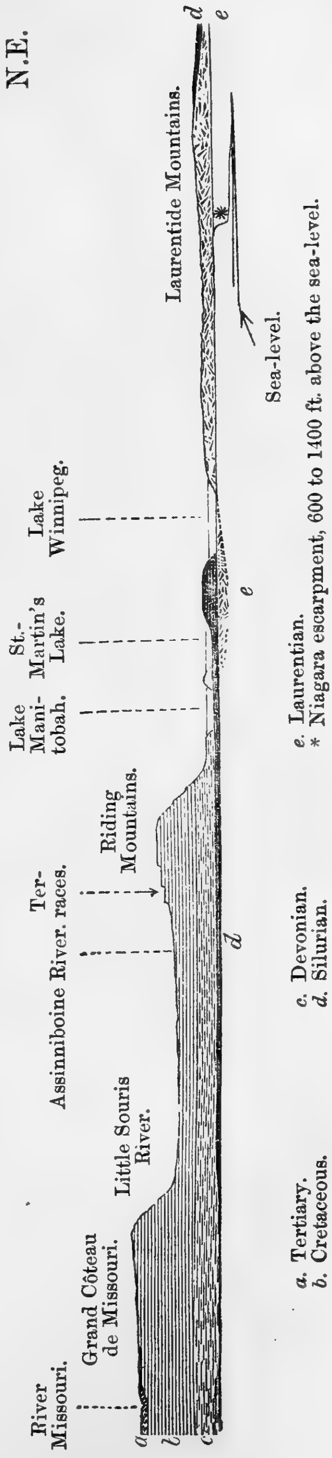
In connexion with this driftless area, the beaches and terraces which form so distinguishing a feature in North America acquire particular interest.

Confining myself to those terraces which have come under my own observation, I shall notice first the vast bank of sand, 55 miles west of Lake Superior, commonly called the Great Dog Portage*. The altitude of the summit of this terrace is 835 feet above Lake Superior, more than 800 feet above Lake Michigan, and 1435 feet above the sea.

120 miles west of Lake Winnipeg the successive steps or terraces of the Riding and Duck Mountains rise in well-defined succession on the south and south-western slopes ; but on the north-east and north sides they present a precipitous escarpment more than 900 feet in altitude, or 1000 feet above Lake Winnipeg, or 1600 feet above the sea ; while Lake Traverse, which sends water during floods to the Red River of the north as well as to the Mississippi, is only 966 feet above the same level; and from 10 to 15 miles west of Lake Traverse and Big Stone Lake (966 feet above the sea) is the abrupt escarpment of the Côteaux des Prairies, whose summit is 1000 feet above them.

Illustrations of a precipitous escarpment on one face, with gentle sloping plateaux separated by terraces on the other side, might be greatly multiplied; they are indeed the common feature in the scenery of the basin of Lake Winnipeg, west of that lake ; and, with a single known exception, mentioned by Dr. Hector†, the precipitous escarpment faces the north-east or the north, and the terraces and plateaux the

Fig. 3.—*Profile of country from Lake Winnipeg to the Grand Côteau de Missouri.*



* For a description of the Great Dog Portage, see 'Narrative of Canadian Exploring Expeditions of 1857 and 1858.' Also Reports on the North-west Territory, 1859. By the Author.

† The Cyprès Hills, Quart. Journ. Geol. Soc. vol. xvii. p. 399.

south or south-west. This feature is also observed in all the outliers in the great prairies and plains of the basin of Lake Winnipeg. The terraces of Lake Superior and the escarpments, with their corresponding terraces in the Lake Winnipeg basin, considered in relation to the driftless area in Wisconsin, point to the former existence of great glacial lakes, as suggested by Mr. Jamieson to explain the origin of the Parallel Roads of Glen Roy. The clean-swept floor of the level country at the foot of the great escarpment of the Riding, Duck, and Porcupine Mountains, in which Lake Winnipeg and its associated lakes lie, indicates the boundary of a vast glacier, which excavated their basins and left its dirt-beds on the prairie country even as far as the south branch of the Saskatchewan, where I observed the forced arrangement of slabs in *unstratified clay* in 1858.

§ 5. *Anchor-ice—Excavation of Lake-basins.*

It has been frequently stated that a difficulty arises as to the *modus operandi* by which a moving glacier can excavate lake-basins. May not the manner in which stratified rocks, at least, over which a glacier may be moving, can be involved in its mass in the form of slabs or mud, constituting dirt-beds, be partially explained by the phenomena attending the formation of 'anchor-ice'? It is no uncommon occurrence for the anchors of the nets of a "seal-fishery" on the north shore of the Gulf of St. Lawrence to be frozen to the bottom at the depth of from 30 to 60 feet; and when anchors are then raised, they bring with them frozen masses of sand. But it is in rapid rivers that the formation of anchor-ice is most remarkable, and most effective in excavating these beds. It forms on the beds of rivers above the head of a rapid, and frequently bursts up with a load of frozen mud or shingle, or slabs of rock, which it has torn from the bottom. This phenomenon is witnessed every winter in the valley of the St. Lawrence, but it is best observed after a prolonged term of cold, when the thermometer indicates a temperature considerably below zero. Anchor-ice has only been observed, as far as my knowledge of the subject goes, in rapid currents in open water; and the sudden and apparently inexplicable rise of the St. Lawrence during extreme cold is most probably due to this cause*. It is not difficult to see how the rivers issuing from beneath the precipitous walls of glaciers, as described by Dr. Rink, may rapidly excavate deep channels by means of anchor-ice, to be widened by the subsequent operations of the glacier itself. Nor is it improbable that by this means a glacier in very cold climates may increase from the bottom upwards with a load of frozen mud and fragments of rock, particularly near its base, when that does not meet the open sea. The great lakes of North America, including Lake Winnipeg, are excavated on the edges of the fossiliferous rock-basins; and these lakes may represent the boundary of a glacial mass similar to that which now covers Greenland.

* See "Notes on Anchor-ice," by C. T. Keefer, C.E., Canadian Journal, New Series, vol. vii. p. 173 (1862).

§ 6. *Parallelism of Escarpments in America.*

In 1860* I described the remarkable parallelism which exists between great escarpments in America north of the 40th parallel of latitude.

1st. The Niagara escarpment.

2nd. The Riding, Duck, and Porcupine Hill escarpment, west of Lake Winnipeg.

3rd. The escarpment of the Grand Côteau de Missouri.

These are all roughly parallel to one another, and are many hundred miles in length. The lowest, the Niagara, varies from 600 feet to 1300 feet above the sea; the second, west of Lake Winnipeg, from 1600 feet to 2000; the third, the Grand Côteau de Missouri, from 2000 to 3000 feet and more above the ocean (see fig. 3). They have all easterly, north-easterly, or northerly aspects, in relatively different parts of their lengths†, and appear to have a common origin. If it can be shown conclusively, as Mr. Whitney believes, that the driftless area in Wisconsin has never been overflowed, these escarpments, as well as those of their great outliers in the "far West," can only be due to the same agent which excavated the basins of the great American lakes.

The symmetrical escarpments of the Grand Côteau de Missouri, the Riding Mountain and its prolongations, and portions of the Niagara escarpments, are probably the result, to a large extent, of the action of glacial rivers undermining and washing away the soft strata of the sedimentary rocks, and excavating *in advance* of the glacial mass itself; and they represent different and closely succeeding glacial periods (the Missouri escarpment being older than that of the Riding Mountain), with, however, a distinct geological interval between them. The close proximity of the isothermal curves in these latitudes to the general direction of the escarpments of the Grand Côteau and Riding Mountain is a very interesting and important feature in connexion with the cause which produced them.

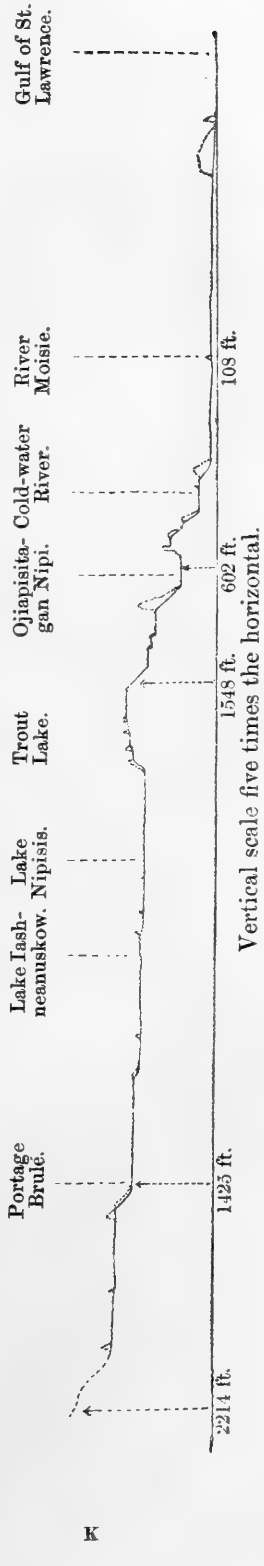


Fig. 4.—*Section of the Canoe-route from the Portage Brulé to the Gulf of St. Lawrence.*

* See my 'Narrative of the Canadian Exploring Expeditions of 1857 and 1858,' vol. ii. p. 266, for a notice of these escarpments.

† The western exception at Cyprès Hills has been already noticed. Here the flanks of the Rocky Mountains are approached.

§ 7. *Conclusion.*

The opinion that many of the phenomena attending the surface-geology of a large portion of North America were caused by glacial ice, appears to be gradually gaining ground among American geologists. First enunciated by Professor Louis Agassiz *, it received the sanction, wholly or in part, of some well-known geologists. In a recent paper by Dr. Newberry, it is stated that "in this 'glacial epoch' all the Lake-country was covered with ice, by which the rocky surface was planed down and furrowed, and left precisely in the condition of that beneath modern moving glaciers in mountain-valleys" †.

Dana considers "the glacial theory the most satisfactory, but the iceberg-theory required, in some cases, for the borders of continents" ‡.

Sir William Logan, when speaking of the innumerable lakes scattered over the Laurentian region of Canada, says, in his 'Geology of Canada', just published, "The rock which is most characteristic of the depressions is the comparatively soft crystalline limestones of the series; and it appears probable that one of the main erosive forces has been glacial action."

Also, with reference to the great Lake-basins, he says, "These great Lake-basins are depressions, not of geological structure, but of denudation; and the grooves on the surfaces of the rocks, which descend under the water, appear to point to glacial action as one of the great causes which have produced these depressions" ‖.

I have great satisfaction in observing that the views which I published in 1859 ¶, respecting the origin of the great American lakes and other glacial phenomena in North America, are continually receiving additional support from various sources; and I venture to think that it is not unreasonable to suppose that we shall find in North America the parallel of that widespread work of ancient glaciers in Europe, which has been so ably described before the Society by its distinguished President, Professor Ramsay.

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2. *Notes on the* Drift-deposits *of the* Valley *of the* Severn, *in the* Neighbourhood *of* Coalbrook Dale *and* Bridgnorth. By George Maw, F.S.A., F.L.S., &c.

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

The general subject of the drift-deposits distributed so abundantly throughout the counties of Gloucester, Worcester, Shropshire, and

* Lake Superior: its Physical Character, Vegetation, and Animals, &c. 1850.

† Notes on the Surface-geology of the Basin of the Great Lakes.

‡ Dana's 'Manual of Geology,' 1863, p. 546.

‖ Geological Survey of Canada, 1863, page 889.

¶ See Reports of the Assinniboine and Saskatchewan Expedition. In 1855 I read a paper before the Canadian Institute, Toronto, "On the Origin of the Basins of the Great Lakes," advocating the view that they had been excavated by means of ice.

Cheshire, and extending east and west beyond their limits, has been so frequently and fully written upon, by Sir R. I. Murchison in his 'Silurian System,' by the Rev. W. S. Symonds in the 'Transactions of the Malvern Naturalists' Field-Club,' by Professor Buckman in his 'Ancient Straits of Malvern,' and by Mr. Prestwich, the Rev. Mr. Lister, and others in the 'Transactions' and 'Quarterly Journal' of the Geological Society, that, in recording my observations, I am enabled to add but little to what is already known; and my reason for making a further communication on the subject is that some remarkably good sections of the drift have recently been exposed in the cuttings of the Severn Valley, Wenlock, and Coalbrook Dale Railways, some of which, in connexion with old sections exposed in gravel-pits, enable examination to be made of superimposed strata upwards of 200 feet in thickness.

Such a consecutive thickness of post-tertiary deposits is very uncommon, and is of the utmost importance for comparison with more fragmentary examples, and for ascertaining to what extent any succession and order of deposition of the constituent strata can be traced between the drifts of different localities scattered so abundantly over the south-west of England.

My observations have, for the most part, been limited to the Severn Valley, from about four miles below Bridgnorth up to Shrewsbury, including a range north and south of about twenty miles.

This may be divided into three distinct districts:—

From Shrewsbury to Buildwas the River Severn meanders through a broad valley, at an average level of about 110 feet above the sea, its course resting upon the Bunter Sandstone and Caradoc Sandstone, the surfaces of which, in the immediate neighbourhood of the river, are covered by perfectly level alluvium, becoming, however, towards its boundary, varied by rounded hills and promontories of the drift about to be described.

At a little below Buildwas, 12 or 13 miles from Shrewsbury, the valley suddenly contracts, and at the entrance of Coalbrook Dale the river breaks through the great Silurian range near where it terminates on the east side of the river.

From Buildwas to Coalbrook Dale, Wenlock shale is crossed for about a mile; and to the south of Coalbrook Dale the great Wenlock-limestone escarpment, including Benthall Edge on the west and Lincoln Hill on the east, guards the entrance to the narrow gorge in the Coal-measures, through which the river rapidly descends for $2\frac{1}{2}$ miles, and continues in a series of rapids to Bridgnorth, through a rather narrow valley bounded by abrupt cliffs of Lower New Red and Permian sandstones. The flanks of this gorge seem to have been almost entirely denuded of drift, and for some miles none, of any extent, is to be seen in the immediate valley of the Severn.

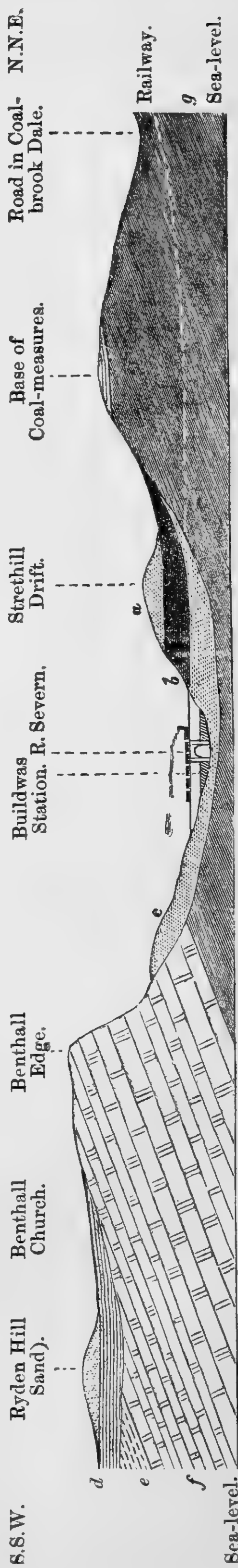
Below Bridgnorth the valley again widens out into a tolerably level plain, which is 30 to 35 feet lower than the level of the river between Shrewsbury and Buildwas, and from 60 to 70 feet above the sea. The ground in the immediate neighbourhood of the river consists of flat "hams" or alluvial meadows; from these, on each side of the valley, the drift ascends in terraces up to the flanks of the New Red Sandstone and Permian hills which ultimately bound it on each side.

In addition to the drift in the immediate neighbourhood of the river, numerous outlying patches occur on the high ground, as at Ryden Hill, in the parish of Benthall, and near the "Hill Top," Benthall, Broseley Churchyard, Posenhall, near the Deerleap, and Willey, and near Much Wenlock on the west side of the Severn; also in several localities on the east side, at altitudes of from 300 to 600 feet above the Severn, and from 400 to 700 feet above the sea. Mr. C. J. Cooper, Secretary of the Severn-Valley Field-Club, to whom I am indebted for much information relating to the Bridgnorth gravels, has also pointed out to me a patch of drift at Burton, $3\frac{1}{2}$ miles to the west of Much Wenlock, and 800 feet above the sea-level. To this I shall presently more particularly refer.

The principal mass of drift occurs at Strethill, a rounded hill rising, close to the north of the entrance of Coalbrook Dale, to an altitude of about 200 feet above the River Severn, and 300 feet above the sea. The section of its upper portion has, for several years, been exposed in a gravel-pit on its north-east side, and the Coalbrook Dale Junction Railway has recently exposed a further section through its centre, which, together with some less important sections on the west side of the river, afford the unusual opportunity of examining 200 feet of consecutive drift-strata. The sections across the valley of the Severn will explain the relative position of the several masses of drift, and their relation in position to older formations.

The base and summit of Strethill consist of clear water-worn sands and gravels, separated by a bed of gravelly clay; the first 60 feet above the river consists of thick beds of remarkably clean sea-sand, interstratified with water-worn pebble-beds, which are exposed for a

Fig. 1.—Section across the Valley of the Severn at the New Buildwas Railway Bridge.



a. Sand and Gravel.
b. Gravelly Clay.
c. Sand and Gravel.
d. Base of the Coal-measures.
e. Ludlow rock.
f. Wenlock Limestone.
g. Wenlock Shale.

Vertical scale twice the horizontal.

The gravel-beds represented on the left-hand side of the valley occur a little to the north of the actual line of section.

few feet at the bottom of the railway-cutting and also on the opposite side of the river, near to Buildwas Station, in the gravel-pits which supply ballast for all the neighbouring lines of railway; and the continuity of these beds is further verified by the section at the end of the cutting next Coalbrook Dale, where these fine sea-sand beds are found coming up under the other beds, and leaning against the old coast of Wenlock shale.

At the height of 60 or 70 feet above the river, and about 165 feet above the sea, these clean sand-beds are replaced by a most heterogeneous mass of drift, in which stratification is almost absent; they are about 60 feet thick, and included within the top and bottom of the railway-cutting. So singularly various is their aspect, and so obvious in irregularity and variety of structure and materials, as to call forth the remark from one of the navvies that "*he had cut through plenty of hills in his time, but that he had never seen a hill with such a many kinds of muck in it as this.*" The transition from the sand-beds is well-marked and sudden, and the beds immediately succeeding them consist of muddy subangular gravel, irregularly stratified, and containing beds of silt, drift-coal, and clay irregularly disposed, and also, in common with nearly the whole mass of drift, rocks and stones of various sizes and from many formations, a list of which is given below.

The middle of this heterogeneous stratum consists of a mass of very tough unstratified clay, containing fragments of Wenlock shale, water-worn and subangular boulders, pieces of flint, and patches of curiously contorted sand and silt, the structure of which is very similar to that of the strata at St. Acheul, engraved at page 138 of 'The Antiquity of Man'; they seem to have been subjected to continual moving, washing, and changing, from constantly varying currents cutting fresh channels and redepositing the materials.

The tough clay is again succeeded by muddy subangular gravel, similar to that in which it rests. The transition from the clay to the muddy gravels immediately under and over it is by no means well-defined or decided, as they break into each other with the utmost irregularity; indeed the centre of the mass is only separately distinguishable by containing more clay and less gravel than its top and bottom.

Leaving the railway-cutting and ascending the hill, the beds which cap it are well exposed in the old gravel-pit; here no traces of mud or clay occur, and the whole mass of 60 feet is made up of evenly stratified, well-defined beds of clean sharp sand and shingle. Their disposition is perfectly level, and, what I would particularly note, *quite independent of the rounded contour of the surface of the hill—a fact which I find holds good with all the stratified gravels of the neighbourhood.*

It has been generally supposed, and perhaps correctly, that the higher gravel-beds on the flanks of many diluvial valleys are the most ancient; but, in the case of Strethill, the fact of immediate superposition proves that the drift occupying the bottom of the Severn Valley, excepting the flat alluvium immediately adjacent to the river, which contains the freshwater Mussel, and may possibly correspond with the freshwater low-level drifts of the Avon and Lower Severn, must have been first formed, as it is merely a continuation of the gravel-beds upon which the upper strata of Strethill repose.

The following is a list of the rocks occurring in the drift between Ironbridge and Shrewsbury. I have avoided naming them before, because the list applies equally to every bed composing the drift, and from careful observation I cannot find that the constituent rocks of the water-worn gravels differ from those in the clay-bed, or the larger masses from the smaller materials.

The only constant fact that impresses one is the very large proportion of the constituents that appear to be of local origin, the variations of colour and character being dependent on purely local circumstances. All who have noticed the superficial gravel-deposits distributed throughout the kingdom cannot fail to trace their variations of colour, &c., to their evident derivation from neighbouring formations. The orange-coloured gravels about London and in the south-east of England probably derive their colour from the ferruginous beds of the Greensand formation, and a similar relation of colour and material can be traced between the New Red Sandstone and the gravels that rest upon it.

In the following list of the rocks of the Severn-Valley drift, I have given the nearest direct distance of the parent formation *in situ*.

List of Rocks occurring in the Drift of the Severn Valley.

Flints, fragments of hard chalk, and chalk Corals in small numbers (80 miles to the S.E., 100 miles to the N.E.).

Oolitic limestone, a fragment (from 40 miles to the south).

Lias fossils, including *Cardinia ovalis* from the Lower Lias, *Gryphæa incurva*, &c. (20 miles to the north, and 30 miles to the south).

Bunter sandstone in fragments and as sand (4 miles to the N.W. and 4 miles to the S.E.).

Permian sandstone ($2\frac{1}{2}$ miles to the S.E.).

Coal-measure rocks and fossils, drift coal, and nodules of ironstone in large quantities ($\frac{1}{2}$ mile to the S.E.).

Mountain-limestone in large masses (2 miles to the north).

Old Red Sandstone (4 miles to the south).

Wenlock shale Trilobites (*Phacops longicaudatus*), Corals, and Shells (immediately adjacent).

Wenlock limestone and characteristic Shells and Corals ($\frac{1}{2}$ mile to the S.W.).

Llandovery sandstone and Caradoc sandstone abundant (3 miles to the west).

Cambrian rocks (12 miles to the west).

Greenstone abundant (evidently derived from the Wrekin, 3 miles to the N.W.).

Various granites from Cumberland (120 miles to the north), and perhaps from Scotland.

Porphyritic syenite, probably from the Malverns (35 miles to the south).

Trap-ash.

I am indebted to Dr. Duncan, Sec. G.S., and to Mr. Jenkins, Assistant-Secretary G.S., for the accompanying list of derivative fossils from the Strethill drift-beds, which they have kindly determined for me.

List of Fossil Corals found in the Drift of the Severn Valley.

	No. of Specimens
1. Cretaceous (upper).	
Parasmilia centralis, *Edwards & Haime*	1
—— serpentina, *Edwards & Haime*	4
2. Mountain Limestone.	
Zaphrentis Phillipsi, *Edwards & Haime*	9
Cyathophyllum Wrightii, *Edwards & Haime*	3
3. Silurian.	
Palæocyclus rugosus, *Edwards & Haime*. Dudley & Wenlock	4
—— Fletcheri, *Edwards & Haime*. Dudley	1
Plasmopora petalliformis, *Lonsdale*, sp. Dudley	1
Ptychophyllum patellatum, *Schl.* Wenlock	1
Cyathophyllum pseudo-ceratites, *M'Coy*, sp. Wenlock	3
—— truncatum, *Edwards & Haime*. Wenlock, Aymestry	3
—— flexuosum, *Edwards & Haime*. Wenlock	4
—— angustum, *Lonsdale*. Wenlock	3
Monticulipora pulchella, *Edwards & Haime*. Wenlock	1
—— lens, *M'Coy*. Lower Silurian	1
Halysites catenularia, *Edwards & Haime*.	

The indeterminable specimens are mostly Silurian, but there are both Carboniferous and Cretaceous forms amongst them.

List of Fossil Shells, &c., found in the Drift of the Severn Valley.

1. Lias.	
Cardinia ovalis, *Stutchb.* Lower Lias	1
Gryphæa incurva, *Sow.*	1
Stems of Encrinites. Several specimens.	
2. Carboniferous.	
Productus scabriculus, *Martin*. Carboniferous Limestone	1
—— hemisphæricus, *Sow.* Small fragments. Carb. Limestone.	
Globulus vetustus, *Sow.* Coal-measures. Coalbrook Dale	1
Calamites. Coal-measures	1
Sigillaria. Coal-measures	1
Stems of Encrinites. Carboniferous Limestone. Several specimens.	
3. Silurian.	
Pentamerus linguifer, *Sow.* Wenlock	3
Atrypa reticularis, *Linn.* Wenlock. Many specimens of all sizes.	
Rhynchonella deflexa, *Sow.* Wenlock	2
Spirifer crispus, *Linn.* Wenlock	1
Strophomena pecten, *Fisch.* Lower and Upper Silurian	1
Orthis calligramma, *Dalm.*, var. Lower Silurian	1
Lituites ibex?, *Sow.* Ludlow	1

On the west side of the Severn Valley, above Buildwas, the drift rests on the flanks of the Wenlock-limestone hills to an altitude of 200 feet above the river, and upwards of 300 feet above the present sea-level, but in lesser masses than at Strethill; for the most part it consists of well-washed gravels and sands, varying much in size and character, and between which and the tough clay-bed of Strethill I have been unable to trace any close stratigraphical correspondence;

indeed, as far as I have been able to observe, the mounds of drift which occupy so much of the valley up to Shrewsbury consist mostly of such beds of sand and gravel as occur at the base and the summit of Strethill, the middle tough clay-deposit being but slightly represented. In the cutting opposite Buildwas Abbey and in the gravel-pits near the station, the clean sea-sand, similar to that at the base of Strethill, is, however, readily distinguishable from the upper beds, which are greyer in colour and rather more clayey in composition, and may possibly correspond with the middle beds of Strethill, though much less tenacious.

Descending the river to Bridgnorth, and, for the present, confining our observations to the valley, the drift ascends to an altitude of 170 feet above the river (which is here 30 feet below the river at Buildwas) or about 240 feet above the sea. On the east side of the valley the drift is disposed in two well-marked terraces, their sides sloping at an angle of 30°, the lower at an altitude of 43 feet above the valley-alluvium, and the higher 43 feet above the lower terrace, and at altitudes of 113 and 156 feet above the sea.

The exact correspondence in height of these two successive terraces of erosion is rather remarkable; and as they have all the appearance of old river-banks, it has been suggested by my friend the Rev. Mr. Wayne, of Wenlock, that they may mark two distinct periods of interruption in the elevation of the land—a supposition which is well sustained by the structure of the crest of the upper terrace, a section of which, in the St. James's gravel-pits, exposes at one point a regular pebble-ridge, or estuary coast-beach, composed of rounded boulders with but a slight intermixture of smaller matter. The bulk of these terraces consists of an even and stratified intermixture of gravel and small rounded boulders derived from a great variety of formations, including the following:—

Fig. 2.—*Section across the Valley of the Severn one mile below Bridgnorth.*

a. Drift Gravel.
b. Alluvium and Drift Gravel.
c. Calcareous Breccia.
d. Bunter Sandstone.
e. Permian beds.

List of Rocks, &c., from the Drift in the Valley of the Severn at Bridgnorth.

Llandovery sandstone.
Wenlock limestone.
Drift coal. Coal-measure rocks and Penneystone ironstone.
Carboniferous limestone.
Red and grey Permian sandstone.
Bunter sandstone.
Basalts and greenstones.
Red, grey, and white granites.
Quartz-rock.
Elvan or compact granite-rock.
Flints and hard chalk, and
A Lias fossil (*Gryphæa incurva*).

The composition of the whole of these Severn-Valley gravels is very similar, and only differs in respect of the formation upon which they immediately rest, which always preponderates; thus, the Bridgnorth drift partakes largely of the components of the New Red Sandstone, especially the beds at Quatford, about two miles below the town, which are almost entirely composed of the detritus of the Bunter sandstone, and contrast strikingly with the tough clays of the Strethill deposit, which I cannot help thinking have been largely derived from the waste of the Coal-measure clays and Wenlock shale in its immediate neighbourhood.

The cuttings of the Severn-Valley Railway below Bridgnorth, on the west side of the valley, expose several sections of drift; gravels and sands, containing a few broken fragments of Shells, generally rest on the older formation, and in some places these are again overlain by a more clayey deposit, which may possibly be related to the clay-beds of the Strethill drift; but as the whole of the drift-beds exhibit so much variety of character, the correlation of their constituent strata in different localities is most difficult and uncertain.

In describing the strata of Strethill, I mentioned that the larger constituent materials were the same throughout, but that the character and aspect of the strata differ considerably, the middle beds being composed of unstratified clay, silt, and muddy gravel, whilst the upper and lower strata consist of clean sand and water-worn shingle, evenly stratified, and without the slightest trace of mud.

That the whole mass was derived from similar sources appears probable from the identity of the constituent rocks and boulders, and its variety of character and aspect must be attributable to the different circumstances under which its component strata were deposited.

The long-continued action of the tide upon a particular level will tend to the removal of all fine matter capable of being held in watery suspension, and leave the coarser particles as clean sand and shingle similar to what we find on our more exposed coasts; and I would suggest that such beds, forming the base and summit of the Strethill drift, may represent periods of comparative cessation in the submergence of the land, during which fresh erosion and accession of new materials would be checked, and the débris already accumulated on the coast subjected to the long-continued cleansing action of the waves above described, thus converting it into clean sand and rounded shingle.

With regard to drift clay-beds, rapid submergence would continually present fresh points of approach for the eroding waters, and might tend to the accumulation of débris at a greater rate than the finer matters could be cleansed away by repeated tidal action. The Strethill clay-bed, which was probably deposited in deeper water, contains a much larger proportion of angular and unworn fragments than the shingle accompanying the clean sand, and also lumps of soft Wenlock shale, which, had they been subjected to long coast-action, must soon have been broken up. I would submit, therefore, that the alternating strata of Strethill present us with evidence of unequal or interrupted action in the submergence of the land, in the same way that the Bridgnorth terraces prove an irregularity in the rate of upheaval.

I believe that the whole of the drift-strata I have described, excepting, perhaps, the flat valley-alluvium, were deposited in the interval between a single period of depression and re-elevation, but that subsequent oscillations of level, represented by a separate series of drifts of a different character at a lower level, are also evident.

The lowest beds of the Shropshire drift are nearly 100 feet above the sea-level; they are, excepting the flat alluvium bordering the river, exclusively of marine origin, entirely devoid of Mammalian remains, and, considering their immense thickness and range of altitude, their monotonous character and paucity of organic remains contrast strikingly with the drifts of lower levels, such as those of the valleys of the Somme, the Avon, and the lower part of the Severn Valley. All of these, from the smaller scale of their constituent strata and close alternation of marine and freshwater beds, appear to have been the result of less extensive variations of level than that involved in the formation of the Strethill drift, and may have gone on during comparatively short periods within the 100 feet separating the present sea-level from our lowest Shropshire drift, and subsequently to its last denudation. They would be more essentially valley-drifts than those now described, which belong to an epoch in which nearly the whole land-surface of Great Britain was probably submerged.

In the valley about Bridgnorth, and on the terraces of drift before described, there here and there occur large boulders of grey granite, Cambrian slate, Llandovery sandstone, Coal-measure rocks, Carboniferous limestone, New Red sandstone, New Red conglomerate, Devonian sandstone, and a volcanic rock, probably from N. Wales. They are for the most part subangular, and, although they do not exhibit any well-marked glacial striæ, the large weight of some of them (from one to two tons) clearly implies some form of ice-action as a means of transport. These erratic blocks occur sparingly amongst the drift all up the valley to Shrewsbury, but much more abundantly on the higher ground at altitudes of from 400 to 800 feet above the sea, where they are not always accompanied by the ordinary drift.

On the high ground to the south-west of Bridgnorth, in the direction of Wolverhampton, blocks of grey granite are most abundant; and at Burton, $3\frac{1}{2}$ miles to the west of Much Wenlock, a considerable area of ground, extending from 700 to 800 feet above the sea, is thickly strewn with them, where they are accompanied by a bed of smaller water-worn gravel or shingle, mostly composed of granitic detritus, and having no apparent stratification. The fine matter of this bed is of a loamy character, and the absence of the beds of clean sand occurring at lower levels is noticeable.

The local distribution of these boulders is rather remarkable. In some places, as at Burton, the ground is thickly strewn with them, and, again, at similar elevations over considerable areas they are almost entirely absent.

I would suggest that their partial distribution may be accounted for by supposing that they were not merely casually dropped from floating icebergs, but deposited wherever they happened to ground. Otherwise the tendency would be for the low ground, which was longer under water than the higher hills, to receive a larger instead of a smaller proportion of them.

The fossils found in the drift-beds, in the determination of which I have been kindly assisted by Mr. Gwyn Jeffreys and also by Mr. Etheridge (of the Geological Survey), Dr. Duncan, and Mr. Jenkins, consist of various marine organisms, sparingly distributed, and including fossils from the Silurian, Carboniferous, Liassic, and Chalk formations; and the vertebra of an aquatic Fowl has recently been found in the gravel near Buildwas Abbey, but I do not think it coeval with the drift. No Mammalian remains have yet been detected. I have endeavoured to ascertain whether any species are peculiar to particular parts of the deposit, but find that, like the rocky constituents, they are indiscriminately distributed through the whole mass of drift, including the clay- and gravel-beds. In the clay the whole of the Shells were exceedingly soft, and difficult to extricate without breaking, and the more perfect examples were obtained from some thin beds of fine gravel immediately over and under it; but, out of several hundred examples, not above six or seven are quite perfect. Of that massive and strong shell, *Cyprina Islandica*, I have detected nothing but fragments scarcely an inch across, and mostly much smaller. The broken and water-worn condition of these remains would support the idea of their long transit from perhaps northern latitudes; but the evidence before us of the repeated tearing-up and redeposition of the beds in which they occur would also account for their fragmentary state. Mr. Jeffreys has, in the second volume of his 'British Conchology' (p. 306), offered another explanation of the condition in which *Cyprina Islandica* occurs in the Boulder-clay.

At the point where the drift-beds rest against the old coast-line of Wenlock shale I made a careful examination of the water-worn surface, with the object of ascertaining if some of the Shells occurred *in situ*, but found nothing different from the usual state: all were broken and fragmentary.

Mr. Gwyn Jeffreys, F.R.S., has made out the following species of Shells, &c., from the drift of Strethill:—

List of Shells, &c., from the Drift at Strethill.

MOLLUSCA.

(*Bivalves.*)

1. Anomia ephippium. A single valve, very soft.
2. Ostrea edulis. Some very thick, others thinner and of younger growth.
3. Pecten opercularis. Mostly small fragments.
4. Mytilus edulis.
5. —— modiolus.
6. Cardium echinatum.
7. —— edule. Abundant; some small valves quite perfect.
8. Cyprina Islandica. Small fragments plentiful.
9. Astarte borealis.
10. Venus exoleta.
11. —— lincta. A very perfect valve.
12. —— verrucosa.
13. —— gallina.
14. Tellina Balthica, var. solidula. { Abundant; several valves perfect and fresh in appearance.
15. —— calcaria.
16. Psammobia Ferroënsis. Eight or nine fragments.
17. Mactra solida.
18. Mya truncata. A single hinge-fragment.
19. Saxicava rugosa, var. arctica.
20. Pholas crispata. Four fragments.
21. Teredo Norvegica. Part of a tube.

(*Univalves.*)

22. Dentalium entale. Four or five examples.
23. Trochus magus.
24. —— umbilicatus. } A single broken example of each.
25. —— cinerarius, var.
26. Littorina litorea. Two or three examples.
27. —— rudis. One example.
28. Turritella terebra. The most frequent species.
29. Aporrhaïs pes-pelicani. Three examples.
30. Purpura lapillus. Five or six tolerably perfect examples.
31. Murex erinaceus. Four or five good examples.
32. Nassa reticulata. One example.
33. Buccinum undatum. Two or three examples.
34. Fusus antiquus. Much broken; one specimen perforated by *Cliona celata.*
35. Defrancia turricula. Three examples.

CIRRIPEDES.

36. Balanus Hameri.
37. —— porcatus.
38. —— sulcatus.
39. —— balanoides.

ANNELID.

40. Pomatoceros triquetra, on *Ostrea edulis.*

SPONGE.

41. Cliona celata in, *Fusus antiquus.*

Mr. Jeffreys suspects that there may have been some mistake as to *Trochus umbilicatus* and the variety of *T. cinerarius,* because they are both southern forms; and he suggests that they may have been intentionally or accidentally introduced into the railway-cutting, or brought to me with genuine drift-shells; but he also remarks that the other species do not indicate peculiarly arctic conditions. The following species have also been brought me by the navvies, respecting the occurrence of which similar doubt exists:—*Patella vulgata*, very fresh in appearance and covered with Conferva; *Meleagrina margaritifera*; *Strombus accipitrinus*, a West Indian Shell; also fresh-looking specimens of *Purpura lapillus*, *Pecten opercularis*, and *Cardium edule*.

The Bridgnorth beds have, up to the present time, afforded but a single specimen of *Purpura lapillus*, from the gravel-pits behind St. James's, in addition to a few very small fragments of bivalves in the Severn-Valley railway-cuttings, two miles south of Bridgnorth. In the Buildwas beds, where vast quantities of gravel have been dug for ballasting the Severn-Valley and Wenlock Railways, broken fragments of Shells also occur, including *Cyprina*, *Cardium*, *Venus*, *Turritella*, and other genera; but, as they have not been examined with the same care as those from the Strethill cutting, a complete list cannot be given.

The vegetable remains of the drift-period of the Severn Valley are limited to drift-wood, of which some very small fragments have been detected in the Buildwas gravels; and a labourer in my employment also informed me that some years ago, when working in the Willey gravel-pits, he came upon a large piece of blackened oak timber. I have recently procured some small specimens from the same locality, and also a small water-worn fragment of yew wood from the Strethill clay-bed.

A careful examination of the drift has convinced me that the great bulk of the materials of those in the Severn Valley, situated within 300 feet of the sea-level, were certainly of local origin. It will be seen from the list of rocks already given that the principal constituents of the Strethill deposits now occur *in situ*, either close at hand or within three or four miles. A few, such as the Lias- and Chalk-remains, are further removed, and the granite-pebbles and boulders appear to have come 120 miles from the north. At first sight, the presence in the drift of such foreign materials furnishes evidence of long transit; but the actual proof of this is only of a negative character, as we know not how near such formations as the Chalk and Lias originally existed, before the face of the country was subject to that erosion which the deposits of the drift represent.

It must be remembered that the mere bulk of a drift-deposit gives but slight evidence of the bulk of eroded strata from which it was derived. We have little evidence to show the proportionate bulk which the gravels bear to the finely triturated matter which would be carried away in watery suspension, or of the extent to which the gravel-beds have been denuded after their first deposition. So that whilst, in the existence of drift between 200 and 300 feet thick, we have strong positive evidence of vast degradation of the older rocks, we see no limit to the extent to which that degradation took place during the deposition of the drift. The more we look into the drift-phenomena, the more convinced are we how very different the contour of the country must have been before the submergence of the land, notwithstanding the probable existence of the present larger river-valleys, and we should hesitate before assigning exact distances for the transit of rocks which now only occur *in situ* a long way off. Two separate epochs of denudation appear evident,—firstly, that of the denudation of the older formations to supply the materials of the drift, and secondly, after an intervening period of comparative rest, that of the erosion of the drift itself, accompanied by a further degradation of the older rocks; for the rounded contour of the knolls of drift occurring at Strethill and Buildwas, as before observed, is quite independent of the stratification of their gravels, and, with the rounded contour of the Wenlock shale and other older formations, appears as though the whole had been eroded together.

I would suggest that the first degradation of the older formations took place during the submergence of the land, that the drift-deposits had attained their greatest thickness when the full submergence was accomplished, and that, during the gradual elevation of the land, when its whole surface would have successively again come under erosive action, the drift was gradually denuded with a further degradation of the older formations.

It is impossible to compare the numerous outlying patches of drift, the various levels at which they occur, and the great individual thickness of some of the isolated patches, without being convinced of the large proportion that has been removed, compared with what remains.

The valley above Ironbridge is shut in by hills rising 500 feet above the present level of the Severn; and as it now contains knolls of drift, upwards of 200 feet high, that have escaped the erosive action of the subsiding waters, it appears more than probable that the valley up to and beyond Shrewsbury was at one time (before the second erosion) filled up with a great and even mass of the drift-deposit. The Strethill knoll was evidently not an isolated patch, for at its very summit, 200 feet above the river, it has a level stratification quite independent of its rounded outline, and must have extended across the valley, and formed a barrier adjacent to the gorge, between the Silurian ridge of Benthall Edge on the west and Lincoln Hill on the east, through which the Severn slowly ate out its course during the elevation of the land. It is scarcely possible to speculate as to the original consecutive thickness of this deposit; but I may mention that at Ryden Hill, on the top of Benthall Edge (see fig. 1), not above a mile and a half from the Strethill knoll, a deposit of drift-sand and shingle occurs, 250 feet above the stratified summit of Strethill, with which it is precisely identical in character.

That such a vast consecutive thickness as nearly 500 feet once existed of a deposit which now has but a local distribution seems scarcely probable; but as such isolated patches, many of them of considerable bulk, occur on the high land immediately adjacent to the valley, at elevations of from 400 to 550 feet above its present bottom, it is easy to understand how such thick masses as that at Strethill might accumulate and fill up the narrow valley.

When we reflect on the variety of conditions under which the drift must have been deposited and modified, from the time of the first erosion of the older formations to the present denuded remnants of gravel, we need not be surprised at the variety of aspects it presents. The vast changes of outline of the older rocks involved in merely providing materials for its formation, and the continual changes of outline of land and water resulting from the depression and subsequent elevation of land, of at least 900 feet, would repeatedly vary the proportion of materials brought under erosive action.

When it is remembered that these changes of contour in an island-covered sea, full of narrow and changing channels, would continually vary the force and direction of the eroding currents, that such changes may have greatly varied in neighbouring localities, and that these deposits of débris must, in the subsidence and elevation of the land, have been often torn up and redeposited with different proportions of freshly eroded matter, we shall not wonder at drifts apparently of contemporary deposition presenting in different localities that variety of aspect which renders their comparison so perplexing, and is so notably different from the persistent character of deep-sea deposits.

Drift may occur, whether on the present surface of the earth or amongst the older geological formations, wherever denudation has taken place, and must essentially be local in character and irregular in distribution; it is often dissevered from the finer sedimentary deposits contemporaneously derived from the degradation of antecedent formations, and probably carried hundreds of miles away into the deepest basins of the ocean.

Drift-matter generally implies the existence of an old coast-line. It was seldom accumulated except near the tidal range; and in tracing it from low to high ground, we must attribute its wide distribution and range of altitude to the progressive advance or retrogression of the waters, making successively every part of the land on which it was formed an old sea-border, and bringing it under the erosive action of the waves.

We may suppose the gradual advance of the waters, first forming estuaries in our lowest valleys, then creeping up the hill-sides, severing England from Wales, and England into two or three large islands, and then forming the mountain-tops into an archipelago, depositing a succession of beaches at various levels during its progress; and possibly the whole land was covered by a widely expanding ocean unmarked by a single mountain-top or islet.

From the very large proportion of the débris that has accumulated in our valleys, compared with that on the high ground, we are too apt to picture to ourselves that the valleys were almost exclusively the scene of the submergence that the drift represents. But the lower the level of the old coast-line, the larger was its circuit, and the greater would be the bulk of eroded matter; and in looking for evidence of the presence of the waters at high levels, we must not expect to find the same bulk of drift as in the lowlands, on account of the smaller proportionate mass of land that would be available for their derivation, and the greater facility with which they would be denuded on mountain-tops. It is only surprising that any record whatever has been left of the presence of the waters over the steep mountain-tops, apparently out of the range of any débris excepting that derived from their own mass.

We have, however, in the occurrence of drift in North Wales at an altitude of 2300 feet, evidence of a submergence vastly greater in extent than that necessary to produce the drift-phenomena of the Severn and other valleys. Whilst we can have no certain proof of the limit to the extent or duration of the submergence, we may be allowed to conjecture that such phenomena as those developed in the drift of the Upper Severn Valley may have been but comparatively very short episodes in the history of the oscillation of level in which their deposition and subsequent denudation was included; the first during the commencement of the submergence, and the second when the present level had been nearly recovered, and the long-submerged land and its drift-beds were again appearing above the waters, presenting their surface along successive new coast-lines to the eroding action of the waves, and soon to be repeopled with terrestrial life.

February 3, 1864.

Charles William Villiers-Bradford, Esq., B.A., of St. Catherine's College, Cambridge, and Greatham Rectory, Petersfield, was elected a Fellow.

The following communication was read:—

On the Permian Rocks *of the* North-West *of* England, *and their* Extension *into* Scotland. By Sir Roderick I. Murchison, K.C.B., D.C.L., F.R.S., F.G.S., &c., Director-General of the Geological Survey of Great Britain; and Robert Harkness, F.R.S., F.G.S., Professor of Geology, Queen's College, Cork.

Introduction. By Sir R. I. Murchison.

The data which are presented to the Society in the following Memoir have for the most part been established by the researches of my associate, Professor Harkness, whose previous labours* on the same subject are well known to geologists, and who, with one exception, has prepared all the maps and coloured sections which are now exhibited.

In the following Memoir, as well as in a brief outline of the same subject communicated by us to the last Meeting of the British Association at Newcastle, we propound that which is, in truth, a new view of the aggregate of the component parts of the Permian Group in Britain. By this arrangement we place these rocks in direct

* Quart. Journ. Geol. Soc. vol. xviii. p. 206.

correlation with their equivalents in Russia and Germany—the regions in which they are most expanded, and to their arrangement in which I first called attention*. This novel feature in British classification is the absolute connexion with the Zechstein (Magnesian Limestone) or its equivalents, of great masses of superposed red sandstones, which, in the north-west of England, we propose to remove from the New Red Sandstone or Trias, to which they have hitherto been assigned, as we consider them, on the contrary, to be the natural upper limit of the palæozoic deposits. In this way, we affirm that the tripartite arrangement which I insisted on some years ago as existing in parts of Germany—of a Lower Sandstone or Rothliegende, a central limestone or Zechstein, and a connected superior sandstone—is clearly developed in the counties of Westmoreland, Cumberland, and Lancashire. As this arrangement involves a considerable change in all previous geological maps, I now present a new edition of my little general map of England and Wales, in which this new delimitation in the north-west of England is given.

It is with great satisfaction that I state, that the conviction of my colleague and self upon this point has been also arrived at by the independent researches of our friend Mr. E. W. Binney, who, more than any one of our countrymen, has vigorously and ably explored and brought into order the Permian rocks of the north-west of England, and has also followed out their relations into Dumfriesshire and the adjacent parts of Scotland†. Incredulous, in the first instance, as he has himself assured me, regarding the natural connexion in Britain between the Upper Sandstone above alluded to and those fossiliferous shales near Manchester that represent the Magnesian Limestone, he has no longer any doubt that, and entirely coincides with us in considering, the sandstones of St. Bees Head, Corby, and other places described in this Memoir, as the upper member of the Permian group.

In the following pages we indicate how essentially the Permian rocks of the north-west of England differ in lithological details from the deposits of the same age in the north-eastern parts of our country, or opposite flank of the Pennine chain—the tract which, on account of the large spread of Magnesian Limestone, and the presence of numerous fossils, has naturally been considered typical of this portion of the geological series; particularly after the masterly description of it by Professor Sedgwick, in the third volume (2nd Series) of the Geological Transactions.

At the period when Professor Sedgwick wrote, the western side of the Permian chain had been comparatively little explored; but he well described the correct mineral character and characteristic fossils of these rocks, particularly in the eastern counties, where he has since been followed by the valuable contributions of King, Howse, and Kirkby.

* See Quart. Journ. Geol. Soc. vol. i. p. 81, and 'Siluria,' 2nd edit. pp. 325 to 347.

† See the various Memoirs of Mr. Binney in Mem. Lit. and Phil. Soc., and Trans. Geol. Soc. of Manchester.

Even in the western region, to which we now invite attention, Professor Sedgwick showed the existence of equivalents of the eastern Magnesian Limestone at St. Bees Head and in Furness, though he did not propose to unite, as we do, the lower and the upper Red Sandstones in the same natural group; on the contrary, the upper sandstone (the Upper Permian or St. Bees Sandstone of our Memoir) has been left to this day in all maps as the New Red or Bunter Sandstone.

The transference of the sandstones of St. Bees and Corby to the Permian group is, we grant, not founded on any evidence of a continuation of a similar type of a fossil Fauna or Flora. We base our conclusions on the evidence afforded by clear and unmistakeable sections, which show that these upper sandstones are connected with the lower sandstone or Rothliegende through the intervention of the Magnesian Limestone or its equivalent, and that, thus united, all these strata, from the base to the summit, form a continuous series. In truth, the central or calcareous member has alone as yet proved to be really fossiliferous; certain footsteps only having been observed in the lower sandstone.

Turning to the consideration of the Continental equivalents of these rocks, let me say, that, in exploring Russia, I was led, by comparing the rocks of this age with those of Britain and Germany, to dwell upon the highly diversified or protean characters of these deposits. I observed that, in the vast regions around the large ancient kingdom of Permia, the lithological distribution was very different from that of synchronous deposits in Germany and Britain, and yet I saw that the age of the strata was clearly proved by order of superposition, and by imbedded fossils distinct from those of the Carboniferous rocks below and those of the Trias above.

My several researches in Germany having strengthened the conviction, as expressed in the second edition of 'Siluria,' and in a Memoir offered last year to this Society, it has given me great satisfaction to examine, in company with Professor Harkness, all the chief localities to which we allude, and to convince myself that these British sections fairly sustain the conclusions at which I had arrived by the survey of foreign tracts. The exploration of last summer, following upon previous examination of the fossiliferous Permian shales near Manchester, as well as my old inference that the south-western Scottish or Dumfriesshire red sandstones were of Permian age, have completely satisfied me that, notwithstanding their very striking lithological dissimilarity, the magnesian strata to the east of the Permian chain, and the red sandstones to the west of it, are truly synchronous groups. Again, in the sandstones of the east and west of England the distinction is most striking. Thus, whilst, according to Sedgwick and all his successors, including myself, the incoherent yellow sandstone of Durham is a true though poor representative of the Rothliegende of the Germans, this rock has not the remotest resemblance to the red sandstones and conglomerates which occupy the same place in the series in our own north-western tract. Even on the eastern side of the island the changeful nature of this Lower Permian Sandstone has been specially pointed out by myself. For the very same strata beneath the Magnesian Limestone, which on the banks of the Wear, in Durham, are soft yellow sandstone, become on the banks of the Nid, in Yorkshire, and west of Knaresborough a pebbly brownish-red and white conglomerate, which closely resembles the Rothliegende of Germany*.

With this vast dissimilarity in the lithological development of rocks of this age in our own island, we need not wonder if we find still greater diversities prevailing when we follow these deposits into Germany and Russia. In the first of these countries the lower member of the group (Rothliegende) has been abundantly transposed by igneous eruptions, which have swollen it out and produced many modifications of original structure†. Again, in Russia, though igneous rocks are not abundant in these deposits, considerable mineral changes have been effected in them,—hot springs, sulphureous vapours, the transformation on a grand scale of cliffs of carbonate of lime into gypsum, and the diffusion of rock-salt and copper ores are abundantly displayed.

Now, although in England no clear evidences of the outburst of those eruptive rocks, or of those signs of powerful chemical action which characterize the foreign Permian rocks, have hitherto been adduced, we bring before our associates that which we consider to be a clear proof that the hæmatite or valuable kidney iron-ore of Cumberland and Lancashire was formed in the early accumulation of the Permian deposits; or, in other words, that that period commenced in the north-west of England with the formation of this ore. Whether this substance resulted from the deposit of hot springs or otherwise, we therefore regard it as one of the signs of that intense chemical agency of which the Permian rocks of the Continent offer so many proofs. As great doubts have prevailed concerning the age of this hæmatite, which occurs in the abraded cavities of the Carboniferous Limestone, we consider ourselves fortunate in being able to show its absolute connexion with the Permian breccia or conglomerate, and thus to sustain a sagacious suggestion of Professor Phillips, that such might prove to be the age of this hæmatite‡.

If it be asked whether the Trias has disappeared altogether in this north-western region, we can only say, that there are sandstones and red and green marls in the environs of Carlisle, superior to our Permian rocks, which we refer to that group; and Mr. Binney, who has also examined this area, has shown that Liassic strata occur in the flat district south of the Solway Firth.

In this Introduction I would remind my associates, that the evidences of a tripartite arrangement of the Permian group, that is, of lower and upper sandstones, and an intermediate limestone, or its fossiliferous equivalent, which we show to exist in England, enable us to correlate our British deposits of this age with the formations I have examined over extensive foreign tracts, and they demonstrate the inapplicability of the term Dyas to this group.

* See 'Siluria,' 2nd edit. p. 348.

† See my last Memoir on the Permian Rocks of North-eastern Bohemia, Quart. Journn. Geol. Soc. vol. xix. p. 297.

‡ See Rep. Brit. Assoc. 1858, Trans. Sect. p. 106.

The more the variable lithological development of these rocks in different countries is established, the more I venture to think that the term Permian, as taken from by far the largest region occupied by these rocks, will be approved, whenever it is applied to deposits which, however changeful in lithological arrangement and composition, are characterized, particularly in their central or calcareous portion, by those organic remains which pertain to the youngest member of the palæozoic series,—the strata of which are as clearly separated from the Carboniferous rocks beneath as from the New Red or Triassic rocks above them.

In the Memoir which follows, the different members of these Permian rocks will be described in ascending order, commencing with the Lower Red Sandstone or Rothliegende, which immediately overlies many of our coal-fields.

Contents.

§ 1. *Lower Permian, or Penrith Sandstones.*

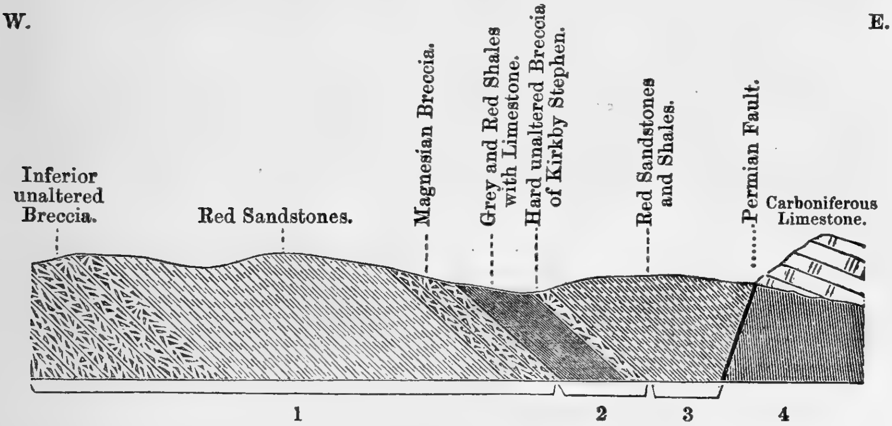
This term, which is equivalent to that of Inferior Sandstone of Sedgwick, Lower Red Sandstone of Murchison's 'Silurian System,' and Rothliegende of the German geologists, is applied to a thick mass of rocks, usually of a light-red colour, and possessing well-marked mineral characters, as exhibited in an extensive district in Westmoreland and Cumberland, especially around the town of Penrith. The area occupied by these sandstones in Cumberland and Westmoreland has been already described*, its western and south-western margin being a line of fault corresponding nearly in extent with the Great Permian fault, as it is developed in these counties, and having nearly the same course. By means of this fault the western and south-western edges of the Lower Permian are brought into contact with the Carboniferous formation.

a. *Valley of the Eden.*—The strata composing the Lower Permian are well exhibited in the section from Great Ormside to Roman Fell,

* Quart. Journ. Geol. Soc. vol. xviii. pp. 206 *et seq.*

which may be regarded as the type-section of this series of rocks*. In this section the base of the series consists of breccias, locally called " brockrams," composed, for the most part, of unaltered fragments of Carboniferous Limestone. To these there succeeds a thick mass of red sandstones, upon which are superposed other breccias

Fig. 1.—*Generalized Section of the Permian Rocks of the Eden Valley.*



1. Penrith Sandstone (Lower Permian). 2. Hilton plant-beds (Middle Permian).
3. Corby or St. Bees Sandstone (Upper Permian). 4. Lower Silurian.

having red sandstones intercalated in them. The higher breccias, locally termed " rotten brockrams," are also to a considerable extent made up of limestone-fragments, but which, in every instance, are converted into dolomite. The inferior unaltered breccias are not seen in Cumberland in connexion with the Penrith sandstones; and in Westmoreland they are confined to the district west of Appleby, where alone the lowest portion of this series is seen. The succeeding sandstones, which spread themselves over the whole of the Lower Permian area, possess peculiar mineral characters. They are, almost exclusively, made up of grains of quartz, many of which retain the facets of the original quartz-crystals, reflecting solar rays therefrom. The quartz grains are of more than usual size, as compared with that of the particles of other siliceous sandstones, are angular or subangular, and give to the rocks which are composed of them the nature of a very fine-grained breccia. Owing to the abundance of oxide of iron, these sandstones have commonly a bright-red colour; but occasionally perfectly white strata are associated with the red beds, the absence of oxide of iron alone distinguishing the two. These white sandstones are largely quarried to the east and north-east of Penrith, and many new houses are built of them.

The higher breccias, " rotten brockrams," like those appertaining to the base of the series, are, in the Vale of the Eden, of local occurrence. They are well seen in the Hilton-beck, a stream descending from Roman Fell to the Eden, which traverses along the dip the greater part of the Permian rocks of Westmoreland; and they also

* *Op. cit. suprà*, p. 207.

occur abundantly in the neighbourhood of Brough and Kirkby Stephen. Here the magnesian-limestone fragments frequently present themselves hollow in the interior, possessing the characters of potato-stone. Besides dolomitic limestones, these higher breccias have fragments of vein-quartz and Silurian slates entering into their composition.

The Lower Permians of the Valley of the Eden have a great thickness (2000 feet), but have hitherto afforded no fossils. Footprints have, however, been obtained from some of the beds near Penrith, and are considered to be analogous to those of Corncockle Muir in Dumfriesshire.

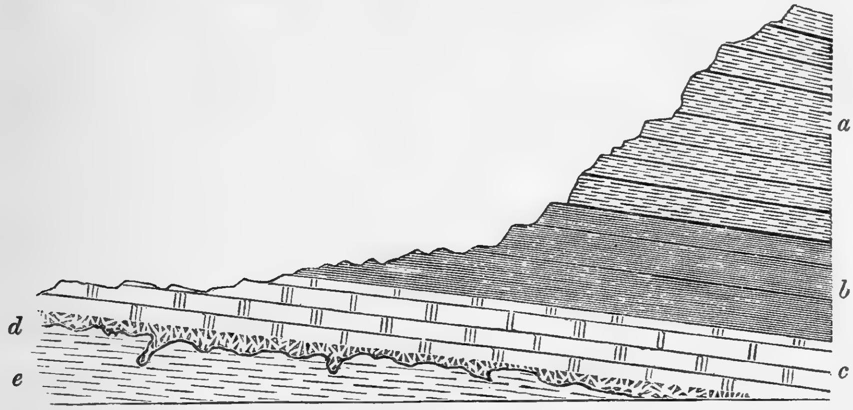
Although the breccias of the Penrith sandstones have, to a great extent, only a local persistence, they afford important information concerning certain superinduced structures which are, perhaps, more peculiar to the Permian formation than to any other of the groups of British sedimentary rocks. This is seen in the abundance of dolomitized or magnesian limestones which are contained in and towards the central portion of the Permian series. These dolomitized fragments of the higher breccias, there is every reason to infer, were originally deposited in the condition of simple limestones like those of the lower breccias of the same group. The magnesian breccias are not confined to the Vale of the Eden; they occur also in the course of the Shalk-beck, about two miles south of Curthwaite Station, on the Carlisle and Maryport Railway, where they form the higher member of the Penrith sandstones.

The Lower Permian sandstones of Cumberland and Westmoreland have a feature which serves to distinguish them from other and higher sandstones of the group, and which will be subsequently alluded to. They abound in hard transverse *veins* composed of quartzose sandstone, the particles of which are similar to those of the ordinary red sandstone. These veins are white in colour, and much harder than the mass of red sandstone which encloses them; every good section of the Penrith sandstones exposes them, but they are best seen in the middle portion of the series. They are strikingly exposed on the banks of the Eden, in the faces of the romantic cliffs near the Nunnery, about two miles north-west of Kirkoswald. Here they stand out from the red and white sandstones in consequence of their superior hardness, and at one spot a vein about two feet thick is a mass of perfect chert.

Veins also occur in connexion with the magnesian breccias at Hilton-beck, where they possess a somewhat different mineral nature, being composed of sand cemented together by magnesian limestone, the latter having doubtless been derived from the dolomitized fragments imbedded in the strata. The character of the veins changes as we descend Hilton-beck towards the underlying red sandstones, where ordinary white-sandstone veins make their appearance. The latter are usually widest in their upper parts, and seem to have been filled in from above.

b. *Barrowmouth, near Whitehaven.*—At Barrowmouth, near Whitehaven, on the north-east side of St. Bees Head, we have a small area of Penrith sandstones exhibited, and here also other Permian rocks occur. This area, which is altogether detached from that of the Vale of the Eden and the Great Cumberland Plain, has been noticed by Professor Sedgwick* and Mr. Binney†. The Penrith sandstones here are very thin—not more than three feet on an average. Their dimensions are, however, very irregular, as they have been deposited on the eroded surface of a purple Carboniferous sandstone on which they repose (see fig. 2). In lithological character these sandstones resemble the magnesian breccias of Hilton-beck, and, as in them, the limestone-fragments have usually the potato-stone feature. The only portion of the Penrith sandstones represented here are the highest beds.

Fig. 2.—*Section at Barrowmouth, near Whitehaven.*



a. Upper Permian, or St. Bees Sandstone.
b. Red and green marls with gypsum.
c. Yellow magnesian limestone with fossils.
d. Breccia of *e*, being the Upper member of the Lower Permian, passing into *c*.
e. Coal-sandstone.

In no other localities in Cumberland or Westmoreland have we any exhibition of the Penrith sandstones, or lowest member of the Permian group. There is, on the Cumberland coast south of St. Bees, a red sandstone which has been referred to by Professor Sedgwick. This, however, is not well exposed, but it probably belongs to the highest portion of the Permian series to be subsequently alluded to.

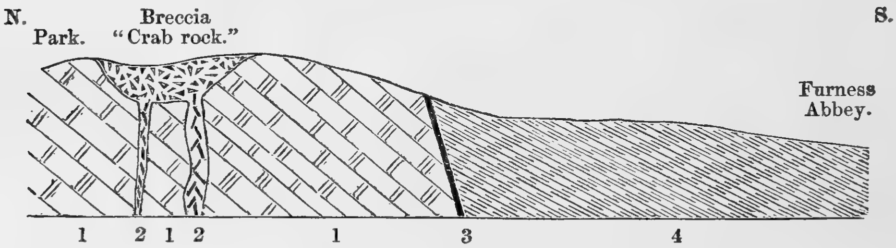
In the district of Furness, in Lancashire, the representatives of the Lower Permian sandstones occur, but only to a slight extent, yet under circumstances of very great interest.

c. *Furness area.*—The Furness Railway, at Park, from about a mile and a half to two miles north of Furness Abbey, exhibits the lowest of the Permian rocks. A section opened out by the railroad-cutting is here in part through Carboniferous Limestone, which forms the lowest rock seen. Reposing upon this limestone is a mass of a peculiar character, consisting of angular fragments of limestone, partially cemented together in the higher part, but having interspaces between the fragments in the lower portion. This peculiar limestone-breccia is locally known as "Crab rock."

* Geol. Trans., 2nd Series, vol. iv. p. 395.
† Mem. of Lit. and Phil. Soc. of Manchester, vol. xii. p. 51.

This "Crab rock," as seen in the section, is in some parts twenty feet thick; but its thickness is very irregular as it spreads over the eroded edges of the Carboniferous Limestone. It is seen, not only reposing unconformably upon the Carboniferous rocks, but also enclosing veins of hæmatite (see fig. 3). Another locality where this breccia or "Crab rock" appears is St. Helen's, about half a mile to the north of the Park cutting, and immediately east from the railway. Here the Carboniferous Limestones have the breccia also spread out upon their surfaces, and into some of the open joints which intersect the underlying strata the "Crab rock" has found its way. At Dalton the same relations occur. Near the church the "Crab rock," consisting of unaltered fragments of limestone cemented together by a red matrix, also covers over the Carboniferous strata. This "Crab rock" is well known to miners, who have noticed that where hæmatite occurs below it, in the Ulverstone district, the latter is always in intimate relation to the former.

Fig. 3.—*Section from Park to Furness Abbey* (1½ mile).



1. Carboniferous Limestone.
2. Hæmatite.
3. Fault.
4. Corby Sandstone.

With reference to the position of the "Crab rock," its mineral characters lead to the conclusion that it is of like age with the lower and unaltered breccias of Burrells, west of Appleby; for it possesses none of the magnesian features appertaining to the higher breccias. Here, therefore, the lowest Permian rocks of the north-west of England are seen; and after the clear and unmistakeable natural section at Barrowmouth, under St. Bees Head, where the Lower Permian is reduced to a few feet in thickness, we have no occasion to call in the agency of great denudation in the Furness district.

In truth, it is quite manifest that along the western flank of the old slaty mountains of Cumberland we meet only with ridges or patches of Carboniferous Limestone, which, with the exception of the very partial breccias above described, are at once surrounded by the middle and higher members of the Permian group, of which hereafter.

d. *Hæmatite in the Lower Permians.*—The mode in which that valuable ore of iron, *hæmatite,* is found deposited in pre-existing cavities of the Carboniferous formation, and sealed up by "Crab rock," is a matter of great geological interest. Joints, fissures, and caverns were doubtless formed in the older rocks antecedent to the deposition of the Permian strata, and in these the ores of iron so widely diffused throughout the Permian rocks have, in this portion of the north-western region, assumed the characters of hæmatite.

This circumstance justifies the inference that these hæmatite ores are the result of an agency which ushered in the Permian epoch. The earlier Permian rocks of both England and Scotland are strongly impregnated with iron, their composition consisting principally of silica and an oxide of this metal.

This latter substance originated from the same source which, during the commencement of the deposition of the Penrith sandstones, filled up the fissures in the Carboniferous Limestone. This conclusion is applicable not only to the Ulverstone district, but also to that of Cleator, south-east of Whitehaven, where valuable deposits of hæmatite are also obtained from the cavities and fissures in the Carboniferous Limestone, which, at one time, was here covered over by an extension of those Permian breccias and sandstones now forming an escarpment a short distance west from Cleator Moor. This inference concerning the Permian age of the hæmatite had been arrived at by Professor Phillips, who in a communication to the British Association, of which a short abstract was published (Report of Brit. Assoc. 1858, Trans. Sects. p. 106), illustrated his opinions by maps and drawings.

There are three other small areas where the Lower Permian rocks occur in the north-west of England. They have been described by Mr. Binney. One of them is at Rougham Point, in the southern portion of the Cartmell Promontory; the second is at West House, near Burton-in-Lonsdale; and the third at Ireby, about four miles south-east of Kirkby Lonsdale. In these localities occur breccias indicative of a low position in the Penrith sandstones.

e. *Lower Permian Rocks of Scotland.*—In Scotland there are several areas where the Lower Permian sandstones occur, the details concerning which have been already published*. It is only necessary, therefore, to state that, lithologically, these Scottish Lower Permian rocks are very nearly allied to those of the Vale of the Eden, there being a breccia at the base, a middle member consisting of red sandstones identical in all respects with the sandstones of Penrith, and succeeded by higher breccias.

The difference in the rocks of the Scotch and English Lower Permians is confined to the nature of the fragments which make up the breccias. These are, in the former, for the most part fragments of the Lower Silurian rocks, against which the Permian strata of Scotland usually repose.

There is, however, one locality, namely, Dalton Hook in Dumfriesshire, where the Scottish members of the lower sandstones are precisely similar to those west of Appleby, being composed of unaltered limestone-fragments; and here the Lower Permian is in contact with the Carboniferous formation. It is not in mineral character only that the Lower Permians of the north-west of England and the south of Scotland agree; there is also a point of agreement in the footprints, the only evidence of life which these strata contain. Even as building-stones the rocks of the two countries have great

* Quart. Journ. Geol. Soc. vol. xii. pp. 254 *et seq.*

affinity; for, taking one of the areas most remote from the English border, that of the centre of the Vale of the Nith, we find that whilst the more solid and thicker red beds, out of which Drumlanrig Castle has been built, resemble the chief masses of the sandstones around Penrith, the thinner and broad flaglike portions which are exposed in the numerous quarries near Thornhill, and used for roofing-purposes in Dumfriesshire, have their exact representatives in Cumberland, in the hilly tracts N.N.E. of Penrith.

§ 2. *Middle Permian, or Magnesian Limestone Rocks.*

a. *Valley of the Eden.*—The middle member of the Permian rocks of the north-west of England—the Hilton shales, sandstones, and limestones of Westmoreland (equivalents of the Magnesian Limestone of the east of England, the Zechstein of the Germans)—has a more varied mineral character than the two other divisions of this formation. This member is well represented in Hilton-beck, overlying conformably the lower sandstones; and, as some interesting fossils occur here, the term Hilton shales, sandstones, and limestones is applied to the central portion of the Permian rocks of the north-west of England. These Hilton beds, or their equivalents, subtend and overlie the Penrith sandstone on the east, in the Vale of the Eden, and the direction in which these strata strike conforms very nearly to the course of the great Pennine fault. Southwards from Hilton-beck the Middle Permian consists of red clays, except as seen in Bela Water, where they approximate somewhat to the Hilton type; and northwards from Hilton-beck red clays are their usual components, with, in some localities, lenticular masses of gypsum. The ordinary form which they exhibit is well seen in the course of the Crowdundle-beck, at Newbiggin, in the grounds of our kind friend Mr. Crackenthorpe.

The basement-beds of the Middle Permian rocks, as seen in Hilton-beck, are finely exposed at Ash Bank, and consist of cream-coloured shaly sandstones with thin partings of grey shale, and occasionally a narrow band of impure sandy limestone which weathers brown. These beds contain a considerable number of vegetable remains, among which Mr. Etheridge has recognized the following:—*Sphenopteris Naumanni*, Gutbier, *S. dichotoma*, Althaus, *Alethopteris Goepperti*, Naum., *Ullmania selaginoides*, *U. Bronnii* (base of cones showing bracts), *Odontopteris*, sp.?, *Sphenopteris*, sp.?, and *Cardiocarpon triangulare*, Gein. Portions of coniferous wood also occur; and as the remains are usually in the form of detached leaves and bracts of cones, they seem to be the relics of autumnal vegetation*.

Of these Plants, two, *Ullmania selaginoides* and *U. Bronnii*, are common at the base of the Magnesian Limestone of Midderidge in Durham, and the other forms occur, along with *Ullmaniæ*, in the Kupferschiefer of Germany. The fossil contents of the lower por-

* Through the kindness of the Earl of Lonsdale, the proprietor of Ash Bank, we were enabled to obtain most of the specimens of these Plants by cutting away a small portion of the escarpment in which they occur.

tion of the Hilton series indicate, therefore, an absolute identity in fossil remains with the base of the Magnesian Limestone, or Zechstein, and even in lithological nature these strata nearly approximate to the marl-slates of the county of Durham.

The plant-bearing strata of Hilton-beck are succeeded upwards by thin-bedded sandstones with impure limestones and shales, the highest member being red clays, having the ordinary aspect of the more common representative of the Middle Permian strata of the north-west of England. As the country is much covered by drift and only laid open by ravines at intervals, it is not to be expected that we should be able to follow out these few feet of plant-bearing beds upon the strike to the north or south, and, in truth, no clear evidence of their occurrence has yet been detected except by the sides of Hilton-beck.

b. *Barrowmouth, near Whitehaven.* — Beyond the Vale of the Eden and the Cumberland Plain we have the Middle Permian rocks more distinctly exhibited in the form of a true yellowish sandy magnesian limestone at Barrowmouth, under St. Bees Head, than in any other locality in the north-west of England, and in them are typical fossil Shells. These strata have been described by Professor Sedgwick * and Mr. Binney †. The latter geologist gives the section of the rocks as seen here in detail, and points out the occurrence of fossil Shells in the magnesian limestone in the state of casts. This limestone is described by Prof. Sedgwick as running S.S.E. to Ben How quarry, about a mile from Barrowmouth. We traced it still further. It is seen in Demain-gill, where it was formerly worked, and also in Chambers Bodell Wood, where it is about seven yards in thickness, and overlain conformably by red shales. This limestone changes greatly in colour, being yellow at Barrowmouth. At Preston How quarry, where it is worked for road-metal, its colour is grey, with purple spots. At Demain-gill it is still darker, and is locally known as "black limestone." Wherever it occurs, it is transgressive upon the coal-measures, as pointed out by Prof. Sedgwick, from an examination of sinkings in connexion with the Croft-pit, near Barrowmouth. This limestone, along with the overlying shales and sandstones, forms an escarpment on its line of outcrop, and this escarpment is the eastern limit of the Permian rocks near Whitehaven.

Succeeding quite conformably to the band of magnesian limestones is the highest member of the middle series of Permian rocks of St. Bees Head at Barrowmouth. This is a mass of red shales, containing fine white gypsum, which Mr. Binney estimates at 29 feet in thickness. The mineral character of this band is identical with the red shales and gypsum forming the middle portion of the Permian formation in the Valley of the Eden. At Barrowmouth, therefore, the middle member of the Permians consists of limestone with Permian Shells, and red shales with gypsum, whilst at Hilton-beck the contemporaneous strata consist of yellow and grey shales

* *Op. cit. suprà*, pp. 395 and 406.

† Mem. Lit. Phil. Soc. Manchester, vol. xii. p. 51.

with true Permian Plants, sandstones, limestones, and red shales, passing upwards into gypsiferous red shales.

c. *Furness area.*—Another locality where the Middle Permian rocks occur is at Hole-beck, near the village of Stank, about two miles south-east of Furness Abbey. The strata here have been noticed by Prof. Sedgwick and Mr. Binney. The exposure of rocks is, however, by no means satisfactory, consisting of a small portion of an old quarry now mostly covered up with soil or by brushwood. The rock is a yellow cellular magnesian limestone, which was formerly used in the village of Stank as a building-stone. Its nature and its position with reference to the Carboniferous rocks on the north-east, and the red sandstones on the south-west, allow of very little difficulty in referring it to the magnesian representatives of the Middle Permian series.

The other areas of the north-west of England, before alluded to as containing Lower Permian sandstones, namely, West House and Ireby, do not exhibit Middle Permian strata, nor are there any clear representatives of them exposed in the Permian districts of Scotland.

§ 3. "*Hard Brockram*" *of Kirkby Stephen.*

Before describing the strata succeeding the Middle Permian rocks in the north-west of England, it is necessary to notice a local deposit intervening between the highest portion of the red shales and the base of the Upper Permian series. This deposit is developed only in the neighbourhood of Kirkby Stephen, especially to the south thereof, and consists of a breccia of angular fragments of Carboniferous Limestone, cemented together by a brown matrix. This is the ordinary building-stone of Kirkby Stephen, and, to distinguish it from the soft magnesian breccias, or upper members of the Penrith sandstones, it is designated "hard brockram." Its position and area have been previously described*. Lithologically this "hard brockram" is nearly allied to the inferior *unaltered* breccias at the base of the Penrith sandstones; and with reference to this, the highest of all the breccias of the north-west of England, it is interesting to notice that its *unaltered* character indicates a deposition *after* the operation of that force which dolomitized the middle members of the Permian group†.

§ 4. *Upper Permian.*

The English equivalents of this division are the St. Bees and Corby sandstones; and the foreign equivalents, the Bunter Schiefer of Germany, and the upper sandstone and conglomerate of Russia. In the north-west of England it consists of red sandstones with courses of red shales, all perfectly conformable to the underlying Permian rocks, there being a regular transition or passage into these from the Middle Permians just described. In all situations where we have examined them, whether in Westmoreland, the east of Cumber-

* Quart. Journ. Geol. Soc. vol. xviii. p. 208.

† This rock, "hard brockram," is mapped as Magnesian Limestone by Prof. Phillips, Geology of Yorkshire (1836), vol. ii., and referred to in pp. 120 *et seq.*

land, or in the north portion of St. Bees Head on the west coast, where they are largely and clearly displayed, they exhibit not only a perfect conformity to the Middle Permian strata on which they rest, but also an intimate connexion with them. Whatever may be the angle of inclination of the one is always that of the other, and nowhere is there to be seen a trace of erosion on the upper parts of the supporting strata from which a separation might be inferred, such as would be expected between rocks of palæozoic age and others of a mesozoic date. We have therefore no hesitation in expressing our conviction that these sandstones of St. Bees Head and Corby, or of the western and eastern sides of Cumberland, must be removed from the Upper New Red Sandstone or Trias, with which they have been hitherto grouped, and be viewed as the upper zone of the Permian group.

a. *Valley of the Eden, and Corby.*—The Upper Permian sandstones are only very partially represented in the higher parts of the Vale of the Eden, having been removed by denudation. They are, however, exhibited in the typical section from Great Ormside to Roman Fell, and have in Westmoreland and Cumberland as their eastern boundary, the great Pennine fault. They increase in thickness as they extend from Westmoreland into Cumberland; and they are admirably exposed in those picturesque cliffs forming the banks of the Eden to the south of Corby Castle, where their varied tints of colour, from deep red to almost pure white, and the natural caverns which have been hollowed out in them, when combined with the richest foliage, have attracted many tourists*.

In separating these Upper Permian rocks from the New Red Sandstones, we may remark that there is one characteristic lithological feature of the latter, which scarcely, if ever, appears in the former: they are hardly, if ever, spotted or "bunter." But, in offering this remark, we by no means attach any peculiar value to it, inasmuch as the Old Red Sandstone of Perthshire, and other parts of Scotland, is, if possible, more curiously and abundantly characterized by white and whitish-green round spots than any portion of the New Red or Bunter Sandstone of England.

The great plain of Cumberland is so covered by drift that only a few spots exhibit Upper Permian rocks: one of these is Shalk-beck, a locality before referred to; and west from this point we have the Upper Permians occasionally exposed by the streams which flow northwards from Brocklebank Fells. These streams exhibit the rocks near their southern margin, which is the line of fault before alluded to as forming the south-western limit of the Lower or Penrith sandstones. This fault, on approaching the centre of Cumberland, near Dalston, takes a curved course, and then running W.S.W. enters the sea near Maryport. On assuming the W.S.W. course, the fault has, on its N.N.W. side, the Upper Permian sandstones, denudation

* Our friend Mr. P. H. Howard, of Corby Castle, has, at the request of Sir R. I. Murchison, obligingly transmitted specimens of these good and beautiful building-stones, of which the fine viaduct over the Eden at Corby is built, to the Museum of Practical Geology in Jermyn Street.

not having been sufficiently powerful in this area to remove the upper and middle members of this formation.

The extreme north-western limit where the Upper Permian sandstones are seen is Maryport, beyond which, along the southern shores of the Solway Firth, no rocks are exposed until Rockcliff is reached.

The Upper Permians, forming a trough under the drift of the Cumberland Plain, reappear on the opposite side of the Solway. They are seen at Torduff Point, five miles E.S.E. of Annan, and their extension and arrangement in the south-east of Dumfriesshire, the only part of Scotland where they have hitherto been recognized, have been already described*.

b. *St. Bees Head.* — The Upper Permian sandstones are admirably represented in the St. Bees section, and have been alluded to by Prof. Sedgwick and Mr. Binney, though referred by the first of these authors to the New Red Sandstone, and not to the uppermost palæozoic deposit as in this memoir. This upper member of the Permian formation forms the whole mass of the promontory of St. Bees Head, from Barrowmouth westwards, and here it has precisely the same intimate connexion with the middle series as in the Vale of the Eden. The upper sandstones of St. Bees are also identical in mineral character with those of East Cumberland and Westmoreland, and have the same thin red shales associated with them (see fig. 2, p. 151).

On the south face of St. Bees Head, where the successive ledges are well exposed at low water, and in the impending cliffs, the beds of strong and hard sandstone, nowhere spotted or "poikolitic," and of brownish-red, whitish, and yellowish colours, are indeed very unlike any beds of unequivocal Trias with which we are acquainted, and have much more the aspect of coaly grits and sandstones. By referring to the section from Barrowmouth upwards it will be seen that there, as in Westmoreland, a perfect and unbroken continuation from the Middle Permian into the upper sandstones prevails, preserving precisely the same dip and strike as the fossiliferous limestones and red shales with gypsum on which these upper sandstones repose.

Along the Cumberland coast, to the south of the village of St. Bees, few indications of rock are seen; and although red sandstones do occasionally occur, they are so covered up with blown sand, and are in such small sections, that it is difficult to assign to them their exact position among the Permian rocks †.

c. *Furness area.*—When, however, we reach the north-west coast of Lancashire, the case is very different. Here, especially in the Furness district, besides the "Crab rock" (the base of the Lower Permians), and the Magnesian Limestone of Stank (a member of the Middle Permian group), we have abundant examples of the Upper

* Quart. Journ. Geol. Soc. vol. xviii. p. 214.

† Prof. Phillips refers to the Permian age a considerable part of the Red Sandstones which adjoin the Lower Palæozoic and granitic rocks about Ravenglass and Bootle. (See Geological Map of the British Isles, new edit. 1862.)

sandstones of this formation. These Upper Permian sandstones are separated, in the south and west, by a fault from the Carboniferous Limestone which contains the hæmatite ores.

Around Furness Abbey there are many fine exposures of the Upper Permian sandstones, adding greatly to the beauty of the scenery; and at Howcoat, about a mile and a half south-west of the noble ruin, these sandstones are largely worked, and are the materials which have been used in the construction of Furness Abbey.

The relation of the Upper Permian to the other members of this formation cannot be seen in Furness, the fault just alluded to bringing the higher member of this formation against the Carboniferous Limestone. The Upper Permian sandstones of the Furness area, in Lancashire, have, however, the same mineral type as those of Cumberland, and, indeed, this has been pointed out by Prof. Sedgwick, who remarks upon the identity of the latter with the sandstones of St. Bees and Furness *. In no other portion of the north-west of England do these sandstones occur save in those before referred to.

The Upper Permian sandstones have a well-marked lithological structure. They have a deeper and duller red colour than the Lower Permian sandstones, but they occasionally exhibit whitish and light-coloured layers. They have a much finer grain than the lower series; and the thin red shales, or wayboards, which are associated with them, is a feature absent from the lower or Penrith sandstones. They also frequently exhibit signs indicative of a littoral origin. But, notwithstanding these slight lithological distinctions, the mass of these lower and upper sandstones of Permian age, with their intervening deposits of limestone and gypsum, forms one unbroken and continuous series, which represents in the north-western portion of England the most complete type of the group in the British Isles, as compared with its foreign equivalents before referred to, and constituting the youngest deposits of the Palæozoic series.

§ 5. *Triassic Strata west of Carlisle.*

Before we take leave of the sandstones of the north-west of England it is necessary to refer to some strata exposed in the course of the Eden at and near Carlisle. At Etterby Seam, purple shales, with greenish-grey layers, and spots of a similar colour, are seen forming the north bank of the river. Below, on the opposite side of the river, at Eden Bank, contiguous to the North British Railway-bridge, the same strata occur, forming here a synclinal trough, the sides of which dip E.S.E. and W.N.W. at 35°. Further down the river, between Eden Bank and Grinsdale, the same strata are seen in a nearly horizontal position. A short distance from Grinsdale Church, on the opposite (north) bank of the river, there occur grey shales and impure limestones having an easterly dip, and resting conformably upon a thin series of grey gritty sandstones with rippled surfaces, the beds being about three feet in thickness. Supporting the latter are

* *Op. cit. suprà*, p. 396.

grey laminated false-bedded sandstones, the lower portion of which forms a cliff, well seen near Cargs. The same light-coloured sandstones form the bed of the river to near Kirkandrews. A short distance below Kirkandrews purple and grey shales are again seen in the west bank of the river, their position being nearly horizontal; beyond which, at Beaumont, the same strata dip south at 35°, and the surfaces of the shales here are frequently marked by pseudomorphs of bay-salt. No further traces of these rocks are seen in the Eden, nor do they occur in the district. At Rockcliff red sandstones of the Permian formation make their appearance.

The nature and arrangement of the strata seen in the sections of the Eden near Carlisle, and west of that place, are altogether different from those of the Permian rocks of the north-west of England. The highest beds here consist of purple shales with grey bands, especially in their lower portions. These purple shales greatly resemble those of the Keuper series, the grey beds upon which they rest having considerable affinity to the water-stones; and the light-coloured sandstones are probably the highest members of the Bunter. That these rocks appertain to the portion of the Trias assigned to them is still further corroborated by the fact that Liassic strata occur within a short distance southwards, as shown by Mr. Binney*.

The occurrence of Triassic and Liassic strata in this part of Cumberland results probably from faults throwing down these and the underlying formations. In no portion of Cumberland, however, have we any evidence of the mode in which the lower members of the Mesozoic group are associated with the upper portion of the Palæozoic division.

§ 6. *Dolomitization.*

Reference has already been made to the unaltered character of the lower sandstones. Their nature shows that the dolomitizing influence had not begun to act when they were being deposited. The period when this agency commenced, and that when it ceased, can, so far as the Permian rocks of the north-west of England are concerned, be very nearly determined. Dr. Blyth, of Queen's College, Cork, has kindly furnished us with the results of his analyses of different rocks from various portions of the Permian formation of Cumberland and Westmoreland.

As regards the red sandstones of the Penrith series, a specimen of these from the Beacon quarry, about a mile east of Penrith, consisted almost exclusively of quartz-granules; the cementing matrix of these granules being silicates of lime, iron, and magnesia, the two former being in greater proportions than the latter. The red colour of this sandstone is owing to a considerable amount of oxide of iron incrusting the silica-granules, which can be dissolved off, leaving the granules quite white. The *white* sandstones, occasionally associated with the lower sandstones in the same locality, consist also of quartz-granules cemented together by the same substances; but here the silicates of lime and magnesia are in excess, while the silicate of

* Quart. Journ. Geol. Soc. vol. xv. p. 549.

iron is in smaller proportions; and in this *white* sandstone there is no incrusting oxide of iron. The presence of oxide of iron as an *incrusting* material at this early period of the Permian formation is a proof of the abundance of the substance, which now occurs as veins of hæmatite filling up the fissures in the Carboniferous rocks, during the commencement of the Permian epoch.

The presence of silicate of magnesia as a cementing material in the quartz-granules in the Penrith sandstones indicates the early occurrence of magnesia, a substance more abundant in the Permian than in any other group of rocks.

Evidence of the occurrence of abundance of magnesia during the Permian epoch becomes more prominent in the upper beds of the Penrith sandstones, a portion of dolomitized Carboniferous Limestone from the magnesian breccias of Hilton-beck yielding Dr. Blyth the following results:—

CaO, CO_2	65·0
MgO, CO_2	29·4
Carbonate of iron and silica	5·6
	100·0

Regarding this rock Dr. Blyth observes that, by deducting the carbonate of iron and silica, and calculating the mixed carbonates of lime and magnesia, we have

CaO, CO_2	68·8
MgO, CO_2	31·2
	100·0

Rammelsberg has given three proportions, to which the composition of bitter spar and dolomite approximates more or less (Bischof, ii. p. 47), namely:—

First,	$1 CaO, CO_2$	54·18
	$1 MgO, CO_2$	45·82
		100·00
Second,	$3 CaO, CO_2$	63·95
	$2 MgO, CO_2$	36·05
		100·00
Third,	$2 CaO, CO_2$	70·28
	$1 MgO, CO_2$	29·72
		100·00

The dolomite of the magnesian breccia of Hilton-beck agrees nearly with the third approximate formula which Rammelsberg gives for dolomite$=2CaO, CO_2+MgO, CO_2$. Of this composition are the dolomites from Kolozomek, of Glücksbrunn *, and a variety from the Tillerthal. The dolomitizing here has been complete.

Reference has already been made to the hard veins of light-coloured sandstone which intersect the lower sandstones. Their

* For a description of the dolomites of Glücksbrunn, and their position, see 'Siluria,' 2nd edit. p. 340.

cementing substance generally consists of the same materials as those which unite the quartz-granules of the rocks in which they occur; but when they appear among the magnesian breccias, they have, however, a different cementing matrix. A portion of one of these from the higher part of the Penrith sandstones of Hilton-beck, as determined by Dr. Blyth, afforded the following results:—

CaO, CO_2	16·00
MgO, CO_2	1·75
Silica	76·20
Carbonate of iron and moisture	6·05
	100·00

Rejecting the sand and iron from this specimen, and calculating the percentage of lime and magnesia, gives the following result:—

CaO, CO_2	91·36
MgO, CO_2	8·64
	100·00

In this case the cementing matrix, although of dolomite, has had the dolomitizing process much less advanced than is the case with the fragments making up the magnesian breccias.

In the Hilton group a specimen of the impure limestones associated with the plant-beds yielded Dr. Blyth the following constituents:—

CaO, CO_2	24·4
MgO, CO_2	1·7
$Si\,O_3$	70·0
Oxide of iron	3·9
	100·0

The dolomitized limestone, the cementing matrix of the sands in this stratum, had the following composition:—

CaO, CO_2	93·1
MgO, CO_2	6·9
	100·0

In this specimen the cementing matrix has a great affinity to that of the siliceous vein just described.

Immediately beneath the red shales of the Hilton section a thin mass of grey limestone occurs, containing drusy cavities, and much resembling in aspect the compact limestone of the county of Durham. This limestone approaches very nearly to a true dolomite.

No calcareous rocks are seen in the Hilton section above this limestone, but in the Kirkby Stephen section the "hard brockram" has a higher position, appearing above the red shales. The unaltered condition of the limestone-fragments in this "hard brockram" indicates the termination of the action of that force which gave rise to dolomites, anterior to the period of deposition of these "hard brockrams," and shows that the action of the dolomitizing agent was confined to the middle portion of the Permian epoch.

The Upper Permian rocks—the St. Bees and Corby sandstones—

afford further proof that the dolomitizing influence had ceased to operate anterior to their deposition. Dr. Blyth finds that these rocks are composed of small rounded quartz-granules, with a cementing matrix of silicates of lime and iron, very little magnesia being present. Their deep-red colour, owing to oxide of iron as in the lower sandstones, is merely *incrusting*, and can be dissolved off, leaving the granules perfectly colourless.

The mode in which the magnesian breccias and limestones occur in the north-west of England leads to the conclusion that the dolomitizing agent must have acted from above. Had this cause exercised its influence from below, it would have operated powerfully on the lower breccias; and yet these, as seen in the north-west of England, are perfectly unchanged, while the higher breccias always exhibit the magnesian-limestone character. These latter have also been subjected to a force which dissolved a portion of carbonate of lime from the fragments, converting them into potato-stones; the dissolved portion, combining with carbonate of magnesia, furnished the materials out of which the regular stratified dolomites were formed, or, becoming mixed with other mineral matter, constituted its cementing matrix; in which condition we have it, in the plant-beds of Hilton, giving rise to dolomitic sandstones.

Concerning the dolomitizing cause, this has been frequently discussed both by chemists and geologists. One circumstance, namely, the occurrence of gypsum, either in beds associated with magnesian limestone or in deposits appertaining to the period when this kind of mineral matter was very abundant, seems to connect gypsum with dolomites, since at St. Bees Head the former occurs in red shales immediately overlying magnesian limestone, and in several portions of the Vale of the Eden gypsum and red shales are the exclusive representatives of the Middle Permian series. This association supports, to some extent, the conclusion that the magnesia of the dolomites originally existed as a sulphate of this earth, from which was derived the sulphuric acid combined with the lime in gypsum.

§ 8. *Conclusion.*

The Permian rocks of the county of Durham have hitherto been regarded as the type of this formation in England. In this county, however, excepting the middle member, the strata appertaining to this portion of the Palæozoic period are very imperfectly represented. Of this group the base is almost absent, the Penrith sandstones occurring only to a very slight extent as soft sandstones, supporting the base of the magnesian limestones—the equivalents of the Hilton series—and in many localities these sandstones disappear altogether. In the county of Durham the portions of the Permian strata which occur are transgressive on the coal-measures, and are spread out upon the eroded surfaces of the latter rocks. At Tynemouth, beneath the "brecciated limestone" forming the upper portion of the cliffs, this eroded surface is seen in the light-coloured sandstone supporting the Permian breccia-beds. This light-coloured sandstone is said to pass downwards into another sandstone with a purple tint, and the latter rests conformably upon shale which equally conforms to the seam of coal seen at Cullercoats and known as the Hebburn seam. In the red sandstones immediately above, and conformable to the Hebburn coal, Plants occur, consisting of species common in the Coal-measures. They have no relation to the true Permian Plants such as are obtained from the marl-slate of Durham and its equivalent—the Hilton leaf-beds of Westmoreland; and the evidence, both as regards stratigraphical arrangement and fossils, removes the sandstones north of Tynemouth from the Lower Permian or yellow sandstones of the Wear, and places them in the Carboniferous formation.

With regard to the nature of the Plants of the true Permian strata, they have a widely different *facies* from that which the carboniferous Plants present. No traces of either *Lepidodendron* or *Sigillariæ*—so abundant in the Coal-measures—have been hitherto met with in the Permian rocks; and with reference to seeds, while *Trigonocarpon*, a fruit appertaining to the *berry-bearing* Coniferæ, occurs in the Coal-measures, it is absent from the Permian group, the seeds occurring in the latter being the products of *cone-bearing* pines which make their appearance *for the first time* in the Permian formation.

Of these Coniferæ of the Permian strata, two forms of *Ullmania*, a genus unknown in the Carboniferous formation, are abundant, the cones of which seem to have been of small size; and as regards Ferns, these also in the Permian rocks are altogether distinct from such as occur in the Carboniferous group. The fossil plants are, therefore, characteristic of, and peculiar to, the Permian series; they also indicate different climatal conditions; and, if we may judge from the relative size of the cones of the Gymnosperms, we should infer that a somewhat lower temperature obtained during the Permian than during the Carboniferous epoch.

Although there is no great band of Magnesian Limestone like that of Durham and Yorkshire to mark the central division of the Permian rocks of the north-west of England, we hold that the series we have described in the Valley of the Eden is much fuller and thicker than its equivalent in the north-eastern counties. In the north-east of England, not only is the Lower Permian or Rothliegende most slenderly and imperfectly represented, but the highest member of the group is entirely wanting. On the other hand, the splendid development of the Magnesian Limestone, in its range from the coast of Durham through Yorkshire and into Nottinghamshire, is so much superior in volume to its feeble equivalent in the region under consideration, that some geologists may be induced to view the Upper Sandstones of St. Bees and Corby as synchronous with the Upper Magnesian Limestones and red marls of the Yorkshire series. In contrasting the siliceous character of the Permian group of the north-west of England with its eminently calcareous development in Durham and Yorkshire, it is to be borne in mind that even the latter band, when it trends southwards into Nottinghamshire, becomes so sandy a rock, that the freestones of Mansfield, of both red and whitish colours, might, from their aspect, be mistaken for sandstones. It was the least calcareous of these masses which was recommended by Sir Henry De la Beche as the building-stone of the Houses of Parliament; and had his advice not been departed from, by resorting to the Anstone quarries in Yorkshire, the beautiful freestone of Mansfield would, we are persuaded, have been through ages unaffected even in our London atmosphere. The sandy varieties of the Magnesian Limestones of Nottinghamshire were long ago well described by Prof. Sedgwick, and recently their analyses were given in the Memoirs of the Geological Survey, in Mr. Aveline's description of the Quarter-sheets N.E. 71 and S.E. 82.

We may, indeed, adopt the view of synchronizing the red marls and sand-beds which overlie the Magnesian Limestone of Nottinghamshire with the St. Bees and Corby Sandstones of the north-west; and in this way, though the thickness of the Nottinghamshire band is small, it has been clearly represented in the Geological Maps of the north and south of Mansfield by Mr. Aveline, and even there we have thus a tripartite arrangement of the group. In Ireland, also, it is probable that the Upper Permian is represented by the red sandstones which at Rhone Hill, near Duncannon, co. Tyrone, afford *Palæoniscus catopterus* (Ag.); for these beds have an intimate relation in mineral nature to the St. Bees and Corby Sandstones.

However this may be, we simply call attention to the fact that on the western side of the axis of the north of England, or Pennine Chain, the Permian Group, from its base to its summit, consists of a *triplex* conformable series similar to that which was long ago described by one of us as prevailing over wide tracts of the Continent of Europe.

The establishment of a vast range of Permian rocks in the north-west of England is connected with the probability that productive Carboniferous deposits will at a future day be attained by sinking through some of the superjacent Red Sandstones. Near Barrow-mouth, at St. Bees Head, coal has been indeed worked for many years under the Magnesian Limestone, the Lower Permian having there become very thin; and we see no reason why coal may not be found, though at greater depths, under the Red Sandstone north-west of the village of St. Bees. Again, immediately south of Maryport, where the productive coal-measures dip northwards, they are flanked on the north by the Upper Permian, from which they are separated by the powerful fault before alluded to. Now, if the Lower Permian should have become thin here, as it has done in the environs of Whitehaven, coal may very well be won by shafts sunk through the Upper Permian Sandstones. Lastly, the small but highly productive coal-field of Cannoby, lying on the northern side of the great Pennine fault in its extension into Scotland, is seen to have its strata dipping southward, or directly towards the Corby Sandstones or Upper Permian. We have therefore little doubt that, at a depth which we will not pretend to estimate, the coal-beds of Cannoby, which have been abruptly broken off by the great downcast fault extending under the Red Permian Rocks, and under the Solway Frith, may in this way be viewed as the north-eastern limb of the West Cumberland or Whitehaven coal-field.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

A MONOGRAPH *of the* AMMONITES *of the* CAMBRIDGE GREENSAND.

By HARRY SEELEY, Esq., F.G.S., Woodwardian Museum.

[Read June 17, 1863*.]

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

(Abstract.)

IN this paper the Ammonites and Scaphites of the Cambridge Coprolite-bed were described, with the endeavour to elucidate the nature of Ammonite-species in a single stratum and a limited area. It was the result of five years' study of about 12,000 specimens.

The special peculiarity of the paper was that many "species" hitherto thought distinct were connected together. This was called "resolving species into the varieties of which they appear to consist." The specific names became varietal, "the idea of the system followed being to make certain forms the indices as it were to their groups," without disturbing the existing nomenclature.

There are three "great species," or groups, called *Ammonites rostratus, A. splendens,* and *A. planulatus*; and a few "small species," mostly new; besides these were a small group of *Scaphites,* and a *Crioceras* from Hunstanton.

Every recognizable variation of form was described, and, in a few marked instances, named, the named forms being merely used as necessary links for connecting together allied species.

In the "*splendens* group," *A. Fittoni* was shown to pass insensibly into *A. splendens*. *A. splendens* was traced on the one hand through a series of variations into a thick and robust, ribbed, and tubercled new species called *A. cratus*; and this again was regarded as passing into another new form, very thin and flat, called *A. leptus.* And, on the other hand, *A. splendens* was traced into *A. Guersantii,* and *A. Guersantii* into *A. Renausianus,* and this again into another new form called *A. gymnus*. *A. Guersantii* passed into *A. auritus*; this species passed into a new form called *A. novatus*; this into

* For the other communications read at this Evening-meeting, see Quart. Journ. Geol. Soc. vol. xix. p. 506, and vol. xx. p. 74.

A. Raulinianus; and that into a new ribless, tubercled form called *A. tetragonus*. *A. novatus* passed into another new form called *A. dendronotus*, very like *A. cratus* and *A. interruptus*. *A. novatus* also passes into *A. Salteri*, as well as into *A. Vraconensis*, which latter may be traced into *A. Studeri*. All these forms were considered to make up, in the Cambridge district, one great natural species, called the "*splendens*"-group. And the author has fortified his conclusions by breaking up many specimens, and finding the inner whorls corresponding to those of other species. Thus, *A. splendens* is found in the interior of *A. auritus*; *A. Studeri* may be extracted from *A. Raulinianus*; and *A. splendens* and *A. Studeri* differ only essentially in the degree of inflation and roughness of ribbing.

The "*rostratus*" and "*planulatus*" groups were similarly described. The former consists of the South of England *A. rostratus*, the Cambridge "*rostratus*" (*A. symmetricus*), two other varieties (new), and a variation from *A. inflatus*, called *A. pachys*; the latter contains *A. Timotheanus* (Pictet, non Mayor), *A. planulatus*, *A. Mayorianus*, *A. octosulcatus*, and *A. latidorsatus*.

The "small species" described were *A. cœlonotus* (new), which is a variation from *A. falcatus*, in which the ribs are not angulated, but have a slight sigmoidal flexure. *A. Woodwardi* (new), like a young *A. Studeri*, only the ribs pass over the back. *A. glossonotus* (new), in which two ribs unite to pass over and form a tongue-like expansion on the back. *A. sexangularis* (new), with few and strong ribs, and three rows of tubercles on the angulated back; the sides are flat and the umbilicus small. *A. rhaphonotus* (new), which is a similar shell, with a round back, crenulated, with one row of small tubercles, and crossed by more numerous and finer ribs. An untuberculated, round-backed variety of *A. navicularis*, called *A. nothus*; also *A. Wiestii*, and some few others.

The *Scaphites* is *S. æqualis*, and shows variation in size, form, and ornament, the latter being the addition of a row of tubercles on each side of the hamus.

The *Crioceras* is *C. occultus*, in which the tetragonal whorl, margined on each side of the back with a row of tubercles, is so coiled as almost to overlap the whorl beneath.

The biological and geological considerations arising out of the facts detailed in the paper were reserved.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 24, 1864.

Edward Easton, Esq., 49 Upper Bedford Place, Russell Square; George Maw, Esq., F.L.S., F.S.A., Benthall Hall, near Broseley; Joseph Elliot Square, Esq., 4 Stanley Crescent, Kensington Park, W.; and Edward B. Tawney, Esq., Assoc. Royal School of Mines, were elected Fellows.

The following communications were read:—

1. Further Discoveries *of* Flint Implements *and* Fossil Mammals *in the* Valley *of the* Ouse. By James Wyatt, Esq., F.G.S.

Since my communication to this Society of discoveries of Flint Implements associated with fossil remains of extinct Mammalia in the Post-tertiary gravels near Bedford, I have been so fortunate as to have the opportunity of examining in this valley several good sections; and there is one especially of which it is desirable to have a record, as it furnishes several important data in reference to the question of the Drift.

The opening of this section appeared to me to present a good opportunity of ascertaining whether the gravels at this lower level of the Ouse Valley exhibited any phenomena different from those of the upper level at Biddenham. With this view constant observations were made throughout the excavation; and some points of evidence were obtained, which tend to support the opinions of Mr. Prestwich in regard to the different periods and climatal conditions under which those deposits were made*. Without doubt I have found this lower portion of the Drift exhibit some features not met with in the higher levels, namely, a marked difference in the grouping of the fauna and in the types of Flint Implements. Although, as might have been expected, there are several species of Mammals in common, yet the section under notice contains some species not known in the localities considered to belong to the upper-level deposits; and the same remark holds good with reference to the land and freshwater Shells.

The new line of railway from Bedford to Cambridge has been made across a large tract of this Drift-gravel to the east of Bedford, but very few fossil bones have been obtained from it, as the levels of the line did not necessitate any deep cutting. In connexion, however, with these works an excavation has been made in a hill contiguous to the line, which has furnished the interesting section now under consideration. Two miles eastward of the town of Bedford, and near the junction of the parishes of Cardington and Goldington, where the general level of the land is not more than four or five feet above the water of the River Ouse, there is a large mound known as "Summerhouse Hill." The Ordnance Map does not give this name, but shows the hill and the brick-kiln on one side of it. The whole of the surrounding flat land is a deep alluvial deposit, and a great portion is under water during part of the winter, through the river-floods. Beneath is an extensive deposit of gravel, which overlies the clay and limestone of the Middle Oolite, and this hill is composed of the same clay.

The hill is a conspicuous object, although only 36 feet above the level of the river, as it is the only natural elevation in this part of the valley. It is exactly four miles from the celebrated pit of Biddenham "*as the crow flies*," but nine miles if the measurement be taken by the present meandering river, the feeble successor of the ancient torrent which scoured the valley. In the absence of an actual survey for the true levels of this district, some idea may be formed of the difference of the levels between the pit at Biddenham and the cutting at Summerhouse Hill when it is stated that the river has, in this distance, four mill-dams; so that the natural fall may be calculated to be at least 30 feet between the two sites.

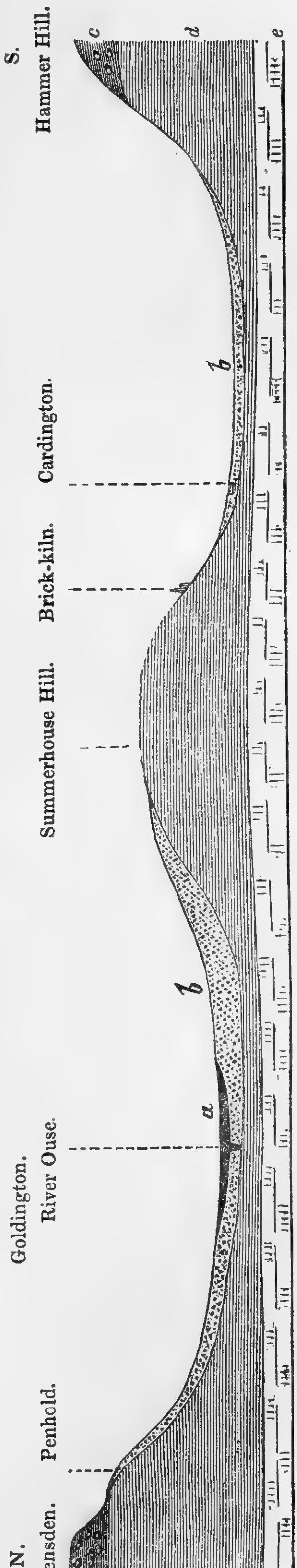
The railway contractors found that there was on the north-eastern flank of this hill a valuable deposit of gravel. This discovery was soon turned to account, and several acres have been excavated to furnish ballast for the line and roadways to the viaducts. I watched the work with great interest, as the gravel-deposit here presents the peculiarity of a great buttress to the hill on that north-east side only. This deposit has a depth of 15 feet at the foot of the hill, gradually decreasing in thickness until near the top, where it ceases altogether; and on the south-western slope *no* gravel is found, but there the hill is excavated for brick-making, the clay coming close to the surface. It would appear as if this mound had caused a shoal, and that

* See his "Theoretical Considerations," in the 'Proceedings of the Royal Society,' March 27, 1862.

the current of the ancient Post-pliocene river had eddied round it, depositing a large bed of gravel, silt, and mud on one flank, and subsequently shifting its course.

The excavation by the railway contractors gave a transverse section of the deposit; and beds of gravel, of the depth stated, were shown between the alluvial soil and the Oolitic clay at the base. The gravel was similar to that at Biddenham, subangular, and composed of flint, limestone, New Red Sandstone, trap, and various old rocks—just such a collection as is found in the neighbouring hills of Boulder-clay; but some of the pebbles are much rolled. The section presented none of those contortions of the strata which are so frequently displayed at Biddenham; but the layers of gravel, sand, and mud were unusually conformable, the constant deposit of the current apparently extending over a long period of time; while the large quantity of marginal and land-shells at different depths, the marks of vegetable fibres in the mud, and the black streaks as from decomposed wood indicate a long continuance of this as a bank or shoal line. There were three very distinct layers of mud; those at the depths of 9 feet and 12 feet from the surface contained an immense number of land and freshwater Shells. A collection of these I have submitted to Mr. Gwyn Jeffreys, who has kindly furnished the following list:—"In the first layer (at the depth of 6 feet) were *Valvata piscinalis*, *V. acuminata*, *Pupa marginata*, *Ancylus fluviatilis*, *Pisidium amnicum*, *P. fontinale*, var. *pulchella*, var. *Henslowiana*, *Limnæa peregra*, *L. truncatula*, *Helix hispida*, *H. pulchella*, *Planorbis spirorbis*, *Bithynia tentacu-*

Section from Ravensden to Hammer Hill, through Summerhouse Hill.



a. Alluvium.
b. Gravel, with Fossil Mammals and Flint Implements.
c. Boulder-clay.
d. Oxford clay.
e. Limestone (Middle Oolite).

o 2

lata. This assemblage of Shells shows the result of a large river-scouring, with a mountainous or hilly stream flowing into it, as well as the vicinity of the sea. In the second layer (at the depth of 9 feet) were *Planorbis spirorbis, Ancylus fluviatilis, Sphærium corneum, Pupa marginata, Limnæa truncatula, L. peregra, Bithynia tentaculata, Pisidium fontinale, Zua lubrica, Unio Batavus.* The *Unio* is the same species as now living in the Oise. In the third layer (at the depth of 12 feet) were *Valvata piscinalis, Helix pulchella, Pupa marginata, Bithynia tentaculata, Sphærium corneum, Pisidium amnicum, P. fontinale, Ancylus fluviatilis, Limnæa peregra, Succinea elegans, Planorbis albus, P. spirorbis.* The shells have the same appearance as those from the Abbeville district; and it is very probable they were coëval, and deposited under similar conditions."

During the excavation great quantities of bones were found, but from the nature of the work very few were preserved at the onset, as a large gang of navvies had to fill ballast-waggons in a given time for an engine to draw away to Bedford; the consequence was that many fine fossils assisted to make approaches to the new bridges. As the demand for ballast slackened, the chances of observation increased, and eventually many valuable specimens were obtained. There were great numbers of antlers of Deer, some shed, and others having portions of the skull attached: there were also teeth and bones of the same species, and many bones, teeth, and cores of horns of a large species of *Bos.* A doubt has been previously expressed whether the gravels in this valley have yet given good evidence of the presence of *Hippopotamus major*; but this excavation removes all doubt on that point, as I obtained portions of two tusks with an astragalus and portions of other bones; and within 500 yards of this spot, in the cutting for a watercourse by the side of the railway a fine tusk was found, which, however, the men broke in pieces. Professor Owen kindly permitted me to forward to him a portion of the fossils for his examination, and amongst them he has found *Elephas antiquus*, Falc., some very fine remains of *Hippopotamus major, Bos giganteus*, Owen, *Cervus elaphus* (large variety), *Cervus tarandus*, and *Ursus.* It may be added that very few of the bones exhibited any signs of having been rolled far, but the great proportion retained their natural form perfectly.

But there is another fact which gives importance to this section, and causes Summerhouse Hill to be added to the interesting localities which have yielded the rude tools of the primitive flint-chippers. The only unsatisfactory point is that no Flint Implement has been discovered *in situ*; but the circumstances under which I found one specimen leave no doubt as to its original place of deposit, and its condition carries the most complete evidence of its antiquity. At a later period of the excavations the sand was sifted out, and only the larger gravel taken away for ballasting purposes. In one of the heaps of this sifted gravel I found a small Flint Implement of oval form, and this heap must have come from the lowest bed of gravel, and was amongst the last material that was removed from the section. Many of the stones were deeply stained with oxide of iron, which I had observed all along a layer about 2 feet from the bottom of the bed; other stones had a whitish patina from immediate contact with the clay, and it was the latter coating which had accumulated on the implement so as to give it a porcellanous appearance. This flint tool is $2\frac{3}{4}$ inches long, and similar in outline to one found in the Champ de Mars at Abbeville, and figured by Mr. Evans in the sheet of typical forms accompanying his paper on Flint Implements, published in the 'Archæologia,' 1862. It is also similar to one found at St. Gilles, near Abbeville, and figured in the paper by Mr. Prestwich, in vol. cl. of the 'Transactions of the Royal Society.' Amongst the gravel I found three flint flakes, on which there are sufficient facets to show that they were artificial. Soon after this discovery, Mr. Evans, who had come to pay me a visit, went to this spot, and on the newly constructed road through this section found amongst the gravel, which had been taken from the lowest stratum, a flint implement of oval form, which is rounder at the cutting end than usual, and altogether of a different type from that of those tools which have been found at Biddenham and St. Acheul.

It was tantalizing to find that just as these diggings were beginning to be productive of interesting results the excavation ceased, the quantity of land agreed upon having been worked out. Sufficient evidence, however, has been obtained to show that the gravels at this part of the Ouse Valley are as rich in fossil remains as on the western side of Bedford.

There are six places at which Flint Implements have been found near Bedford, within a radius of four miles, in the following order of succession:—Biddenham, Harrowden, Cardington, Kempston, Summerhouse Hill, and Honey Hill. The evidence which warrants the addition of Honey Hill is curious. A few weeks ago I was on my way to inspect the neighbouring pits, and passed along an occupation-road which had lately been repaired. If the same regulations were adopted for farmers' roads as Mr. MacAdam insisted on for the public turnpike trusts—where a man's mouth is taken as the gauge for the size of the stones to be laid down—a most interesting relic would have been sacrificed. Fortunately for the interests of science this regulation had not been insisted upon here, and so I saw a flint hache reposing snugly in a rut. The rude wheels of dung-carts had gone over it and pressed it down, making one additional and unnecessary conchoidal fracture on one side, and taking off the point, but not sufficiently damaging it to prevent its identification as a true Implement of the Drift. I ascertained from the occupier of the farm that he had made a small pit at Honey Hill, and taken out such gravel as he required, and then levelled it up. This site is about a mile west of Bedford, at the junction of the parishes of St. Paul, Biddenham, and Kempston. This is on nearly the same level as the Biddenham pit, and the Implement is of the type of the pointed haches of Amiens.

In reviewing the facts now under notice, and keeping in view the circumstance of the freshwater Shell, the *Unio Batavus*, found in the valley of the Oise (France), being discovered in a fossil state at Summerhouse Hill, and not in any spot higher up the valley of the Ouse, and the different assemblage of Mammalian species, I think they may be taken as of importance in the consideration of Mr. Prestwich's theory. And, in conclusion, I must beg to express my regret that the section was not open sufficiently long to be examined by those who still doubt the high antiquity of these fluviatile valley-gravels.

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2. *On some* Recent Discoveries *of* Flint Implements *in* Drift-deposits *in* Hants *and* Wilts. By John Evans, Esq., F.G.S., F.S.A.

Having within the last few days visited, in company with Mr. Prestwich, the scenes of two recent discoveries of Flint Implements in gravel in the south of England, I think a few notes upon the subject may be of interest to this Society.

The discoveries in question have taken place, the one on the sea-shore, about midway between Southampton and Gosport, where Implements have been found by Mr. James Brown, of Salisbury; and the other at Fisherton, near Salisbury, where they have been discovered by Dr. H. P. Blackmore, of that town.*

The first-mentioned discovery was made accidentally in May last. Mr. Brown being on a visit at a friend's house, near Hill Head, a spot about 2½ miles south of Titchfield, was walking along the shore about the middle of the cliff westward of Hill Head, and between that place and Brunage, and picked up a worked flint, in which he at once recognized a form of Implement peculiar to the Drift. Diligent search, renewed on several subsequent occasions, enabled him to find five more, all within forty or fifty yards of the place where the first was picked up, and near the spot where a large mass of gravel had fallen from the cliff on to the shore only a short time previously. Three of these Implements are oval, equally convex on both sides, and with a cutting edge all round. Two out of these three are more sharply curved at one end than at the other, and a fourth is more lanceolate in form. The fifth is the heavy butt end of a large Implement, probably a pointed one; and the sixth a broad flake with numerous facets on the convex side.

On the occasion of our late visit, I was fortunate enough to discover another specimen, of the spear-head form with a rounded point, exactly similar to many of those found at St. Acheul. I did not, however, find it at the spot where the other implements were discovered, but about a mile to the west, nearly midway along the cliff between Brunage and the lane leading down to the shore between Chilling and Hook. It was lying among the shingle on the shore opposite the highest part of the cliff, which there attains a height of about 30 feet above the top of the beach, or probably about 35 feet above high-water mark.

* See also the 'Geologist,' vol. vi. p. 395.

We examined the cliff eastward from Hook, nearly to Lee, a distance of three miles, and found it to consist of sands of the Bracklesham series, capped with gravelly beds in many places 10 to 12 feet thick, and in some as much as 15 or 16 feet. They are almost continuous, and rest on a nearly horizontal base, except where the cliff is intersected by transverse valleys draining portions of the adjacent country, as at Hook, Chilling, Brunage, and Hill Head.

The gravel consists almost entirely of subangular Chalk-flints, among which are some of considerable size, and some quite fresh and unrolled. There are also a few large sandstone-blocks of Tertiary origin in the beds, and several on the shore, apparently derived from the gravel. Of these we measured one which was six feet by three feet four inches, and one foot six inches thick; and another which was 22 feet in circumference, and fully two feet six inches thick. There are a few quartz- and chert-pebbles in the gravel; there are also a few sandy seams with false bedding intercalated in it, as well as some loess-like and marly seams; between Brunage and Hill Head there is a band of loam three feet to four feet in thickness, continuous for some distance, a little below the top of the cliff.

Some of the flints in the gravel are almost unstained, but the great majority have their surface considerably altered, and are either white, grey, or ochreous, in some cases with a porcellanous lustre. The Implements have precisely the same character of surface, and, though not as yet found *in situ*, it can be proved almost to demonstration that they are derived from the gravel capping the cliff, as that is the only available source for the whole of the shingle on the beach.

We were unable to discover any traces of Shells or Bones in the gravel, nor had it in any way the appearance of being a raised beach. On the contrary, it had many of the characteristics of being a fluviatile gravel, as will have been observed from the description already given. The area covered by these drift-beds appears to be very extensive. They seem to cap the cliffs as far as the shingle-beds near Alverstoke, S.W. of Gosport, and we found what was apparently the same gravel in several places between the coast and Titchfield and Fareham. Mr. Prestwich informs me that they also extend along the coast to Southampton, and are moreover found on the other side of the Southampton Water. Taking all things into account, there can indeed be but little doubt that these gravel-beds are merely an extension of the valley-gravels of the rivers Test, Itchen, Hamble, and other streams, which, at the time they were deposited, flowed at this spot in one united broad stream, at an elevation some forty feet above the existing level of their outfall, over a country which has since, by erosive action, been in part converted into the Southampton Water. Such an alteration in the relative positions of land and water may seem to claim for the Flint Implements contained in the gravel an almost fabulous antiquity; but it must be remembered that at Reculver we have a perfectly parallel instance of fluviatile beds, containing Implements fashioned by the hand of man, capping cliffs abutting on the sea, at a height of fifty feet above it. We shall presently see that at Fisherton, to which I will now direct attention, the evidence of the extreme antiquity (historically, not geologically, speaking) is no less strong.

The Drift-deposits of Fisherton, near Salisbury, have long been known to geologists. As early as 1827* Sir Charles Lyell communicated to this Society a notice of the brick-earth and rubbly-chalk beds occurring there, and mentioned the discovery in them of the bones of the Elephant, Rhinoceros, and Ox. Subsequently, in 1854, Mr. Prestwich and the late Mr. John Brown, of Stanway, communicated a paper "On a Fossiliferous Drift near Salisbury," in which the Drift-beds at Fisherton, and more especially the section exposed in Mr. Harding's brick-pit, are accurately described, and an extended list of the Mammalian and Molluscous remains, which up to that time had been found, is given. What, however, invests these Fisherton beds with peculiar interest, is their similarity to those at Menchecourt, near Abbeville, in which Flint Instruments have been found; a similarity pointed out by Mr. Prestwich in his account of the discoveries made in the Valley of the Somme, read before the Royal Society in 1859†, and which led both him and me to pay visits to Fisherton in the hope of discovering Implements there also. It was not, however, in these beds of brick-earth or loess that such a discovery was destined to be first made, but in certain beds of gravel at a still higher level, in which up to the present time no organic remains have been found; though the persevering researches of Dr. Humphrey P. Blackmore have been rewarded by the discovery in them of three well-defined Flint Implements, as well as of some more simply fashioned flakes. The Implements are all of oval form, more sharply curved at one end than at the other, and equally convex on both sides. They are all considerably stained and discoloured, and two of them are much rolled. In form they present the closest analogy to many of those from the Valley of the Somme and from Icklingham. I have some specimens from the latter place which in point of colour and character of surface exactly correspond with those from Fisherton.

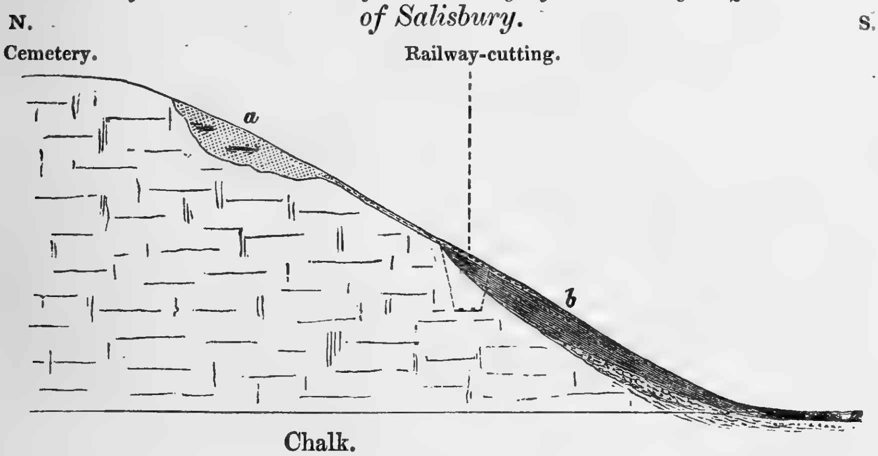
The pit from which is dug the gravel, in which these Implements were found, is about a mile to the west of Salisbury, nearly opposite Bemerton new church, and close to the lane connecting the roads to Wilton and to Devizes, and nearly midway between them. It is an old pit, for a portion of it that has been worked out is planted with fir-trees, now of considerable size. There appears, however, to be a large quantity of gravel still left unworked, and it is, moreover, dug in a neighbouring field. The deposit lies upon the southern side of the spur of chalk dividing the valley of the Wiley, or Nadder, from that of the Avon, about a mile and a quarter above the confluence of the two rivers, which are here about a mile apart. It consists of

* Proc. Geol. Soc. vol. i. p. 25; Lyell's 'Antiquity of Man,' 3rd edit. p. 519.
† Phil. Trans. 1860, p. 302.

angular and subangular gravel in a red clayey matrix, almost unstratified, but with a few loamy patches. The stones are principally chalk-flints with a few Greensand pebbles and Tertiary sandstone blocks, some of them nine or ten inches long. Its thickness is about ten or twelve feet. Though less distinctly stratified than the gravels of Moulin Quignon, there is a strong general resemblance to them. I have not got the exact measurements of this chalk-ridge, but near the Cemetery it probably attains a height of at least 100 feet above the level of the river, and the surface of the gravel-beds of which I have been speaking may be about 20 feet lower. As we descend the hill we find the chalk in places coming almost to the surface, but at the railway-bridge it is seen that the cutting has been carried through beds of brick-earth and gravel, resting on flinty chalk-rubble, similar to those exhibited in Mr. Harding's brick-pit nearer Salisbury. These beds are continued down to the bottom of the valley, and may be traced in various clay-pits on the south of the Wilton road.

The relation of the high-level gravels (in which the Implements were found) to these lower beds will be best seen in the Section. I

Section of the North Side of the Valley of the Wiley, 1½ mile west of Salisbury.



a. High-level gravel. *b.* Brick-earth and gravel, resting on chalk-rubble. *c.* Alluvium.

may add that Mr. Prestwich informs me that there are similar high-level gravels on the eastern side of the valley of the Avon near Salisbury. It is needless to enter into any description of the geological character of the low-level beds of drift, as they have already been fully described in the paper by Mr. Prestwich*, to which I have before referred. As, however, the careful researches of Dr. Blackmore have considerably extended the fauna of this deposit since that paper was written, it will be well to give an amended list of the organic remains found in it.

* Quart. Journ. Geol. Soc. vol. xi. p. 101.

The Mammalia are as follows, as determined by Dr. Blackmore:—

Canis vulpes.	Equus caballus.
Hyæna spelæa.	Asinus fossilis? (or small horse).
Felis spelæa.	Sus scrofa?
Spermophilus (superciliosus?).	Cervus tarandus.
Lemmus (Grœnlandicus?).	—— Guettardi (or young *C. tarandus*).
Lepus timidus.	—— elaphus.
Elephas primigenius.	Bison priscus.
Rhinoceros tichorhinus.	—— minor.
Equus plicidens.	Bos primigenius.
—— fossilis.	—— longifrons.

Of the remains of birds there are a portion of a femur and a coracoid bone of a Wild Goose (*Anser palustris?*), and, what are most curious, portions of two egg-shells, the one corresponding in size with the egg of the Wild Goose, the other with that of the Wild Duck. They are both stained of a pale fawn-colour, and in many parts are covered with superficial incrustations.

Dr. Blackmore remarks that the lowest-level clay-pits produce but few Mammalian remains; but he has procured from them bones of Mammoth, Rhinoceros, Horse, and small long-fronted Ox; while in Harding's and Baker's pits, at a rather higher level, remains of Mammoth and Rhinoceros are comparatively rare, but the bones of Horse, Ox, and Deer occur in great numbers.

He has kindly furnished me with the following list of land and freshwater Shells found at Fisherton:—

Land Shells.

Helix arbustorum.	*Zonites rotundatus.
*—— nemoralis.	*—— fulvus.
—— pygmæa.	Pupa marginata.
—— radiatula.	Zua lubrica.
—— pulchella.	Carychium minimum.
—— rufescens.	Acme lineata.
—— hispida.	Limax agrestis.
—— concinna.	

Freshwater Shells.

Succinea putris.	*Planorbis carinatus.
*—— gracilis.	*Bithynia tentaculata.
*—— oblonga.	Valvata piscinalis.
Ancylus fluviatilis.	Pisidium amnicum.
Limnæa truncatula.	*—— fontinale.
*—— palustris.	—— pulchellum.
—— peregra.	—— pusillum.
*Planorbis spirorbis.	*—— obtusale.

Those marked * are not included in Mr. Brown's list. *Succinea oblonga* is the only Shell not found in the neighbourhood.

This is perhaps the most extensive list of fossils collected from the fluviatile beds of a single locality that has ever yet been made; and it is the more remarkable, since, besides comprising remains of so many of the animals which are known to have inhabited this country during the Post-pliocene period, it furnishes us with the names of several new British fossils. The *Spermophilus*, the Lemming, and the Wild Goose have all, I believe, been found, for the first time in this country in a fossil state, by Dr. Blackmore*. Of the *Spermophilus*, or pouched Marmot, an animal about the size of a Squirrel, portions of the remains of at least thirteen individuals have been found, including parts of the skull with the teeth remaining in their sockets, and the last or ungual phalanx, which shows that the animal must have been armed with strong sharp claws. Of the Lemming, which is closely allied to, if not identical with, the Owinyak, or Greenland Lemming, a native of Hudson's Bay, remains of two or three have been discovered. The two most remarkable fossils are the egg-shells before mentioned, one of which appears to be that of the Wild Goose.

Now, it is not a little curious that all these additions to the list of British fossils of the Post-pliocene period afford, as has already been pointed out by Sir Charles Lyell †, some presumptive evidence of our climate having been colder at that period than it is at present. The Greenland Lemming, the Marmot, and the breeding-place of the Wild Goose are all associated in our minds with Arctic regions or an Alpine climate.

The large blocks of sandstone in the gravel and on the shore near Hill Head could hardly have been transported, except by ice-action; and the chalk-flints in the gravel, which must have travelled a distance of at least twelve miles, and some of which are, nevertheless, entirely fresh and unrolled, testify to a similar means of transport. Altogether the evidence of the two cases which I have attempted to describe tells much in favour of the theory advanced by Mr. Prestwich, that the greater excavating powers of the rivers of the Post-pliocene period, as compared with those of their representatives of the present day, were mainly due to a more rigorous winter climate, probably accompanied by a more abundant rain-fall and a greater tendency to floods.

Still we have ample testimony that the climate of that period was such as to permit of abundant animal life, and that the rain-fall was not so excessive but that there was a sufficient supply of vegetable food. The denuding and excavating power of the rivers cannot, therefore, have been out of all proportion to what they are at the present day, and the effect produced in the course of a single year, or even a century, can hardly have been appreciable in valleys, such as those through which the rivers now run.

When, therefore, we look at a Section like this at Fisherton, with its high-level and low-level gravels, or at that of the valley of the Somme at Abbeville, in which these beds have their exact parallels in those of Moulin Quignon and Menchecourt, and when we find that in the high-level gravels which must have formed the bed of the river when it ran at an elevation of 80 or 100 feet above its

* Since this paper was written, Dr. Falconer has informed me that, in 1858, he had identified, in the collection of the late Rev. Daniel Williams, amongst the fossil Mammalia of the Mendip Caverns, two lower jaws of a species of *Spermophilus*, which he named *S. erythrogenoides*, and which appears to be identical with that found in such abundance in the cave-fissures of Montmorency, near Paris, by M. Desnoyers.

† 'Antiquity of Man,' 3rd edit. p. 520.

present level, are contained Flint Implements worked by the hand of man,—when we find that at a time long subsequent, when the river had excavated the greater portion of its present valley, the Mammoth and Woolly Rhinoceros, or, as at Fisherton, the Cave-lion and Hyæna, the Lemming and Marmot, were still denizens of the country, —we are almost staggered at the inevitable conclusions which must be drawn as to the period that has elapsed since the Implements such as those before us were fashioned.

Geologically speaking, indeed, the time may appear insignificant, as compared with the vast lapse of ages represented by even a single formation; but where man is concerned, we are involuntarily led to compare the period of his duration with the short space of time embraced by history and tradition.

I will only add that most of the Implements and Mammalian remains I have mentioned are deposited in the museum lately opened at Salisbury, which owes its existence mainly to the exertions of Dr. Blackmore and Mr. E. T. Stevens, and from the Descriptive Catalogue of which I have borrowed some of my facts.

P.S.—Since this paper was read (the 24th February last), I have employed Mr. H. Keeping to make a further examination of the shores of Southampton Water. His search in the gravels on the western coast, and on the eastern, north of Hill Head, were unsuccessful; but on the shore at Brown Down, about three miles south-east of Hill Head and two miles west of Alverstoke, he found two well-defined specimens. The one is of nearly triangular form, with a slightly rounded point, and with the butt end retaining the natural surface of the flint; the other is of oval form, thicker at one end than the other, and retaining a considerable portion of the old surface of the flint upon the less convex side. Both specimens are considerably discoloured on the surface. Though their salient angles are slightly worn, they cannot have been long exposed upon the beach, and were doubtless derived from the gravel capping the cliff near Brown Down, which is a continuation of that which I have described in the paper. Mr. James Brown has also found five or six more Implements near Hill Head. —[J. E.]

March 9, 1864.

William Eassie, Esq., High Orchard House, Gloucester; Francis Ablett Jesse, Esq., F.L.S., Llanbedr Hall, Ruthin; and Henry Lucas, Esq., 19 Hyde Park Gardens, were elected Fellows.

The following communications were read:—

1. *On the* Discovery *of the* Scales *of* Pteraspis, *with some Remarks on the* Cephalic Shield *of that* Fish. By E. Ray Lankester, Esq.

[Communicated by Prof. Huxley, F.R.S., F.G.S.]

[Plate XII.]

Prof. Agassiz * was the first to describe certain remains found in

* 'Poissons Fossiles,' vol. i. p. 135.

the Cornstones of Herefordshire, associated with the well-known *Cephalaspis Lyellii*. He considered these remains as portions of the cephalic shield of three distinct species of *Cephalaspis*, which he named *C. rostratus*, *C. Lewisii*, and *C. Lloydii*, respectively. At the same time he expressed his doubts as to whether, on account of the peculiar structure of the test, it might not be advisable to place these three Fish in a distinct genus. In 1847, Dr. R. Kner, writing in Haidinger's 'Abhandlungen *,' considered the fossils in question as the remains of Cephalopoda, and he proposed, therefore, to place them in a new genus, *Pteraspis*, remarking that the structure of the test preserved in these fossils corresponded closely with that of the calcareous plate or "cuttle-bone" of *Sepia*. Prof. Huxley has since investigated the structure of both *Cephalaspis* and *Pteraspis*, and published his results in this Journal †. It will therefore only be necessary to remark that he came to the conclusion that *Pteraspis Lewisii*, *P. Lloydii*, and *P. rostratus* were the remains of Fish, and presented no real analogy to *Sepia* in the microscopic structure of the test. This, he showed, was similar to that of *Cephalaspis*, but differed in the absence of bone-cells or lacunæ; and he adopted Kner's name of *Pteraspis* for these Fish, considering that the differences in form and structure between the two groups warranted a generic separation.

The only thing required to remove the doubts which yet lingered in the minds of some palæontologists as to the piscine nature of *Pteraspis* was the discovery of the scales. These, at length, have come to light, in a quarry at Cradley, near Malvern, where the Cornstones of the Devonian system are worked. The specimen (Pl. XII. figs. 3 & 4) which I obtained last summer consists of a small portion of the cephalic shield, of which the internal nacreous layer is exposed; closely attached to its posterior margin, and apparently partially underlying it, is a row of rhomboidal scales, eight in number; these are followed by eight other rows of similar scales, and they are all that remained preserved in the specimen. The scales which are shown are, therefore, only those of a small portion of the anterior dorsal surface.

It might be suggested that these were the scales of some other Fish, since the portion of the cephalic shield preserved is hardly sufficient from its form alone to warrant the assumption of their Pteraspidian nature. Fortunately, however, on one surface of the specimen (which presents a part of the shield crushed into this position) a small portion of the characteristic external layer of the test is shown. This is marked superficially by delicate striæ running parallel to one another; and at the edge, where broken off, it shows the middle layer containing the polygonal *cavities* described by Prof. Huxley. This structure, which has no parallel among Fishes, or, indeed, any group of the animal kingdom, leaves no possibility of a doubt that the specimen is a fragment of *Pteraspis*.

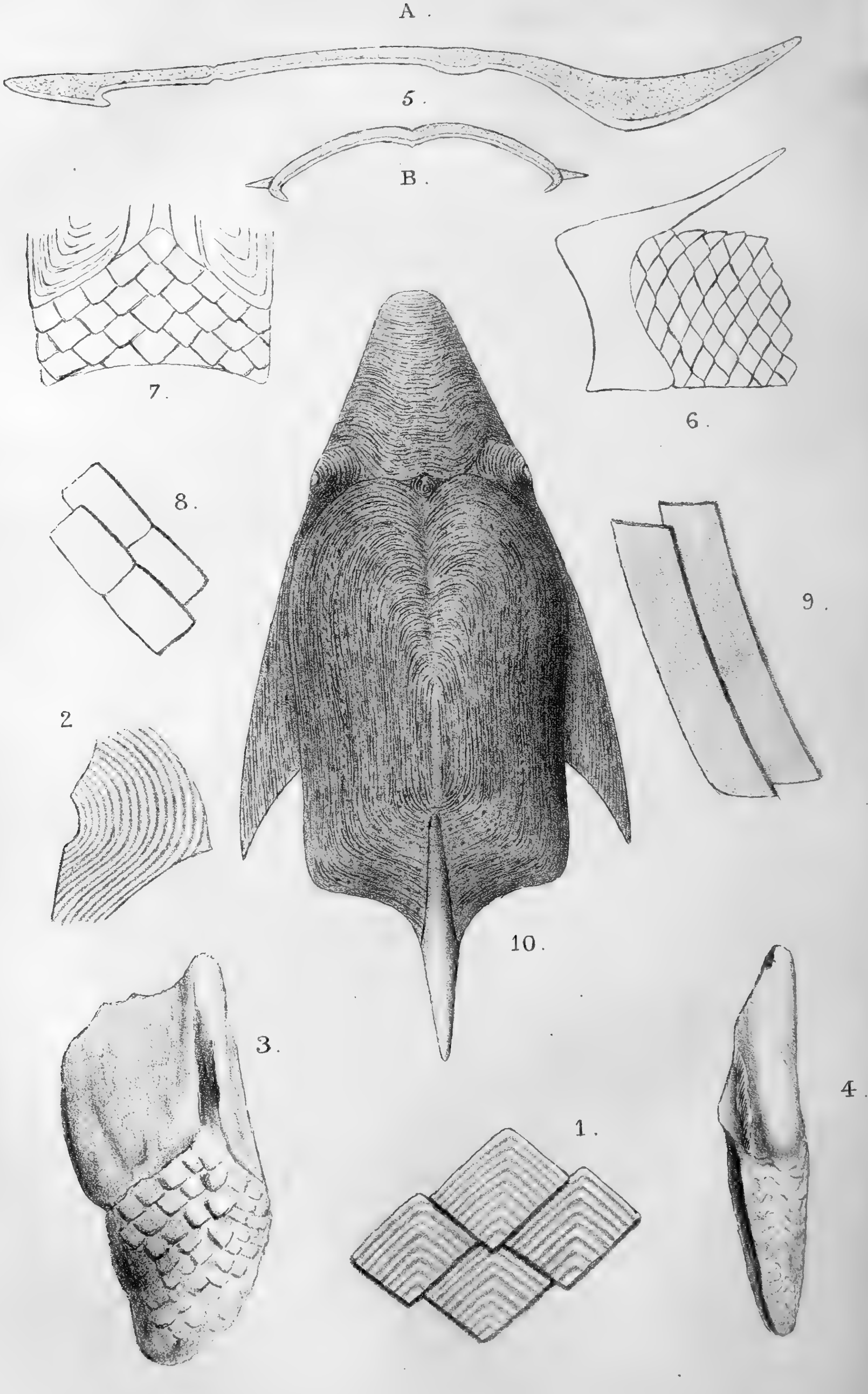
* Haidinger's 'Naturwissenschaftliche Abhandlungen,' vol. i. p. 159.
† Quart. Journ. Geol. Soc. vol. xiv. p. 267.

The scales which are thus preserved agree in general form and arrangement with the uppermost, or dorsal, series of *Cephalaspis*. The scales of this latter genus consist of three vertical series on either side of the median line *; namely, a dorsal range of four rows of rhomboidal scales (fig. 8), a second series of elongated plates (fig. 9) similar to those of the recent genus *Callichthys*, and a third series formed by two rows of smaller plates placed in an obliquely posterior direction. In *Pteraspis* (figs. 6 & 7), a single row of large square scales runs along the median line, from the sides of each of which arise a row of rhomboidal scales. The successive rows are so disposed that the anterior margin of each scale is overlapped by the posterior margin of the one in the preceding row, directly in front of it; at the same time the superior margin is concealed by the overlapping of the inferior margin of the preceding scale in the same row. This constitutes a general imbricated arrangement, whereby the inferior and posterior margins only are exposed. There are no traces of large lateral plates in my specimen, like those of *Cephalaspis*, although it is quite possible that these may have existed. It would, however, be unsafe to predicate anything concerning the scales of *Pteraspis* from what we know of *Cephalaspis*, since the analogies between them are merely general, and not of a generic nature.

The ornamentation of the scales (fig. 1) of *Pteraspis* is shown but imperfectly in the specimen under description. Two, however, of the scales preserved show delicate striations, which appear to exist on a superficial layer of bony matter, which easily separates from the rest of the scale, and is destroyed. The arrangement of the markings is drawn in fig. 1. No trace of a fin is observable, although it seemed probable that the posterior spine was intended for the support of some such appendage. The scar only remains where the spine was inserted, both it and the fin, if it ever existed, having been destroyed.

The restoration of the cephalic shield of *Pteraspis* has already been given by Prof. Huxley in this Journal † in outline. I have no additions to make to this; but since the markings on the surface of the test are extremely curious, and have in certain species ‡ from older rocks been made the grounds for specific separation, a description of them in the *Pteraspis rostratus* will no doubt prove interesting. Fig. 10 represents the cephalic shield restored. The striations which mark the whole surface are very minute, and about the $\frac{1}{50}$th of an inch apart. In the median line, above the insertion of the posterior spine, a slight elevation exists. This is the centre whence a series of concentric elliptical striations proceed, gradually assuming the form of the outline of the scute as they approach its margin (*a*). A slight groove or depression marks the anterior portion along the median line, disappearing towards the elevation of the central boss, whence the lines of striation arise. The lateral cornua (*b*)

* 'Poissons Fossiles,' vol. i. p. 137.
† Quart. Journ. Geol. Soc. vol. xvii. p. 163.
‡ *Ibid.* vol. xii. p. 100.



E. Ray. Lankester delt. M. & N. Hanhart. imp. G. West lith

PTERASPIS AND CEPHALASPIS.

are marked by similar minute lines running parallel with the sides of the scute to which they are attached. The piece between the rostrum and dorsal scute in which the orbits are placed is ornamented by a series of curved striations, parallel with the margins of the orbital apertures (*c*, and fig. 2). The striations on the rostrum run in parallels across the median line, describing four curves, which become one at the termination of the snout (fig. 10 *d*). Between the rostrum and the scute a small quadrangular piece exists, in which the markings are arranged somewhat differently (see figure). Besides these delicate striæ, there are found on the dorsal scute two series of minute round depressions, one on each side. Another series surrounds the insertion of the spine, and a third and fourth run from the posterior angles towards the central elevation. The posterior spine itself is devoid of any markings; a large portion of it is filled into the back of the scute as a distinct piece.

The internal aspect of the shield presents a surface quite free from any ornamentations in the form of striæ, being composed of the nacreous or internal layer of Prof. Huxley. The most prominent feature is a small circular depression which corresponds to the quadrangular piece mentioned as existing on the convex side. Two very conspicuous elevations exist also on either side of the median line, immediately beneath the elevated boss of the outer surface. Certain inequalities of surface also exist, which correspond to the contour of the exterior. The sutures visible on the exterior, where the various portions of which the plate is composed are joined, are not obvious on the concave surface.

These few remarks are merely intended as a small contribution to our knowledge of this most interesting Fish. Further researches and discoveries are still needed to elucidate the form of the fins and of a large portion of the body; and it is to be hoped that it will not be long ere tolerably perfect specimens of this genus will be exhumed from the Cornstones of Herefordshire.

EXPLANATION OF PLATE XII.

Illustrative of the Scales and Cephalic Shield of Pteraspis.

Fig. 1. Diagram of the Scales of *Pteraspis.*
2. Diagram of a portion of the cephalic shield of *Pteraspis*, showing striations parallel to the margin of the orbital aperture.
Figs. 3 & 4. Portion of the cephalic shield of *Pteraspis*, with scales attached to the posterior margin. Natural size.
Fig. 5. Diagram-sections of the cephalic shield of *Pteraspis*: *a*, from rostrum to spine; *b*, from side to side.
Figs. 6 & 7. Diagrams illustrating the arrangement of the scales of *Pteraspis.*
8 & 9. Diagram of the Scales of *Cephalaspis.*
Fig. 10. Restoration of the cephalic shield of *Pteraspis*: *a*, margin; *b*, lateral cornua; *c*, orbital region; *d*, rostrum; *e*, dorsal spine.

2. *On some* Remains *of* Bothriolepis *from the* Upper Devonian Sandstones *of* Elgin. By George E. Roberts, Esq.

[Communicated by Prof. J. Morris, F.G.S.]

[The publication of this paper is unavoidably deferred.]

[Abstract.]

Remains of a large Dendrodoid Cœlacanth, obtained by the author in Elgin, were referred by him to the genus *Bothriolepis*. These consisted of two large casts of a central head-plate, with portions of the test; a natural cast considered by him to represent the parietal, squamosal, scapular, and coracoid boces; casts of the nasal bones, and teeth of the upper jaw; together with tooth-like bodies, which were suggested to be teeth originally situated in the posterior region of the mouth.

The ornament borne upon the head-plate was next described by the author; and, in conclusion, the affinities between the genera *Bothriolepis*, *Asterolepis*, *Pteraspis*, and *Cephalaspis* were discussed.

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3. *On* Missing Sedimentary Formations, *from* Suspension *or* Removal *of* Deposits. By J. J. Bigsby, M.D., F.G.S., formerly British Secretary to the Canadian Boundary Commission.

Contents.

I. Introduction.

Although it has been long known that formations or parts of formations are frequently absent from their places * in the vertical series of sedimentary rocks, little notice has been hitherto taken of this absence, except in single unconnected cases; and that little consists almost entirely of a few remarks in Mr. Jukes's excellent 'Manual' and an allusion or two in the writings of Sir R. I. Murchison, Mr. Darwin, and Prof. J. Hall, of New York.

As circumstances, relations, processes, and purposes well worthy of our attention are here concerned, it is proposed now to open out and examine this subject as well as it can be done in a first attempt.

The progress of geological knowledge, as of all science, is usually

* As Lias from between Oolite and Trias; Upper Silurian from between Devonian and Lower Silurian: the roof being the upper, and the floor the lower side of the place which the missing rock should have occupied; thus occasioning a blank.

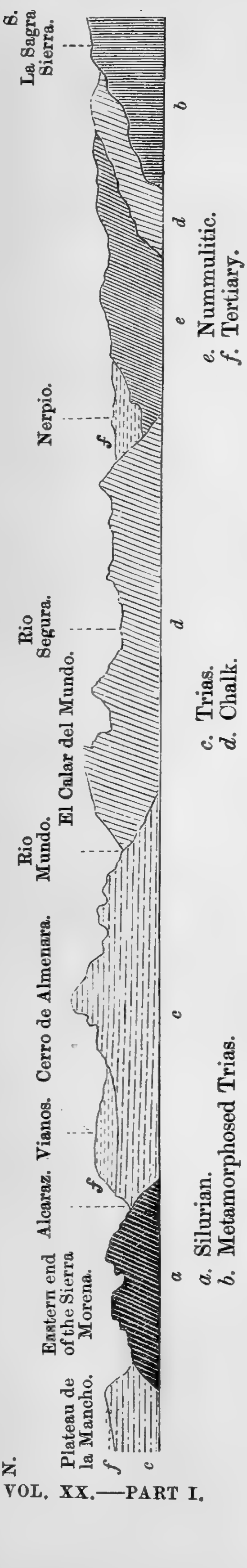


Fig. 1.—*Diagram-section from the Eastern end of the Sierra Morena to the Sagra Sierra* (after MM. de Verneuil and Collomb).

by steps. The general idea of any advance arrives first, and may perhaps lie dormant for years, when follows its development by another workman, and perhaps in another country; just as Vicomte d'Archiac, in 1848, sketched in unmistakeable language the principal features of the great Terripetal Theory, which Bronn, in 1862, made his own by the most masterly elaboration, —Ami Boué, in 1852, having prepared the way by an elaborate article in the 'Bulletin de la Société Géologique de France,' 2nd series, vol. ix. p. 437. While in their vertical order of succession the sedimentary rocks never vary, unless disturbed, they differ greatly in thickness and extent—far stretching out and thin in plains, thick and limited in area among mountains, as we see abundantly verified in the Americas, India, Russia, &c. But they have also been from the very earliest periods largely, and frequently, absent from their normal situations, and much more so than appears in systematic works; and it is easy to see, from the vast and universal prevalence of these suspensions and removals of deposits, that it will be one day proved that the emerged tracts were at all periods so extensive and so united as to constitute from one-fifth to one-third of the whole surface of the globe.

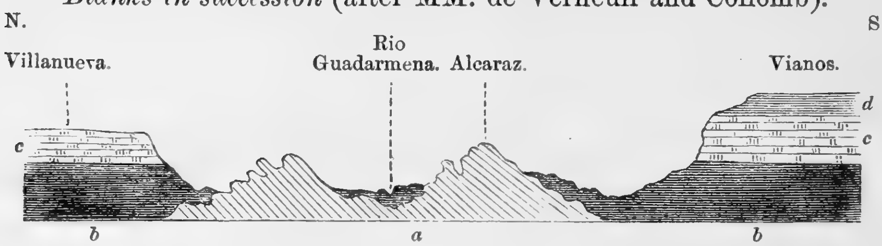
While any given district was in a state of emergence, various sediments were being deposited in the neighbouring sea, which was at the same time tenanted by a fauna so balanced and harmonized that the individuals could thrive and follow the promptings of their instincts—whole races dying out, we may safely suppose. Now, if only one such epoch commence, become mature, and decline, we see that the raised land must have remained as such for an immensely long period. What then must have been the length of that period of time during which an emerged tract remained through ten or twenty epochs above water, as has frequently occurred?* Missing formations, then, hold a high and important place as a result of one of the constructive processes of

* Canada, Hudson's Bay, Germany, &c. &c.

the earth's crust; and the work is still going on. It is not a thing of the past only; but the ocean-bottom, parcelled out like the dry land into geological districts, is still receiving accessions from animal débris and insoluble matter suspended in its waters.

The Sections, Figs. 1 & 2, I owe to Messrs. De Verneuil and Collomb; and they form one of the results of their very extensive and methodical investigation into the geology of Spain. They exhibit the structure of a region, 150 miles long, overspread by great blanks, which, for our purpose, is sufficiently explained by the sections themselves, which are placed here in proof of the importance of our subject.

Fig. 2.—*Section of the Sierra Morena (Spain), showing two great Blanks in succession* (after MM. de Verneuil and Collomb).



a. Silurian.
b. Red sandstone and variegated clay (Trias).
c. Muschelkalk.
d. Calcaire Grossier.

From an abundant supply of instances of blanks (the indications of an emerged surface) those described in this memoir have been selected, as apt to our purpose, and having an ascertained horizon. They are given in descending order, each successive epoch supplying the roof of a blank.

II. Instances of Blanks or Gaps.

1. *With a Quaternary Roof.*—Throughout by far the greater part of the extensive countries of Norway, Lapland, Sweden, and Finland, Quaternary Diluvium and Northern Drift lie directly on Laurentian and Huronian rocks; little or no deposition having taken place there (through 25° of longitude and 13° of latitude) during the vast interval of time between that of the contiguous formations. Marks of denudation are many and powerful here; and though there are patches of younger strata, they do not require notice from us.

On the opposite coast of North America all this is repeated, through Labrador and Canada to beyond the Upper Mississippi River, in a broad belt of rugged land 2000 miles long, where no Mesozoic nor old Tertiary rocks, loose or fixed, have been met with, though often looked for. From this block of older metamorphic formations another broad band of the same antiquity, sprinkled with sand, gravel, and boulders, runs from Lake Superior into the Arctic Ocean, through Rupert's Land, for 1500 miles*. Messrs. Foster and Whitney also remark that "Between the Northern Drift of the south side of Lake Superior and the Devonian there are no deposits, but

* Quart. Journ. Geol. Soc. vol. xi. p. 500.

an immense gap in the series of formations. Of the condition of the ancient surfaces we have no evidences; but we now see it covered with stratified drift of sand and clay, sometimes 1000 feet above the present level of the lake." *

In Nova Scotia there is, according to Dr. Dawson †, no formation between the Drift and the Upper Trias.

An important section, running 550 miles due east through the States of Mississippi, Alabama, and Georgia, from Vicksburg on the Mississippi to the Atlantic, has been pointed out by Sir Charles Lyell ‡. It gives successively Loess, Eocene, Chalk, Coal, and Granite, and again, on the other side of the range, Coal, Chalk, Eocene, and Loess; and thus tells of four blanks or gaps on opposite sides of the central mountains (granitic and metamorphic), each showing the absence of several assemblages of strata. In South America, the two Guianas, Brazil, and Chili present large surfaces of Palæozoic and other rocks covered by Quaternary beds §.

Large portions of the Ural Mountains, and especially their eastern flank, have no deposits between the Drift and the Carboniferous rocks; and the same may be said of Siberia, showing that it was for a long time a subaërial continent, although in parts not without newer sediments ||.

The Quaternary beds on which the town of St. Girons (France) stands most probably conceal the Lias, as is certainly the case at Audinac, close by ¶.

At Maubert Fontaine, in the Ardennes, loose Quaternary beds repose on Silurian schists **; and Della Marmora †† reports several similar cases in Sardinia.

It is an old observation of the late Mr. Warburton, and quoted by Sir Henry De la Beche ‡‡, that the alluvial beds in which the bones of Elephants are found, in consequence of previous denudation, are discovered resting on the blue clay of London, Oxford Clay, or any other bed.

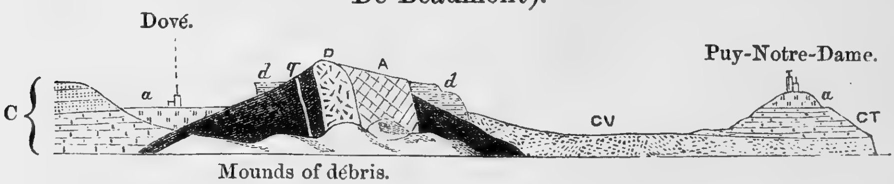
These few examples have their analogues abundantly in other countries, and they form no insignificant part of the earth's surface, especially when we take into consideration other gaps commencing with lower epochs.

2. *With a Tertiary Roof.*—Sir Roderick Murchison §§ found on the River Vaga, in northern Russia, a beautiful section of Pleistocene strata resting conformably on horizontal Permian beds. It therefore indicates the prolonged rest of that country. In like manner

* Geol. Surv. of Lake Superior Land Districts.
† Quart. Journ. Geol. Soc. vol. xii. p. 103.
‡ Second Visit to the United States, vol. ii. p. 279.
§ D'Orbigny, 'Voyage dans l'Amérique Méridionale,' vol. iii. 3e partie, pp. 210, 222, &c.
|| Murchison, 'Geology of Russia,' vol. i. pp. 352–391.
¶ D'Archiac, 'Histoire des Progrès de la Géologie,' vol. vi. p. 550.
** Gosselet, Bull. Soc. Géol. de France, 2e série, vol. xviii. p. 5.
†† Voyage en Sardaigne, vol. i. p. 414.
‡‡ Mem. Geol. Survey of Great Britain, vol. i. p. 239.
§§ Geology of Russia, vol. i. p. 331.

Cap la Hêve *, near Havre, exhibits Upper Tertiary strata lying horizontally and conformably on abraded Lower Greensand. M. Elie de Beaumont gives an instructive example of Miocene beds at Clain †, covering an ancient gneiss; but a few hundred yards off also incumbent on Lias and other Lower Secondary rocks, the gaps therefore being numerous. Messrs. de Beaumont and Dufrénoy also give us in the section below a most interesting series of blanks or absences, as will be understood without explanation ‡. Dr. Von Dechen § describes the Miocene lignite-beds of the Siebengebirge as reposing on Upper Devonian rocks; and thus exhibiting an interval of fifteen of D'Orbigny's stages; in this case, probably, through denudation.

Fig. 3.—*Section from Dové to Puy-Notre-Dame* (after Dufrénoy and De Beaumont).



a. Miocene.
CT. Tufaceous Chalk.
C. Greensand.
CV. Lower Greensand.
d. Jurassic.
e. Micaceous and talcose schist.
A. Devonian.
D. Diorite.
q. Vein of black quartz.

M. d'Orbigny ‖ gives several instances of great blanks beneath the Miocene stage, as in the Department of La Manche, where the latter rests on Trias; there being in that district a void of twenty-five of his stages. In the Ligurian basin this author says that patches of the Faluns lie directly on Azoic or Plutonic rocks, with the loss of twenty-five stages. At Gahard they cover Palæozoic strata, twenty-two stages being absent; and at Tournay (Deux Sèvres), &c., they overlie Chalk, four stages being missing.

M. d'Archiac ¶ quotes M. Ribiero as stating that, four miles north of Thomar in Portugal, lacustrine limestones of the Miocene age are underlain by Upper Lias and Trias. At the foot of the Sierra Morena, near Cordova, and over extensive districts, Miocene is incumbent horizontally on inclined Carboniferous strata. It was first seen by the late Mr. S. Peace Pratt **. A remarkable series of gaps, indicated by the absence of Chalk, Oolite, Permian, Devonian, &c., is described by Prof. Peters †† as occurring near Bleiberg. The section begins with

* Dufrénoy and De Beaumont, 'Explication de la Carte Géol. de France,' vol. ii. p. 198.

† *Ibid.* vol. ii. pp. 124, 125.

‡ As all the Sections are self-explanatory, each will be found at the head of the period to which it refers, without any further notice.

§ Bull. Soc. Géol. de France, 2ᵉ série, vol. x. p. 319.

‖ Cours de Paléontologie, vol. ii. p. 768.

¶ Histoire des Progrès de la Géologie, vol. vii. p. 217.

** D'Archiac, 'Histoire des Progrès,' vol. iii. p. 9.

†† "Die Umgebung von Bleiberg," Jahrbuch der k. k. geol. Reichsanstalt, &c. vol. viii. p. 67.

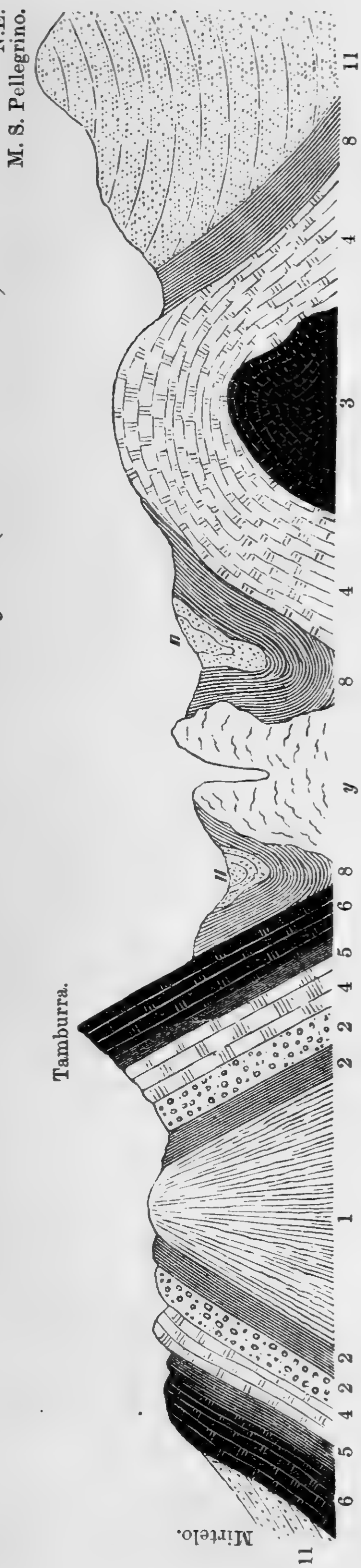


Fig. 4.—*Section from near Massa to Monte San Pellegrino* (after M. L. Pareto).

1. Gneiss and schists.
2. Upper Verrucano.
3. Black marble or Bardilio (Triassic).
4. Liassic marble and schist, with *Ammonites*, &c.
5. Jurassic Clay-slate.
6. Upper Jurassic black dolomitic limestone.
8. Galestro schists.
11. Macigno (Eocene).
y. Ophiolite.

Tertiary strata, which rest directly on Lower Lias; and then occur successively, in descending order, Upper and Lower Trias, Carboniferous schists (diorites intercalated), conglomerates, mica-slate, and, finally, gneiss. It is occasionally seen that the Tertiary beds* of the great plains of Prussia, which stretch uninterruptedly from the mountains of Saxony, Magdeburg, and Brunswick, northwards to the sea, repose on the Muschelkalk.

Sir R. I. Murchison † discovered that on the northern edge of the Bavarian and adjacent Alps, the upper part of the Eocene formation (together with some Miocene strata) was either never deposited or had been swept away; and he justly considers their absence an important fact. The Tertiaries of these countries have no connexion with the Chalk.

General Della Marmora ‡ met, near Pianedda and Gonessa, as well as on Mount Cardiga, in Sardinia, as also at Goni and Terra Segada, in the same island, with Nummulite-limestones and sandstones incumbent horizontally on the upturned edges of Silurian schists.

The Lower Eocene §, with Nummulites, forms the roof

* Histoire des Progrès de la Géologie, vol. viii. p. 522.

† Quart. Journ. Geol. Soc. vol. v. pp. 227, 228.

‡ Voyage en Sardaigne, vol. i. pp. 32, 228, 233. See also Lyell's 'Principles,' p. 187 (on the Pyrenees).

§ D'Orbigny, 'Cours de Paléont.' vol. ii. p. 701.

of a considerable gap in the same parts of Europe. In France it covers Neocomian at Orgon, there being six of D'Orbigny's stages missing. At Aude it is placed on Palæozoic rocks, and in the Department of the Var it is on Jurassic. In Brittany it overspreads successively Cretaceous, Jurassic, Palæozoic, and Azoic rocks. Mr. Hamilton (our present President), in one of his addresses *, deriving his information from Captain Grant and others, informs us that wide expanses in India, namely, in Scinde, Cutch, Beloochistan, and the Punjaub, are covered with Nummulitic Limestone capping arenaceous and clayey strata, which lie, not on Cretaceous, but on Jurassic or some still older bed.

On the Upper Missouri, Dr. Hayden †, in 1861, described Eocene strata lying first upon some thin Cretaceous and Jurassic beds, and then on Primordial sandstone, supported unconformably by Laurentian gneiss and granite. Here, therefore, the gaps are many and very great.

Nummulite Limestone rests, near Thun, on Neocomian ‡, and in the Diablerets on Gault, the fossils of the two formations being sometimes mingled together.

3. *With a Cretaceous Roof.*—Premising a few words on the members of this formation, I may observe that a valuable table, drawn up by Vicomte d'Archiac, and referring to seventy-one different regions, both small and large, enables me to state that, massing together all the subdivisions of the Cretaceous series, little more than one-third of the whole has been actually laid down in these seventy-one countries. They are found in twos and threes; and it is exceedingly rare to find the whole, or nearly the whole, succession in one place. Gaps, therefore, among the members of the chalk-beds, implying subaërial conditions, are all but universal in space and time; and this is the case also in other portions of the sedimentary series. We see from this elaborate table § that of our four Cretaceous groups, 1, White Chalk; 2, Chalk-marl and Upper Greensand; 3, Gault; 4, Neocomian, the most constant is the second, for it occurs in 65 regions out of 71; then comes the first, found in 38 regions; the fourth in 32; and the third only in 13 regions.

As to their thickness, and the lapse of time represented, they are in the following order:—the fourth group is the thickest; then the second, first, and third successively.

The series is most complete in England and France; next follow the north of Germany, and the province of Constantine in Algeria.

The south flank of the Maritime Alps and the north flank of some of the other of those high ranges present, each, six subdivisions of Cretaceous rocks (13 in the whole series, D'Archiac); but elsewhere over the surface of the globe, as far as is known, this formation may be described as poorly, or very poorly, represented, or quite absent; although in some parts, as in North America, its superficial extent is

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

† Annals of Nat. Hist., 3rd series, vol. xi. p. 371.

‡ D'Archiac, 'Histoire des Progrès,' vol. iii. pp. 87, 89.

§ 'Histoire des Progrès,' vol. v. p. 610 *bis*.

vast. Thus, following the Chalk-beds from west to east, from the eastern frontiers of Gallicia and Podolia to the south end of the Oural Mountains, we have 30° of longitude, and from north to south, from Simbirsk to Orenburg, nearly 7° of latitude. Throughout the whole of this space we have only the White Chalk, and it is never more than 300 feet thick; and in Russia it lies exclusively on Oxford Clay, Kimmeridge Clay, and Portland Stone—a fact of great interest. The highly fossiliferous chalk of Trichinopoly and South Arcot is subdivided by Mr. H. T. Blanford * into six groups; and some of these are often missing.

a. *Chalk.*—The following instances of blanks occurring from beneath the Chalk might be multiplied almost indefinitely. Very many more are implied in the blanks treated of under other epochs. In most cases the area is considerable, and reaches to many hundreds or thousands of square miles.

The Cretaceous rocks in England are always unconformable to the Oolitic †, with considerable denudation of the latter, as in Oxfordshire (Prof. Phillips). There is, therefore, a hiatus between them.

According to Mr. Darwin ‡, Upper Cretaceous rocks lie on Jurassic strata in the Chilian Andes, Neocomian beds being absent; and at Coquimbo and other places Cretaceous and Jurassic fossils are intermingled in the same beds, from which it is inferred that the passage has been gradual, and that there has been no gap. On Lake Tiberius § and about the Dead Sea, in Palestine, in the Duchy of Brunswick ||, on the north flank of the Hartz, Chalk covers Lower Jurassic strata ¶; while in the plains of Poland, Gallicia, and Volhynia it lies horizontally on the newest Jurassic. In the Department of the Var ** this rock caps Jurassic strata, which latter are incumbent on Bunter Sandstone.

In Yorkshire this formation rests both upon Lias and upon the curved and inclined beds of New Red Sandstone †† (Trias). Casiano de Prado ‡‡ found it, in the province of Segovia, to lie, by overlap, successively on Trias, Silurian, Gneiss, and Granite, all deeply denuded.

M. Ivanitski §§ met with Chalk lying directly on Keuper at Bakhmoutha (Donetz, Russia); and nearly the same thing occurs at Jumilla, in Spain, as we learn from a fine section in the Salines of Rosa ||||.

Chalk overlies Upper Carboniferous Limestone unconformably in

* Palæontologia Indica, vol. i. p. v.

† Jukes, 'Manual of Geology,' pp. 620, 621.

‡ Bull. Soc. Géol. de France, 2e série, vol. iv. p. 508.

§ D'Archiac, 'Histoire des Progrès,' vol. v. p. 388.

|| *Ibid.* vol. vii. p. 511. ¶ *Ibid.* vol. v. p. 334.

** *Ibid.* vol. vi. p. 556. †† Lyell, 'Principles,' p. 187.

‡‡ Bull. Soc. Géol. de France, 2e série, vol. xi. p. 337.

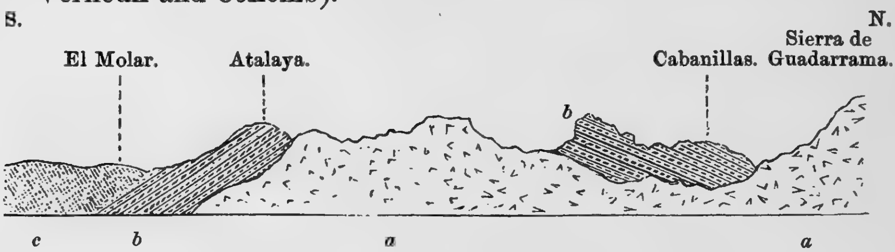
§§ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 567.

|||| De Verneuil and Collomb, Bull. Soc. Géol. de France, 2e série, vol. xiii. pp. 677, 683.

New Mexico * over large spaces; also in Texas and Tennessee, and over great tracts in the valley of the Missouri; thus indicating several extensive blanks.

The "Craie tuffeau," in Westphalia, covers Carboniferous schists and limestone †, and we have the same in the Don country of South Russia. At Harwich ‡, Kentish Town §, and Calais, deep borings, after having passed through the Cretaceous series, have struck at once into rocks apparently Palæozoic, and which at Calais are true Coal-measures. Near Seu d'Urgel, on the River Segra (N. Spain), M. Noblemaire ‖ met with Cretaceous rocks resting on Upper Silurian; and M. Della Marmora ¶ describes them as reposing on Lower Silurian in Sardinia. Parts of Scania, in Sweden, exhibit the same kind of facts. At and about Segovia **, at Cerada and Lozoya (Spain), beds of this formation rest upon ancient schists and granite; we find them also upon the latter, extensively, in Saxony, in Sweden ††, in Southern India ‡‡, and (Hippurite limestone) at Tavolara, and elsewhere in South-west Sardinia §§.

Fig. 5.—*Section in the Sierra de Guadarrama, south of Cabanillas, showing Chalk resting on Granite of unknown age* (after MM. de Verneuil and Collomb).



a. Granite. *b.* Chalk. *c.* Diluvium.

In these twenty-eight instances of blanks, which were taken nearly as they came, the Cretaceous beds are found in contact with the following rocks (once sea-bottoms). They lie on Jurassic six times, Lias once, Trias four times, Carboniferous Limestone or schist seven times, on Silurian twice, and on old granite, gneiss, and mica-slate eight times.

Why the Chalk is not recorded as lying directly on Permian, Devonian, &c., I cannot tell; perhaps for want of a more extensive search.

b. *Upper Greensand.*—Neocomian, Gault, and Lower Greensand are missing in France, on the west side of the Anglo-Parisian

* James Hall, 'Boundary Report of Mexico,' vol. i. p. 117.
† D'Archiac, 'Histoire des Progrès,' vol. v. p. 224.
‡ Austen, Quart. Journ. Geol. Soc. vol. xii. p. 41.
§ Prestwich, *ibid.* vol. xii. p. 6, vol. xiv. p. 249.
‖ Annales des Mines, 5e série, vol. xiv. p. 52.
¶ Voyage en Sardaigne, vol. i. p. 414.
** D'Archiac, 'Histoire des Progrès,' vol. v. p. 49.
†† *Ibid.* p. 251.
‡‡ Blanford, 'Palæontologia Indica,' vol. i. p. v.
§§ Della Marmora, 'Voyage en Sardaigne,' Part 3. vol. ii. p. 24.

basin, and in that of the Pyrenees; but the Upper Greensand occurs in both regions.

The transgressive and ever-varying relations of some deposits are finely illustrated by the Upper Greensand. It lies on Portland Stone near St. Jean d'Angilly; on Kimmeridge Clay at Cap la Hêve (Normandy) *; on Coral Rag at Ecommoy; on Oxford Clay at Dinas; on Kelloway Rock at Ballon, and on the Great Oolite. At Tournay this rock covers Coal-measures; at Tonvois, and in La Vendée, we find it on Azoic beds †.

Prof. Cook, from surveys and borings, has published ‡ some apparently accurate details on the true stratigraphical relations of the Greensand of New Jersey (North America); and he announces that it is in direct and discordant superposition to Laurentian gneiss.

Neither of these beds is seen on the north flank of the Pyrenees, nor on the Lower Pyrenees, in the Landes on the north-west, nor on the opposite border of the Cretaceous sea, in the Périgord, the Angoumais, the Saintonge, and finally in the basin of the Loire—and the result is a proportionately great gap. Dr. Geinitz does not admit the presence of Gault in the valley of the Elbe §.

c. *Gault and Neocomian.*—I have under this head only to mention that M. Lory ‖ has recognized Neocomian strata resting on Oxfordian limestones in the Departments of the Drôme and the Isère, north-west of the town of Gap.

4. *With a Jurassic Roof.*—I shall be rather minute in treating of the omitted portions of the Jurassic strata, partly because we meet with good matter, and partly to show what the other periods would disclose if treated with equal fulness.

We shall find here denudation in general and intense activity, and suspension of the processes of deposit. We shall sometimes find much of the formation absent, and often notice its fragmentary occurrence, as well as its disguise by metamorphism; that process, however, from time to time relaxing in force, and then not destroying the characteristic fossils.

Rarely, if ever, is the Jurassic series complete. Generally we find only one of the four principal members ¶. The most constant, if we are to judge from organic remains, is the Oxford Clay; then the Lias; thirdly, the Lower Jurassic; and fourthly, the Upper Oolite, the smallest of them all, and not seen out of Western and Central Europe. A glance at Dumont's large geological map of Europe will show us very well the superficial extent of the European Jurassic formation. It appears to cross the English Channel from Dorsetshire into Western Normandy, and to proceed to near Angers (Department of Maine and Loire), and so on, in two principal masses, both directed E.N.E., into the Departments of Vienne, Cher, the

* D'Orbigny, 'Cours de Paléontologie,' vol. ii. p. 610.
† Lory, Bull. Soc. Géol. de France, 2e série, vol. xi. p. 782.
‡ Boundary Report, Mexico, vol. i. p. 128.
§ D'Archiac, 'Histoire des Progrès,' vol. v. pp. 46, 277.
‖ Bull. Soc. Géol. 2e série, vol. xi. p. 782.
¶ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 699.

Côte d'Or, the Doubs, and the Jura. From thence it proceeds E.N.E. by Schaffhausen and parts of Würtemberg, to near Ratisbon (Bavaria), and then is not visible eastwards until we reach Prussian Poland, where it shows itself in two basins, near Oppeln, and in Sandomir, respectively. North-east from this, the Jurassic series does not come into view until we arrive in the Russian Governments of Smolensko and Kalouga. From thence it spreads in broad sheets to near Moscow, where, with increased width, it occupies great spaces on the west side of the Oural, and as far north as the Icy Sea. It extends from near Moscow in a south-easterly direction to Astrakan, and to the Caspian, Aral, and Black Seas.

The Alps of Mid-Europe abound in Jurassic rocks, in several very interesting forms, which run down much of Italy in two long and narrow strips.

Of the Jurassic strata of America and of the remaining quarters of the globe no notice will be taken here, because they are too imperfectly known to answer our present purpose.

The facts now to be brought forward will place in a very strong light the flitting nature of the process of deposition, its rapid changes from the accumulation of vast masses to absolute cessation, causing the loss of important stages. We may consider, says D'Archiac *, that the chain of the Jura and its ramifications occupy the zone of the greatest normal development of this formation. Escher von der Linth also remarks that in the Western Jura of Switzerland, as far as Lucerne, no violent dislocation has taken place between the Jurassic period and that of the Chalk †. In the valley of the Saône hard by, about Mâcon and other parts, nearly the whole series of stages is frequently present ‡. But even here, among the mountain-ranges between the Rhone and the Rhine, the lower of the three Oolites is very feebly developed, and the beds are constantly varying by absence or by presence, in extent, thickness, and contents, everywhere. The occasional coarseness of the beds shows that they then must have been within the influence of wave-action. To go now to the Alps, Sir R. I. Murchison § concludes, as one result of his investigations, "that the Jurassic system of the Alps and Apennines is made up of two distinct calcareous formations, the inferior representing the Lias and Lower Oolites, the superior the Oxfordian group."

Here are important gaps ; and we know that none of the sections, north and south of these mountains, are comparable with each other. Some member or other is absent from one, though present elsewhere. This irregularity and want of persistence in stages occasionally well characterized, and the sudden appearance and extreme thickness of some which are either altogether missing or very thin a few leagues off, are equally common and puzzling. Then, again,

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 600.

† Quart. Journ. Geol. Soc. vol. xi. part 2. p. 21.

‡ Berthand and Tombach, Bull. Soc. Géol. de France, 2e série, vol. x. p. 269; Thiollière, *ibid.*, 2e série, vol. v. p. 34.

§ Quart. Journ. Geol. Soc. vol. v. p. 307.

all these deposits being horizontal and undisturbed in one place, but fractured, faulted, displaced, and folded in another, makes the study of the Alpine Jurassic strata extremely difficult. This polymorphism of the Jurassic rocks of the north slope of the Alps we find represented in all the chains of *complex* mountains, that is, of those which owe their existence to a *repetition* on the same spot of the phenomena of fracture and upheaval.

On the south flank of the Maritime Alps*, and of Piedmont generally, there are, as far as we know, only two great Oolitic horizons, those of the Oxford Clay and the Lias, and these without any distinct subdivisions. Over large spaces, as on Monte Rosa †, Monte Cervino, the Gries Pass, in the Formazza Valley, and at Andermatt (Switzerland), the Jurassic strata, by metamorphism, become gneiss, and repose on another and older form of that rock. On the south slope of the Italian Alps ‡, as well as in Tuscany and in the Central Apennines, observers are agreed that the upper group of the Jurassic formation is wanting, and that the middle and lower groups are very poor, and represented rather by some species of fossils than by distinct beds; that the Lias is greatly developed to the exclusion of the rest of the series; and that the distribution of the fossils of these different stages does not constitute distinct faunas as in Western and Central Europe.

As to Italy, the Jurassic rocks, in the two districts in which they occur, have little thickness, and are defective in other respects.

In every direction from the Jura Mountains, and not southward only, this formation diminishes in completeness §, and becomes gradually simpler; for instance, as we advance eastward through Würtemberg, Moravia, and Silesia, until we arrive on the frontier of Europe and Asia, where it is found to consist of only a single term of the series. In these various countries the second group of Jurassic rocks is the sole representative of the epoch; and it is important to note that in Germany ||, in the broad interval between the Rhine and Vienna, the petrographical characters of the Jurassic beds, their local divisions, stratification, and fauna, all become incapable of detailed comparison with the type of the Jura chain, so great and multiplied have been the changes in the constitution of this formation from movements of oscillation of level.

In the South of France ¶, and in various other parts of that empire, the Oolite presents numerous irregularities in the deposition of its stages and groups; and there are many blanks, as in the Departments of Calais, the Var, and the Gard. The Upper Oolite is wanting on the east flank of the Beaujolais Mountains and on the south side of the Côte d'Or, while in the Valleys of the Isère, of the Drac, and in the Drôme the lower group is lost **.

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 281.

† *Ibid.* (Sismonda) vol. vii. p. 226. ‡ *Ibid.* vol. vii. p. 337.

§ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 677. || *Ibid.* vol. vii. p. 703.

¶ Dufrénoy and De Beaumont, 'Explication Carte Géol. de France,' vol. ii. p. 555.

** D'Archiac, 'Histoire des Progrès,' vol. vi. p. 559, vol. viii. p. 193.

In Spain * all stages of the Oolitic series are poorly developed. The Oxfordian gives to it its chief feature, the others being quite rudimentary. In the Pyrenees the Oolite is distinctly seen, but it is in mere fragments (Leymerie).

The Oolite of England is more complete and better characterized than in most other countries ; for in them it is everywhere imperfect, and in some places is thin, displaced, and even scarcely represented; but in England also, rich in mineral condition and fossil contents as the different beds often are, they are frequently either absent or non-persistent. All along the coast of Dorsetshire †, and indeed throughout the south of England, the Great Oolite is wanting; and commonly this series of beds is supported by Lias; but between Norton Phillips and Frome horizontal beds of the former abut against, not Lias nor Trias, but inclined strata of Carboniferous Limestone.

A formal description of the rocks of this epoch is not now our object; but we may add that, generally speaking, we find only one of the stages in the same locality: the most constant, as has already been observed, is the Oxford Clay ‡.

The peculiar circumstances attending the occurrence of the Oxford Clay, and especially its enormous range, must form my excuse for dwelling on it, before proceeding to point out some blanks connected with the Jurassic strata.

The Oxford Clay, with its beautiful fossils, which are said by D'Orbigny § to be identical from the equator to the pole, is spread over a far greater geographical space than any other stage of the Oolitic period. It occurs all through Western Europe, in England, Italy, Spain, France, and Germany ‖. Together with the Coral-rag, it gives to the Jura Mountains ¶ their strongest orographic characters. In the Salt Range of the Punjaub ** and in the Himalayas of Northern India it is very conspicuous; but in Russia it particularly claims the attention of the geologist.

Sir Roderick Murchison and his colleagues say that the Oxfordian is almost the only Jurassic bed in Russia ††. It is there capped by the Cretaceous strata, and lies on Palæozoic rocks, as near Plas, Mackariof, and Moscow; and whether seen near Moscow, on the Volga, in the Oural, or in the Petchora Valley, &c., its composition is surprisingly uniform. It is always very thin, and is accompanied by shreds of Kelloway Rock, Coral-rag, or Calcareous grit.

Sir Roderick was rightly much struck by the simplicity, uniformity, and thinness of the Russian Jurassic strata, which doubtless continue, on the north-east, across the immense plains on the coasts of the Icy Sea to New Siberia, and extend over 100° of longitude and 27° of latitude. The necessarily uniform action which must have prevailed over this vast surface is not without its

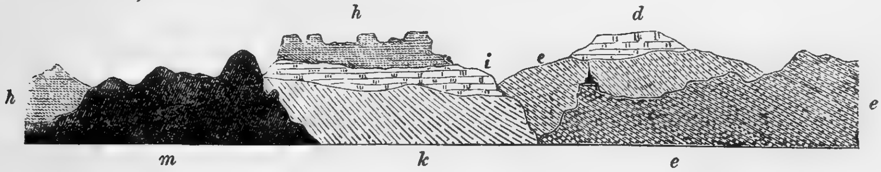
* D'Archiac, 'Histoire des Progrès,' vol. vi. pp. 163, 206.
† *Ibid.* vol. vi. p. 102. ‡ *Ibid.* vol. vii. p. 699.
§ D'Orbigny, 'Cours de Paléontologie,' vol. ii. p. 521.
‖ D'Archiac, 'Histoire des Progrès,' vol. vi. p. 100.
¶ *Ibid.* pp. 50, 56, 57. ** Quart. Journ. Geol. Soc. vol. ix. p. 194.
†† Geology of Russia, vol. i. pp. 230, 231, 245, 247, 253, 256, vol. ii. p. 428.

parallel, namely, the Estuarine beds of the Pampas of South America, the phosphatic deposit in Russia, and the deposit of chlorite-earth on the south side of Lake Superior; but the upper and lower lacunæ brought to light here have no equal in dimensions. The upper is bounded by White Chalk and the Oxford Clay; and the strata absent are portions of the Cretaceous series (including all the Neocomian) and much of the Jurassic. The lower gap is made by the loss of the Lower Oolite, the Lias, the Trias, and often the Permian; the Oxfordian always resting either on Permian or Carboniferous. The Chalk and the Oxford Clay (the latter being floor and roof at the same time) of this great region were therefore above water during the deposition elsewhere of the remaining Secondary rocks. These remarkable blanks are not so distinct and continuous in Western Europe; for there the Secondary formations are better represented. In the Doubs and the Cevennes (France) the Oxford Clay is followed normally by the lower rocks; and in other parts of France it is supported by the Great Oolite and other members of the third group *.

The following is only one instance out of many in which the great eastern blank is filled up in the west; but as it is very striking, it may receive brief notice. It is seen in a section of the Jurassic rocks extending from Donzenac † (Department Corrèze) to Sasseginnies (Lot), in the south-west of France. In the interval between these two towns seventeen important stages, between Tertiary strata and a gneiss, probably Laurentian, succeed each other conformably. These stages represent Chalk, beds belonging to each of the three Oolite Groups, four beds of Lias, Keuper and red clay of the Trias, two Carboniferous beds, a roofing-slate (Silurian?), mica-slate, and, lastly, gneiss.

a. *Oolite.*—I will now mention some of the blanks which begin at the Oolite, as a few out of the many; my difficulty throughout this paper being not to overload the subject.

Fig. 6.—*Section near Albarasin, between Madrid and Alicante, showing Oxford Clay resting on Lias, and Trias on Silurian* (after M. Collomb).



d. Oxford Clay.
e. Lias.
h. Clay and Gypsum (Trias).
i. Muschelkalk.
k. Bunter Sandstone.
m. Silurian.

M. Triger ‡ gives a large and beautiful section from near Mans, which tells us of the absence of the Great Oolite, and of a vast gap from the Lias-marls down to the schists of the Lower Silurian.

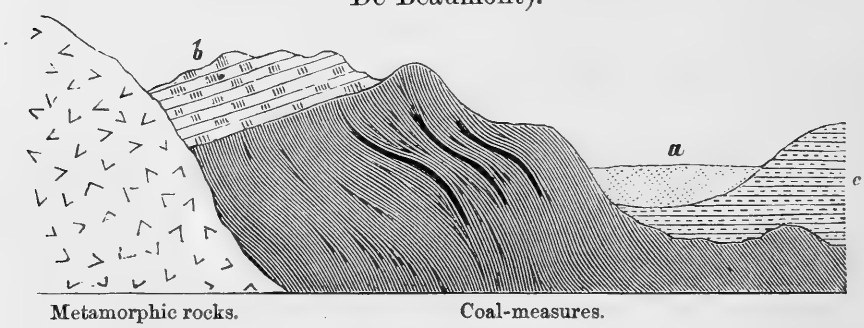
* D'Archiac, 'Histoire des Progrès,' vol. vi. p. 464.
† *Ibid.* vol. iv. pl. 2. fig. 1.
‡ Bull. Soc. Géol. de France, 2e série, vol. vii. p. 762.

M. Hébert * also points out in a striking manner the variable nature of the Jurassic rocks of France, from the frequent oscillations then affecting the north of that empire. In the Grindelwald † (Switzerland), and in large areas around, M. Escher von der Linth found Jurassic beds superposed directly on granite and subcrystalline rocks. In the Valley of St. Ortee Mannee, and at Perdas de Fogue (Isle of Sardinia), a magnesian limestone (Jurassic) covers horizontally carbonaceous shales, which, in their turn, rest on Lower Silurian, and thus indicate two separate and large blanks. We miss Lias, Trias, Permian, Devonian, &c. ‡; and I infer, among other things, that a Carboniferous basin laid long bare to the sky; but not without effect, as we shall see.

In the South of France, M. Fournet § met with Oxford Clay resting on Trias, near Valence, and likewise near St. Ambroux.

In Poland, Oolite is incumbent on Muschelkalk, and the sandstone of its third stage on both porphyry and melaphyr ‖; Oxfordian also rests on Muschelkalk in the Himalayas ¶. The Jurassic series is in two places on Carboniferous shales in Sardinia **, and once in Poland ††. In the latter country we find it on Carboniferous sandstones, as well as in France.

Fig. 7.—*Section at Rochebelle, near Alais* (after Dufrénoy and De Beaumont).



a. Alluvium. *b.* Jurassic limestone. *c.* Lower Chalk.

In Russia we have seen that the Oxfordian always rests either on Permian or Carboniferous (Murchison, *passim*), and in the Mendip Hills ‡‡ (Gloucestershire) on the latter. In the Napoleon Quarry §§ of the Bas Boulonnais this formation is met with on Lower Silurian, with, of course, the omission of many great epochs.

I have now shown how variable in quantity and constitution is

* Comptes Rendus, vol. xliii. p. 853.
† D'Archiac, 'Histoire des Progrès,' vol. vii. p. 553.
‡ Della Marmora, 'Voyage en Sardaigne,' vol. i. p. 111.
§ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 193.
‖ *Ibid.* vol. vii. p. 553.
¶ Strachy, Quart. Journ. Geol. Soc. vol. vii. p. 306.
** Della Marmora, 'Sardaigne,' vol. i. p. 111.
†† D'Archiac, 'Histoire des Progrès,' vol. vii. p. 553.
‡‡ Ramsay, Mem. Geol. Surv. Great Britain, vol. i. p. 320.
§§ Dufrénoy and De Beaumont, 'Explication Carte Géol.' vol. ii. p. 155.

the Oolitic formation, and have selected fifteen cases of gaps in different countries, besides the two mentioned in Table B, passing in silence many more. The reader will perceive how frequently the subject has been enriched by the valuable writings of Vicomte d'Archiac.

b. *Lias.*—As in the Oolite just reviewed, so in its closely connected group, the Lias, all its parts are seldom found in the same place. Beyrich reports that the first stage is absent on the north side of the Hartz*. We seek in vain in the Swabian Lias for Corals, which are especial evidence of shallow seas; while Calvados is very rich in them. In Burgundy, the Jura Mountains, and Normandy, whole banks and reefs of Corals are met with in the Brown Jurassic rocks; in Swabia they are rare †.

In Würtemberg, where this formation is well developed, it is never complete ‡; and Chev. von Hauer, in the eastern or Austrian Alps, perceived that one or two terms were always missing §. In the Bocage of La Vendée, Fournet ‖ says there is no Lower Lias, and very little of Upper; and in the Swiss Jura the Lower Sandstone of this group is absent ¶.

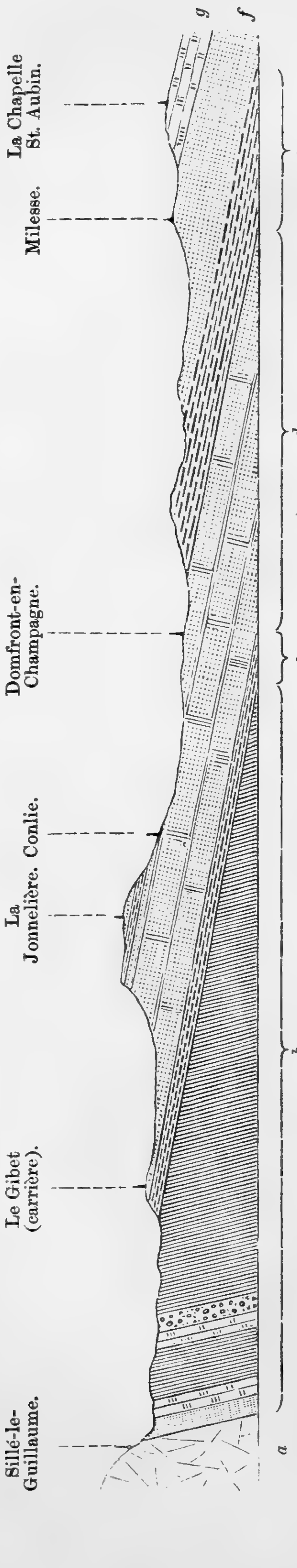
In his Bridgewater Treatise (vol. i. p. 307), Dr. Buckland gives two excellent proofs of the occurrence of an interval between the deposition of the component parts of the Lias: the one is from the floor being sprinkled with coprolites; and the other the fact of the Belemnites lying in thousands, spread out horizontally, and covered with Serpulites and Mollusks. In two cases the Lias rests on Carboniferous Limestone (France and Wales)**. In two others it lies on Old Red Sandstone (Scotland and Wales ††), and in two more on Silurian in France (Gosselet and De Beaumont ‡‡). It lies on an old granite in the Valley of the Yonne (France §§), and on metamorphic rocks in Scotland ‖‖.

The nature of the gaps resulting from these imperfect stratigraphical sequences is easily recognized.

5. *With a Triassic Roof.*—There are extensive blanks, of which Triassic rocks form the roof. In the *central part* of Russia in Europe ¶¶ this formation does not exist. Of Muschelkalk there is not a vestige in England (unless we consider the waterstones as such), nor in the large tracts of Trias in France—in the Departments of the Saône and Loire, of the Côte d'Or and the Rhone, and the mountains of Charolois and Tararc ***.

* D'Archiac, 'Histoire des Progrès,' vol. vii. p. 518.
† Fraas, Quart. Journ. Geol. Soc. vol. vii. p. 43.
‡ *Ibid.* p. 459. § *Ibid.* p. 394.
‖ Bull. Soc. Géol. France, 2e série, vol. xvi. p. 416.
¶ D'Archiac, 'Histoire des Progrès,' vol. vii. p. 74.
** Fournet, Bull. Soc. Géol. France, 2e série, vol. xvi. p. 416; De la Beche, Mem. Geol. Survey, vol. i. pp. 262, 269, 279.
†† Portlock, Quart. Journ. Geol. Soc. vol. xiv. p. cxxxvii.
‡‡ De la Beche, Mem. Geol. Survey, vol. i. pp. 262, 269, 279.
§§ Ebray, Bull. Soc. Géol. France, 2e série, vol. xvi. p. 427.
‖‖ Portlock, Quart. Journ. Geol. Soc. vol. xiv. p. cxxxvii.
¶¶ D'Archiac, 'Histoire des Progrès,' vol. viii. p. 566.
*** De Beaumont and Dufrénoy, 'Explication Carte Géol.' vol. ii. p. 99.

Fig. 8.—*Section from Sillé-le-Guillaume to St. Pavace, near Le Mans.*



a. Porphyry.
b. Lower Silurian.
c. Upper Lias.
d. Inferior Oolite.
e. Oxford Clay.
f. Greensand.
g. Fontainebleau Sands.

Fig. 11.—*Section of part of the Silurian Basin of Bohemia* (after Barrande).

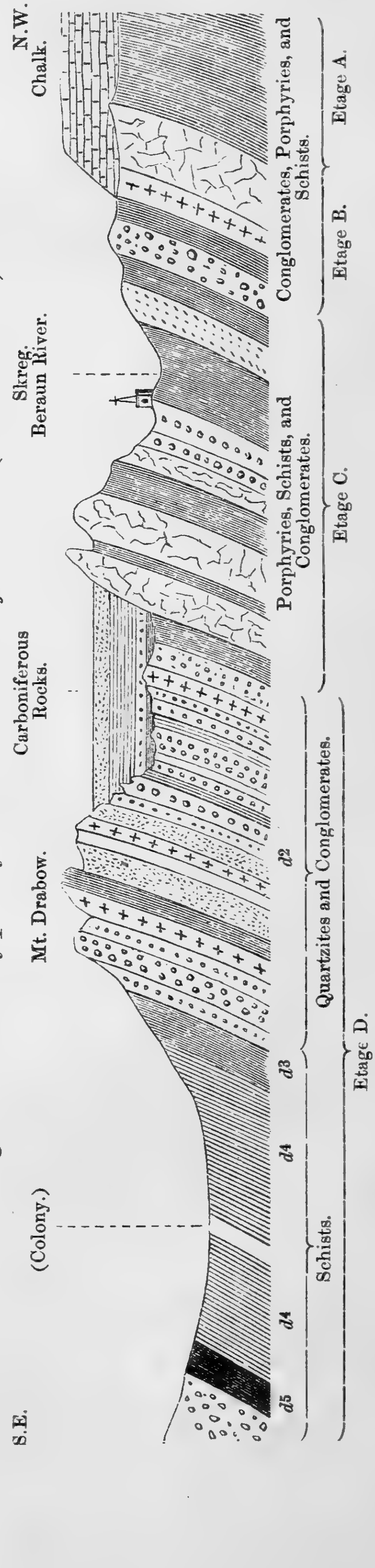
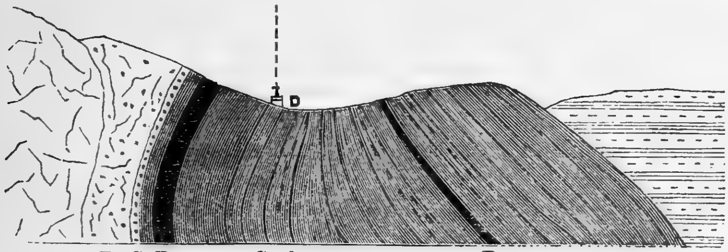


Fig. 9.—*Section of the Coal-basin of the Saône et Loire* (after Dufrénoy and De Beaumont).

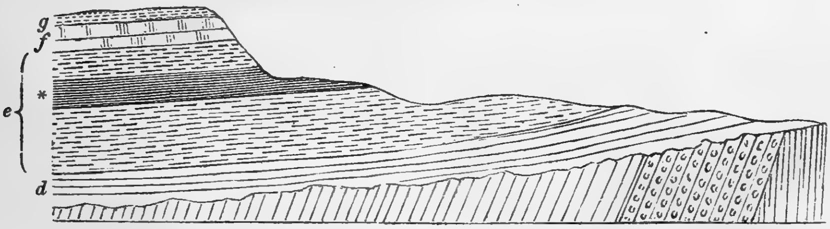


A. Granite.
B. Porphyry.
C. Pudding-stone.
D D D. Coal-beds.
E. Keuper.

At Sierck, on the Moselle*, all the three members of the Trias, considerably inclined, lie on old quartzose rocks, also inclined, but in another direction. The Triassic strata of South Staffordshire † are in contact with Silurian; both Carboniferous and Devonian being missing in parts. D'Orbigny mentions a similar instance in South America. The Upper Trias (4500 feet thick) of the eastern or Atlantic flank of the Appalachian Mountains abuts upon the older metamorphic rocks, and thus indicates the absence of five great formations ‡. The Triassic coal-field, near Richmond in Virginia, is superimposed on a granite newer than itself; for it is penetrated by veins of the latter.

6. *With a Permian Roof.*—A few examples must suffice in evidence that gaps are not uncommon between this formation and those below it. They occur in countries very distant from each other, and differ from those of other epochs in the interval rarely consisting even of one whole period. They are, as far as known to

Fig. 10.—*Diagram showing the general Relations of the Palæozoic Rocks of Saxony* (after Murchison and Morris).



a. Silurian.
b. Devonian.
c. Lower Carboniferous.
d. Upper Carboniferous.
e. Rothliegende. } Permian.
* Plant-beds.
f. Zechstein.
g. Sandschiefer.

* De Beaumont and Dufrénoy, Explication Carte Géol. vol. ii. p. 13.
† Jukes, 'Bibliothèque Universelle de Genève,' vol. xiii. p. 69, 1850.
‡ Emmons, 'Geology of North Carolina,' 1856.

me, simple discordances, but with interspaces of conglomerate (South America*, Russia†).

In England, and in many other places, the Permian usually graduates into the Carboniferous; but in the north of England Prof. Sedgwick has observed its lowest beds resting unconformably on the Coal. And the same holds good with the Dolomitic Conglomerate of the neighbourhood of Bristol, and also with respect to the south-eastern part of the South Wales coal-basin. In like manner De la Beche‡ has inferred great disturbances after the deposition of the Coal-measures, the effect being to place the various Permian beds unconformably in places on the Carboniferous rocks.

Sir R. I. Murchison § met with the same facts in Russia over great regions (Oural), though elsewhere, in that country, there is a distinct transition between the two formations in question.

The Permian of Kansas ||, in North America, is superposed conformably on Carboniferous shales, clays, and limestones, with intermixture of their organic remains; but that of Illinois (North America) is reported by Mr. Worthen ¶, the Government Geologist of that State, to lie unconformably on Carboniferous rocks in a highly disturbed country.

Mr. David Forbes **, in his paper on South American geology, found the Permian among the vast sedimentary accumulations of that part of the world; it lies in discordance as regards the Devonian at Coniri in Bolivia, where the red conglomerates, the lowest of the series, abut against the nearly vertical Devonian shales.

7. *With a Carboniferous Roof.*—It will probably be seen, in a later part of this paper, that unusually large expanses of emerged land existed in several parts of the world during the Carboniferous period.

As in the case of all the preceding strata, the different parts of the Carboniferous deposits vary greatly with the locality. This applies, according to Logan, Dawson, and Lesley ††, particularly to Nova Scotia. They are here very minute and almost endless. In Missouri, Prof. Swallow has divided the whole coal-field of that State into seventy-five parts, from mineralogical and other reasons. All these parts vary in thickness, and the several coal-beds cannot be identified except by their position with respect to the hydraulic limestone (No. 66). The coal-beds (Nos. 62 and 64) are wanting in many places; and in Marion County all the strata below No. 60 have disappeared ‡‡. The intervals of non-deposit below coals are of various extent; and they commence at various stages of the epoch. In England and in Western Europe, according to Murchi-

* E. Forbes, Quart. Journ. Geol. Soc. vol. ix. p. lxx.

† *Ibid.* vol. v. p. li.

‡ Travels in South America, vol. iii. p. 60.

§ Geol. of Russia, vol. i. p. 146.

|| Meek and Hayden, Proc. Acad. Nat. Sciences Philadelphia, 1859.

¶ Meeting of the American Association for the Advancement of Science, Baltimore, 1855?

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

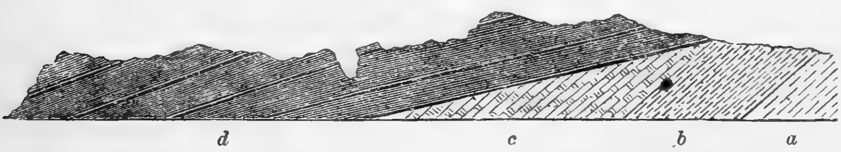
†† Lesley, American Journal of Science, 2nd series, vol. xxxvi. p. 183.

‡‡ Swallow, 'Geol. Rep. of Missouri,' 1855, p. 86.

son *, the Coal-measures are generally in concordance with the Carboniferous Limestone; but this is not the case in parts of Bohemia and Poland, where great dislocations took place *after* the deposition of the Carboniferous Limestone, and *before* that of the Coal-measures. The former of those two, together with the Devonian and Silurian rocks, dips at a high angle, while the Coal-measures are horizontal. In this unconformity we have a breach and an interval of time represented. Sir R. I. Murchison observes that a great fracture between the lower and upper divisions of the Carboniferous groups extends not only throughout Germany, but through France also. Blanks whose roofs are of Carboniferous rocks are numerous, because coal-basins are numerous. Dr. Dale Owen † informs us that near the eastern limits of Montgomery County, Kentucky, a bed of coal rests on a Devonian sandstone (Chemung), the latter being on another sandstone full of the Cauda-galli fucoid. In Brittany ‡ and the west of France the Lower Carboniferous beds are in direct superposition to the Lower Devonian; and at Lesmahago § (west of Scotland) the coal-beds repose transgressively on several horizons—on the Old Red Sandstone, and Silurian of different ages. These three conditions arise from distinct crust-movements. At the mouth of the gorge of L'Echappe, in the valley of Firminy, it is interesting to observe that the Carboniferous sandstone, where in contact with the mica-slate, is composed of small and often angular fragments of the slate; thus indicating an interval of time between their deposition. Their respective dips are different ||.

Out of thirty-two instances, from my ordinary note-book, of blanks downwards from the Coal-formation, twenty have their base on Silurian strata, partly because they are stratigraphically near; but still a blank of great duration is involved. A few instances will now be stated, and some of the rest will be referred to in a foot-note.

Fig. 12.—*Section showing Coal-measures lying unconformably on Lower Silurian* (after Hall and Daniell).



a. Calciferous Sandstone. *c*. Trenton Limestone
b. St. Peter's Sandstone. *d*. Coal-measures.

Prof. James Hall, of Albany (in a short tract, published separately), describes Coal-measures lying unconformably on Trenton Limestone,

* D'Archiac, 'Histoire des Progrès,' vol. iii. p. 135.
† Geol. Surv. Kentucky, 4th Report, p. 341.
‡ Murchison, 'Siluria,' 3rd edit. p. 441.
§ Geikie, Quart. Journ. Geol. Soc. vol. xvi. p. 320.
|| De Beaumont and Dufrénoy, 'Explic. Carte Géol.' vol. i. p. 520.

in North Illinois. Both Dr. F. Roemer and Dr. B. F. Shumard* found on the River San Saba, in Texas, Carboniferous Limestone lying conformably on Lower Silurian (Bird's-eye Limestone), and the latter geologist saw it under the same circumstances in the Black Hills of the Upper Missouri. In the Upper Mississippi Valley† Coal-measures successively overlap the inclined edges of the subjacent rocks, from Carboniferous Limestone to Lower Silurian—a fact which has several points of interest. Mr. Lesley ‡ gives an instance at Arisaig, in Nova Scotia, of Coal-measures unconformable on the Clinton group (Upper Silurian). It is stated by Prof. Haughton § that on the west coast of King William's Island, in the Arctic seas of America, extensive beds of Carboniferous sandstone, with bituminous coal, capped by blue limestone of the same period (?), rest horizontally and conformably upon Upper Silurian.

Prof. Edward Forbes ‖ relates that, in the north of England, Carboniferous Limestone lies on highly inclined Silurian strata, the former being nearly horizontal. In South Staffordshire the Coal-measures usually lie directly upon Upper Silurian shale, &c., according to Mr. Jukes ¶ and others, in the midst of great denudation; and Mr. Godwin-Austen extends this statement to Wire and Charnwood Forests, as well as to Coalbrook Dale **.

On the River Jezem, in the Oural, Carboniferous Limestone reposes concordantly on Silurian masses ††.

In the foot-note ‡‡ are placed references to many cases of Carbonifero-Silurian blanks.

* Bull. Soc. Géol. France, 2e série, vol. xviii. p. 261.

† J. Hall, Amer. Journ. Science, 2nd series, vol. xxxiii. p. 294.

‡ *Ibid.* vol. xxxvii. p. 189.

§ M'Clintock's 'Voyage,' &c., Appendix.

‖ Quart. Journ. Geol. Soc. vol. ix. p. lxx.

¶ Mem. Geol. Surv. South Staffordshire Coal-field, 2nd edit. p. 180.

** Quart. Journ. Geol. Soc. vol. xii. p. 53.

†† Murchison, &c., 'Geol. of Russia,' vol. i. p. 409.

‡‡ The following are a few instances of Carboniferous rocks in contact with Silurian or other very ancient formations:—

Barrande, Bull. Soc. Géol. France, 2e série, vol. xi. p. 311, &c. Bohemia: on Azoic Rocks.

Murchison and Morris, Quart. Journ. Geol. Soc. vol. xi. pp. 417, 427. Thüringerwald and Saxony: on Gneiss.

Grüner, Bull. Soc. Géol. France, 2e série, vol. xvi. p. 414. Département de la Loire: on old Metamorphic rocks.

Murchison, Geol. of Russia, vol. i. p. 22. In the Donetz (11,000 square miles): on very ancient Crystalline rocks.

Ramsay, Lecture, Roy. Instit. Lond. 1858. On the Longmynd.

Nicol, Quart. Journ. Geol. Soc. vol. vi. p. 58. On Lower Silurian in South of Scotland.

Fournet, Bull. Soc. Géol. France, 2e série, vol. i. p. 785, and vol. vi. p. 626. Near Roannes.

Tract on Mississippi Carboniferous Limestone. James Hall. On Laurentian and on Trenton Limestone, North Illinois.

Tuomy, Report on Geology of Alabama, pp. 8, 11, 20, 26, &c. On Lower Silurian; very extensively.

Henwood, Trans. Roy. Soc. Cornwall, 1840. Nova Scotia: on Granite.

Shumard, Geol. Surv. Missouri, 1855. On Trenton Limestone, at Sulphur Spring and Salt Creek, Upper Mississippi.

H. D. Rogers, see Dana's 'Manual,' p. 228. Upper Silurian of Kittatinny Mountain lies unconformably on Lower Silurian.

8. *With a Devonian Roof.*—Prof. James Hall remarks * that the Chemung group of North America affords distinct evidence of its having been subaërial from time to time: in its ripple-marks, its ever-changing laminations, in the increasing quantity of its Plants, some being terrestrial and others marine, all of which facts bespeak the immediate proximity of land. There are in the Ithaca subdivision long but somewhat indistinct traces of lanceolate and falciform Plants; some are waifs, and others are natives. It is at Cooper's Town, on the eastern edge of the Hamilton Sea, where the earliest remains of terrestrial Plants have been found.

The Oriskany Sandstone (a Lower Devonian bed), thick in New York and Pennsylvania, almost entirely disappears, together with other members of this system, about the Upper Mississippi.

On the river just named, the Portage and Chemung groups, at the top of the Mid-Devonian, lie directly on the Hamilton Shales, and so create a gap. Here also we might expect the Cattskill Mountain group (Old Red Sandstone, or Formations IX. X. XI. of the Pennsylvanian Survey); but its place is occupied by great masses of Lower Carboniferous limestones, full of typical fossils, and covering Chemung rocks, a deep-sea condition having suddenly supervened.

In St. Louis County (Missouri), Chemung rocks repose directly on Trenton Limestone †, the great deposits between them having no representative there. In the Report quoted below, Dr. Shumard ‡ mentions a similar fact as occurring on Grassy River, in Rall's and Pike Counties, Missouri.

At Marston's Bridge, on the River Lamine (Missouri), the Devonian formation rests on Calciferous Sandstone (Primordial). Prof. Swallow gives a useful table, in which we see that many and extensive blanks occur in these highly interesting countries. In the centre of the State of Tennessee §, according to Mr. J. M. Safford, there is an area, about eighty miles in diameter, which was probably raised above the ocean by the disturbances at the end of the Lower Silurian period. Here an Upper Devonian Shale overlies Lower Silurian; both Upper Silurian and Lower Devonian being absent.

These same blanks or gaps are plentiful in Europe. The following are a few examples. As in America, so in Russia ‖ (at Czarskoe-celo) sandy and marly Devonian beds are conformably placed over Lower Silurian (Pleta Limestone), the Devonian rocks being loaded with Ichthyolites, and the Silurian with *Orthoceratites*, &c. In the middle of the Cantabrian Mountains ¶ (Province of Leon, Spain) and on their south flank are two bands of red limestone containing fossils indisputably Primordial. These two bands are at least seventy-five miles long **, and are vertical. They are enclosed conformably within massive beds of Devonian Sandstone. In this in-

* Palæontology of New York, vol. iii.

† Shumard, 'Geol. Surv. Missouri,' p. 184.

‡ Geol. Surv. Missouri, p. 123.

§ Dana's 'Manual,' p. 228.

‖ Murchison, &c., 'Geol. of Russia,' vol. i. p. 31.

¶ Casiano de Prado, Bull. Soc. Géol. France, 2e série, vol. xvii. p. 517.

** Casiano de Prado and Barrande, Bull. Soc. Géol. France, 2e série, vol. xvi. *passim*, and vol. xvii. p. 789.

stance the interval was great, and involved the occurrence of many lithological changes, and the appearance of many successive generations of living creatures, about the site of the blank.

M. Bureau*, in the course of some interesting observations on the geology of the Upper Loire, reports the conformable junction there of Devonian with Azoic rocks, and with the granite of La Vendée, both seemingly pre-Silurian.

The little we know of the Devonian formation of Ireland appears to promise the discovery of curious phenomena. Mr. Godwin-Austen considers much of it to be a fluvio-lacustrine deposit, and that it was a terrestrial surface anterior to the oldest sediment of the Carboniferous period. It lies, we must not forget to say, on Lower Silurian, and therefore marks the existence of a wide gap.

Mr. Tate found, in the Lammermuir Hills of the south of Scotland, Carboniferous rocks overlying Old Red Sandstone conformably; and then follows downwards a great blank, the Devonian being in unconformable contact with the so-called Cambrian rocks†.

The space allotted to this subject will allow me merely to mention that seventy-eight highly suggestive cases have been brought forward by Mr. John Kelly‡, in which the Old Red Sandstone of Ireland rests upon beds belonging to thirteen different epochs; and forty-eight times on clay-slate and mica-slate.

9. *With a Silurian Roof.*—No inhabitants of dry land have as yet been found in the sediments of this epoch, except some spores and fragments of low-classed Land-plants. Prof. Edward Forbes's dredgings, however, have shown that this fact may lead to fallacious conclusions; and our Government surveyors § not very long ago determined that land did exist in Shropshire at this time; and they have begun to trace the boundaries of a Silurian sea-shore.

Potsdam Sandstone (Primordial) must have been frequently above the reach of wave-action, as we learn from the tracks of large Crustaceans, which may almost be said to be common near Perth, in Upper Canada, and a few miles west of Montreal.

The multitudes of large Coprolites found about the base of the Silurian strata for several thousand square miles of the lower part of the Valley of the Ottawa lead to a like belief. The districts join, and are nearly the same.

The Silurian formation, in all respects so instructive, behaves like those already reviewed. The remark of Prof. John Phillips ||, that no district yet discovered exhibits the Silurian deposits in their full development, is perfectly true. Abounding in blanks, its lost parts are innumerable, as Sir R. I. Murchison ¶ has shown in profuse detail.

A few distinct and authentic cases will now be produced, and references to others will be found in a foot-note.

* Bull. Soc. Géol. France, 2e série, vol. xvii. p. 789.

† Geologist, vol. iii. p. 240. ‡ Journ. Geol. Soc. Dublin, vol. vii. p. 122.

§ Lyell, Quart. Journ. Geol. Soc. vol. vii. p. liii.

|| Mem. Geol. Surv. Great Britain, vol. ii. p. 217.

¶ Siluria, 2nd edit. p. 111; and Murchison and Morris, Quart. Journ. Geol. Soc. vol. xi. p. 440.

Prof. Ramsay* finds Wenlock shale resting at right angles on upturned Llandeilo beds, and on the so-called Cambrian in the Shelve and Longmynd countries, as well as near Builth in Radnorshire; the gaps, in the Professor's opinion, being connected with denudation.

Chev. Fr. von Hauer †, assisted by eminent geologists, has executed a section across the Eastern Alps, from Passau to the Illyrian Karst. He found considerable Silurian beds on their north slopes, while on their south flanks these rocks are unknown, the older Carboniferous occurring in their place.

In British America, according to Sir W. E. Logan, the Lower Silurian occurs as tilted strata beneath the beds of the Upper, showing that an upheaval had occurred before the latter had been laid down. Similar facts have been observed at the eastern base of the Green Mountains of Vermont (U. S.), where limestones of Upper Silurian and Devonian age rest unconformably on the altered strata of the Quebec group ‡.

Dr. D. D. Owen observed §, on the south shore of Lake Winnipeg (Hudson's Bay), limestones of the Lower and, perhaps, of the Upper Silurian series lying on granite and syenite, without the usually intervening Primordial zone; as we likewise abundantly see at the village of Lorette, and on the sides of Cap Tourment, both near Quebec (Canada).

Wenlock ‖ is said to be the oldest limestone in the Arctic regions. If this be so, we have there either the non-deposit or the removal of the whole body of the Lower Silurian series.

In Iowa, on the west of the Mississippi, the upper beds of the Onondaga salt-group (Upper Silurian) are water-worn, and sometimes strewn with coarse sand and gravel, hardened occasionally into little patches of conglomerate; thus indicating, says Prof. James Hall ¶, a lapse of time before the deposit of the next succeeding stratum, some representative of the Lower Helderberg beds. The same eminent geologist remarks that ten of the seventeen Silurian stages found in the State of New York are wanting on the north of the River Ohio, or west of Lake Michigan—a very noteworthy fact **.

Since the happiest generalizations must rest on details, I am sure the Society will pardon the length of these.

* Quart. Journ. Geol. Soc. vol. ix. p. 175.

† L'Institut, 1857, p. 30.

‡ Dana's 'Manual,' p. 226.

§ Geol. Report, Wisconsin, p. 182.

‖ Murchison, Quart. Journ. Geol. Soc. vol. xi. p. 537.

¶ Palæontology of New York, vol. iii. pp. 290, &c.

** With reference to a few other instances of intervals with a Silurian roof, consult the following authorities:—

Della Marmora, Geol. of Sardinia, vol. i. p. 29; on Granite.

Sharpe, Quart. Journ. Geol. Soc. vol. ix. p. 143; conformably on Coal-measures, at Brazielo and Quinta da Lomba, Portugal.

Tuomy, Geol. Rep. Alabama, p. 8; on old Metamorphic rocks, extensively.

Hall, Palæontology of New York, vol. ii. (introductory review) pp. 20, 22, 46; absence of various important parts of the Silurian system. Vol. iii. p. 36; Lower Helderberg rocks on Utica Slate.

Murchison. See 'Siluria,' 2nd edit. p. 111; Pentamerus-sandstone, at May Hill, on unfossiliferous slate (below Lingula-flags).

III. Conclusion.

1. *General considerations.*—Missing formations are among the several consequences of emergence and immersion, themselves the effects of one of the great cosmic agencies—oscillation of level—which may be gradual or paroxysmal, through all the degrees of velocity and energy.

Oscillation is, in a sense, universal in time and place; but, apparently, its action is irregular. While its influence is felt in most places, as well in the interior of continents as in the ocean depths, it is most easily detected near great waters; and there seem to be both great and small breadths of country which are at least places of *comparative* rest. The most conspicuous of these are the axial lines of Scandinavia and the South Seas; but Egypt *, parts of the Danubian Valley, of Borneo, and Venice (E. de Beaumont) all seem to have been long stationary. Oscillation is the result of a power which operates from beneath through all existing groups of strata. It necessitates and facilitates the emigration of animals and plants, kills or multiplies life, driving it far and wide in search of proper pressure, food, shelter, and such like. Great elevation conduces to variety in life, and great depression extinguishes the higher forms of life.

Emergence gives us dry land of different forms and heights, with processes belonging to the latter in action. Such tracts are surrounded by seas, which lay down their insoluble contents, and are charged with living communities during countless ages, largely fed and varied by the drainage of the emerged soil. The dry surfaces are subjected to a particular course of operations; minute subdivision, redistribution, and removal of their substance set in; and they undergo fertilizing and other changes from solvent, solar, and chemical influences. Marshes, lakes and rivers, ridges, slopes and plains, are formed, receiving stray germs of life from other quarters, which they nourish and multiply, but often suffer to perish. The dry land thus serves as a nursery and storehouse to the seas around it, as they lay down the representatives of a new epoch.

I will not follow this process now through its many changes, but must be well content to refer my readers to Dana's 'Manual.'

So much for emergence in few words; but denudation has also been a mighty agent in the destruction of strata and their contents. It must always occur at the point just before emergence is attained; and also when changes of level occur elsewhere within

* Prof. J. Phillips finds that the valleys of the Somme, of the Aire, and of Amiens have undergone no convulsion nor upheaval since the period of the *Hippopotamus major* and the Irish Elk. There has been simply a continuous river-action (Quart. Journ. Geol. Soc. vol. xvi. p. 54).

For points of rest, see Agassiz, in Bache's Report of the Atlantic Coast Survey, 1850; Hochstetter, New Zealand, Bull. Soc. Géol. de France, 2e série, vol. xvii. p. 108; Darwin, Edin. New Phil. Journ. vol. lv. p. 250; Phipson, Nieuport, West Flanders; Hugh Miller, Testimony of the Rocks, p. 124, Roman Wall, St. Michael's Mount; Rozet, Fixed Axis, Bull. Soc. Géol. de France, vol. xiii. p. 175; Durocher, Bull. Soc. Géol. de France, 2e série, vol. vi. p. 200.

certain distances; and therefore denudation must have been both common and extensive. Its enormous and wide-spread effects have hitherto not been sufficiently noticed. Masses of rock, many thousands of feet thick, have been pared, sliced off, and then swept away from the deposits of every great period; so that the earth's surface on which we now tread is not that which was inhabited by the extinct animals of bygone ages. It has been raised and depressed many times even since the Liassic period *.

As Sir Charles Lyell says †, "The evidences of the work of denudation are defective, because it is the nature of every destroying cause to obliterate the signs of its own agency." But this remark best applies to extreme cases.

The most material of these indications may be thus summed up:— The disappearance of a stratum may be attributed to denudation when its place is occupied by patches of the lost stratum, or by its boulders, grits, or sands, especially when its peculiar organic remains remain attached; when the basement-bed, burrowed by lithophagous mollusks, is polished, streaked, and guttered, or scooped into hollows, often very deep; when the lines of division are strong, all vestiges of transition destroyed, together with every mark of intermixture of fossil life.

M. Hébert, in his able paper on the "Oscillations of the North of France during the Jurassic Period" (Comptes Rendus, vol. xliii.), states that he has observed on the surface of certain strata, and especially on that of the calcareous beds, marks of polish, rubbing and excavation by water, together with lithophagous perforations in the same places, and often collections of rolled stones scattered about—the clear indications of emergence. They are to be seen, says Hébert, at several levels; and he cites in particular the quarries of Meziers and the Butte Chaumitton (Sarthe). Among other like facts, D'Orbigny gives numerous instances of the occurrence of sand, gravel, boulders, and transported mollusks between contiguous formations, as between Miocene and Lias, or between Neocomian and Chalk, or Upper Greensand, or Chalk-marl ‡.

The thinner the lost stratum, the sooner it is gone. Examples of these statements have been placed in the foot-note below §. In North America two very instructive instances on a large scale occur, in which

* Sir Henry De la Beche is our great authority on this subject, in the admirable thirty-seventh chapter of his 'Geological Observer;' and he has been more recently followed, with practical observations of great importance, by Prof. Ramsay, in the first volume of the 'Memoirs of the Geological Survey of Great Britain,' and in his Presidential Address of the year 1863 to this Society.

† 'Principles,' p. 154.

‡ Cours de Paléontologie, pp. 455, 640, 771, 783, &c.

§ The outliers and patches at Pradalis and Honrubio in Spain: Casiano de Prado, Bull. Soc. Géol. France, 2e série, vol. xi. p. 331. At Farringdon: Sharpe, Quart. Journ. Geol. Soc. vol. x. p. 182, &c. Scooping, &c., in South Staffordshire: Jukes, South Staff. Coal-field, p. 27. In the Onondago Salt-group and Delthyris Shaly Limestone: Hall and De Verneuil, Bull. Soc. Géol. France, 2e série, vol. iv. p. 657. The change from Bird's-eye to Trenton Limestone (Lower Silurian) at Fort Plain, &c., in the Mohawk Valley, is perfectly abrupt, and the fossils distinct, the two strata being in contact.

the effects of elevation, denudation, and deposition come successively into view. One is on the Upper Mississippi, and the other on the River Ohio; and they both, though not near each other, are on the same horizon. They consist of prolonged dome-shaped elevations of ruptured Devonian rocks, disclosing great masses of Lower Silurian, all now covered by Quaternary beds. Denudation by exposure to the weather, that is, to air and water, must be very slow; for Della Marmora gives a good woodcut of Cap de l'Ours, in Sardinia, which is so named from having from time immemorial resembled a bear. It is mentioned by Ptolemy, and therefore is still older than his time.

Mr. Darwin long ago showed that the great requisites for any large accumulation of sediment are three:—namely, (1) a long-continued supply of sediment; (2) an extensive and shallow sea; and (3) an area slowly subsiding to a great depth. How seldom, says he, in the present day do these conditions concur! Hence the general want of that close sequence in fossiliferous formations we might have theoretically anticipated.

A gap or blank is sometimes merely an omission—a defect in stratigraphical succession—and does not include any idea of vertical space. The expression refers to time as well as to deposits. Gaps are met with from the beginning of geological time, as far as that is known; and they show themselves throughout all epochs and parts of epochs, from place to place. (See the instances we have given.)

It may be remarked, and with surprise, that few examples are known where the absence of a set of strata is attended by, or in any way connected with, rupture of beds from beneath, or the outburst of igneous rocks; the occurrence has been usually due to broad elevation alone. Sections (Muirkirk Coal-field and Lesmahago), however, in Western Scotland, by Mr. Geikie *, may afford instances of this.

Some of the blanks are of limited extent, as when caused by the absence of a bed or two; but they are usually large, and in certain cases occupy an important portion of the earth's surface—one or more millions of square miles. Such are the Quaternary deposits resting directly on Laurentian, &c. (North America, South America, Scandinavia, &c.).

These gaps or blanks are often very large and numerous (existing contemporaneously and long); they arise from so many common and so many different floors or beginnings, that we may safely assume that, at various times and in a thousand ways, they ran together and coalesced into vast spaces of dry land of diversified geological structure, in the form of continents, peninsulas, and islands, just as we have it in the present day, and probably as extensively.

2. *Summary*.—The greater number of gaps, and especially of those which become important by reason of duration or size, spring from the Silurian, Carboniferous, or Jurassic ages; and this partly from

* Quart. Journ. Geol. Soc. vol. xvi. p. 322, pl. 18. fig. 3; (Murchison), *ibid.* vol. xii. p. 18.

their early date; an opportunity being thus afforded for possible or, rather, probable coalescence with other emerged lands. In the one hundred and fifty instances of gaps given in this paper (taken indifferently), forty-six times has the Silurian, in different parts of the world, formed the floors of gaps, which have extended up to nine different epochs; namely, into higher portions of its own period three times, into Devonian nine, Carboniferous thirty-one, into Trias and Lias once each, into Jurassic once, Cretaceous four, Eocene twice, and up to Quaternary four times. On three occasions the Silurian rocks have become the roof or covering to lower Palæozoic formations. The Silurian, we see, has to do with more than one-third of all the instances I have given, and must have had a wide diffusion.

The older Palæozoic rocks (including only Laurentian and some other metamorphic beds, once thought azoic) furnish us with the next greatest number of floors—twenty-five, or nearly one quarter of the instances. Here the epochs reached vertically by these twenty-five gaps, without intercalation or interference, are ten: namely, Silurian, Devonian, Trias, Lias, Jurassic, Neocomian, Chalk, Eocene, Miocene, and Quaternary. Most of these blanks, I need hardly say, are of incalculable duration.

The blanks commencing with the Carboniferous formation are twenty-two, or about one-seventh of our one hundred and fifty cases. They range upwards into seven separate epochs in separate countries —to the Permian and Jurassic six times each, to Upper Greensand, to Lias, and to Quaternary once each, and to Chalk five times, always indicating omissions greater or less in number. In addition to its importance as being the roof of the great Russian Carbonifero-jurassic gap, the Jurassic is the base or floor of ten other and newer sedimentary absences. Five occur in the midst of its own parts or stages, two extend to the Chalk, and three to the Tertiaries.

These four periods, the Laurentian, &c., Silurian, Carboniferous, and Jurassic, comprise one hundred and thirteen—more than three-fourths of our instances. Since these one hundred and fifty are mere representatives of great numbers of like phenomena, known, indeed, but necessarily unnoticed, we may infer that they are periods predominating and spread largely over the earth; and so field-observers tell us.

The Devonian occurs as a base but four times; that is, eight to a gap connected with Coal-measures, thrice with Lias, and once with Miocene.

Other epochs still more rarely form floor or roof. The Upper Mesozoic and Upper Palæozoic seem to be oftenest in connexion with gaps.

These gaps recur again and again, in the vertical column of sediments, upon the same locality or base, in consequence of what Thurman has formulated as the "*recurrence of elevation*" (repeated disturbance, in simple words), a fact well exemplified by M. Favre in a section of Mont Salève, near Geneva. The one hundred and fifty cases I have described introduce us to two separate gaps on the same spot ten times in the sedimentary column, to two threes and two fours vertically. More than these could easily be collected, were it desirable. M. Ebray furnishes us, from Vespillière (Département Isère), with a vertical section, passing downwards from diluvium to Gneiss, through Jurassic, Liassic, and Carboniferous strata, where, on successive floors, at least ten great epochs are wanting *.

M. Thurman † gives a curious but not a unique section, which was brought to light in digging a well near Wietlisbach, 1100 feet deep. There are here not only several important strata missing (Lias, &c.), but the whole mass has been inverted. It is an overthrow: on the top are Keuper Marls and Muschelkalk, followed downwards by the Great Oolite and, finally, by Oxford Clay, largely developed.

3. *Inferences.*—The Laurentian, Silurian, Jurassic, and other gaps (naming them from their floors) occur on the same horizon in various parts of the earth; and, those of each series being approximately synchronous, though wide apart in solar time perhaps, they must frequently unite with neighbouring gaps (floors) of all ages, as they emerge to about the same level. The site of each is always passing through its own local changes, both in level and in various natural processes.

The duration of one of these blanks, as we have seen, varies beyond human estimate. We cannot comprehend the vastness of geological time. Where a blank only affects a few beds in the midst of an epoch, the time may be small; and this occurs perpetually: but they are usually long, and longest, according to our present knowledge, when we can count upwards from Laurentian to Quaternary; though the time must be very great when it endures from the Silurian to the Tertiary, of which interval we have four examples. In sixteen cases the Silurian waited open to the sky for the advent of the Carboniferous period, and was the base of forty-five gaps in all, as just stated.

The duration of these periods of suspension or denudation is best measured, though only relatively and remotely, by the number of lost epochs, or parts of epochs, which ought to have been between the floor and roof; thus Carboniferous upon Silurian involves far less unrepresented time than Eocene upon Silurian.

When the floor and roof of proximate epochs are conformable, or nearly so, and when their uniting surfaces show few signs of surf-action, the duration of the gap may be small; but it may be considered long when beds normally more distant from each other meet, when there is some discordance of position, and when there is an interspace, with fossils ground to powder, or occupied by foreign matters.

D'Orbigny (Cours de Paléontologie, vol. i. part 2. p. 500) gives a beautiful example of this in the littoral deposits of the Bathonian and Callovian stages of the Jurassic. He remarks, "We have seen that at Colleville and its vicinity the first-mentioned beds of the cliffs of that coast have been ground, corroded, polished by the waters, before the first clay-beds of the Callovian were laid down. To look at that

* Bull. Soc. Géol. de France, 2e série, vol. xx. p. 297.

† Fourth Letter on the Jura.

surface polished before these first deposits were made, and as it were gnawed, we acquire a certainty that that rock was already consolidated before the first life of the epoch following was buried there; and this implies a considerable lapse of time between."

Gaps are the most numerous in mountainous countries; they are, however, by no means the largest there, either vertically or horizontally. They appear to have the greatest horizontal extension in plains; and, further, it is probably true that the vertical succession of deposits is the most perfect in the least disturbed districts; which we see (with exceptions) in the gently undulating regions of New York State, and on the west side of the Mississippi.

It is true that the floors and roofs of gaps have no relation to each other but such as is impressed on them by crust-oscillation. There is complete stratigraphical independence of the two contiguous beds; the floor of the one is a *mere support* to the other, with no resemblance to the new deposit either in mineralogy or in fossil contents. The floor of the breach remained subatmospheric, and subject only to agencies already noticed, until immersion and its consequences covered it up.

Table A will be found useful by showing the epochal relations of roof and floor at a glance. Their total absence of anything like connexion in nearly all cases becomes in it at once manifest.

TABLE A.—*Synoptical View of the Roofs and Floors of Gaps in their Epochal Relations.*

Roofs of Blanks.	Floors of Blanks.																
	Pleistocene.	Pliocene.	Miocene.	Eocene.	Chalk.	Neocomian.	Jurassic.	Lias.	Trias.	Permian.	Carboniferous.	Devonian.	Silurian.	Palæozoic*.	Laurentian.	Plutonic.	Total Roofs.
Quaternary	1	1	1	1	...	...	...	...	1	1	1	...	4	1	4	...	16
Pliocene	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1
Miocene	...	...	...	1	1	...	...	1	1	1	...	1	...	1	...	1	8
Eocene	...	...	...	...	2	1	3	1	1	1	...	...	2	2	...	...	13
Chalk	...	...	...	...	...	1	2	1	3	1	5	...	4	8	...	...	25
Neocomian	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	2
Jurassic	...	...	...	...	...	...	5	1	1	1	6	...	1	1	...	1	17
Lias	...	...	...	...	...	...	...	...	...	...	1	3	1	1	1	...	7
Trias	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	2
Permian	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	...	6
Carboniferous	...	...	...	...	...	...	...	...	...	...	2	4	31	...	...	...	37
Devonian	...	...	...	...	...	...	...	...	...	...	...	...	9	...	1	...	10
Silurian	...	...	...	...	...	...	...	...	...	...	...	...	3	...	3	...	6
No. of Floors	1	1	1	2	4	2	10	4	7	5	22	8	56	14	11	2	150

* Rocks of doubtful age; but below Trias.

There are, however, other appearances which are worthy of notice. Those which refer to the mineral condition of the surfaces, and to

TABLE B.—*Showing the Stratigraphical Relations of the Floors and Roofs of Missing Formations* (Gaps).

Roof.	Floor.	Locality.	Author.	Reference.	Roof and Floor: Conformably Inclined.	Roof and Floor: Horizontal.	Roof and Floor: Unconformably Inclined.	Floor Inclined.	Roof Horizontal.
Drift	Trias	Nova Scotia	Dawson	Quart. Journ. Geol. Soc., vol. xii. p. 102.	...	...	...	*	*
Drift	Eocene	Alabama	Lyell	American Journal of Science, 2nd series, vol. iv. p. 190.	...	*	...	...	...
Drift	Permian	Oural, R. Vaga	Murchison	Geol. of Russia, vol. i. p. 331.	...	*	...	...	...
Pliocene	Greensand	Cap la Hêve, France	De Beaumont and Dufrénoy.	Explication Carte Géol. de la France, vol. ii. p. 198.	...	*	...	...	...
Miocene limestone	Coal-measures	Cordova, Spain	De Verneuil	D'Archiac, Histoire des Progrès, vol. iii. p. 9.	...	...	...	*	*
Calcaire grossier	Muschelkalk	Sierra Morena, Spain	De Verneuil	Bull. Soc. Géol. France, 2e série, vol. xiii. p. 691.	...	*	...	...	...
Eocene sandstone	Coal-measures	Alabama	Tuomey	Geol. Report, Alabama, p. 164	...	...	*	...	...
Eocene (Nummulitic)	Silurian	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. pp. 228, 233, 245.	...	...	...	*	*
Tertiary	Chalk	Pyrenees	Lyell	Principles of Geology, p. 187.	...	...	...	*	*
Tertiary breccia	Silurian	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. p. 32.	...	...	...	*	*
...	...	Ootatoor, India	Blanford	Palæontologia Indica, vol. i. p. 6.	...	...	*	...	...
Chalk	Trias	Yorkshire	Lyell	Principles, p. 186	...	...	...	*	*
Chalk	Trias	Spain	De Verneuil	Bull. Soc. Géol. France, 2e série, vol. xiii. p. 678.	...	...	*	...	...
Chalk	Upper Carboniferous	New Mexico	James Hall	Report, Mexican Boundary, vol. i. pp. 128.	...	...	*	...	...
Chalk	Coal-measures	Alabama	Lyell	Visit to North America	...	...	*	...	...
Chalk	Carboniferous Limestone	Russia	Murchison	D'Archiac, Histoire des Progrès, vol. v. p. 352.	*	...	...	...	...
Chalk	Silurian	Spain	C. de Prado	Bull. Soc. Géol. France, 2e série, vol. xi. p. 337.	...	...	*	...	...

Upper Greensand	Laurentian	New Jersey	Cook	Report, Mexican Boundary, vol. i. p. 128.	...	...	...	*	*
Oolite	Coal-measures	Tarentaise	Favre	Bull. Soc. Géol. France, 2e série, vol. v. p. 262.	...	...	*	...	...
		Gloucestershire	Ramsay	Mem. Geol. Survey Great Britain, vol. i.	...	...	...	*	*
Lias	Carboniferous Limestone	Wales	De la Beche	*Ibid.* vol. i. p. 269	...	...	...	*	*
	Coal-measures	France	Ebray	Bull. Soc. Géol. France, 2e série, vol. xx. p. 297.	...	...	...	*	*
	Metamorphic series	Scotland	Geikie	Quart. Journ. Geol. Soc., vol. xiv. p. 3.	*	...	...	*	*
Middle Lias	Silurian	Belgium	Gosselet	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 514.	...	...	...	*	*
	Granite	France	Ebray	*Ibid.* vol. xvi. p. 427	...	...	(fault.)		...
Trias	Quartzite	France	De Beaumont	Explic. Carte Géol. de la France, vol. ii. p. 13.	...	...	*	...	...
	....	....	Lyell	Principles, p. 187	...	...	...	*	*
Lower Trias	Coal-measures	Limousin, France	De Beaumont	Explic. Carte Géol. de la France, vol. i. p. 619.	...	...	...	*	*
Permian	Devonian	Coniri, South America	D. Forbes	Quart. Journ. Geol. Soc., vol. xvii. p. 38.	...	...	*	...	...
Coal-measures	Carboniferous Limestone	Bohemia and Poland	Murchison	D'Archiac, Histoire des Progrès, vol. iii. p. 135.	...	...	...	*	*
	Silurian	Iowa	Hall	American Journal of Science, 2nd series, vol. xxiii. p. 196.	...	...	...	*	*
		Arctic Seas	Haughton	M^cClintock's Voyage, Appendix.	...	*	...	...	...
		Alabama	Tuomey	Geol. Report, Alabama, p. 80.	...	...	*	...	...
		Nova Scotia	Lesley	American Journ. of Science, 2nd series, vol. xxxvi. p. 189.	...	...	...	*	*
		North Illinois	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
		North of England	E. Forbes	Quart. Journ. Geol. Soc., vol. ix. p. lxx.	...	...	*	...	...
		Salt Lake, Rocky Mountains.	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
		Thüringerwald	Murchison, &c.	Quart. Journ. Geol. Soc., vol. xi., pp. 412–417.	...	...	*	...	...
		West Scotland	Geikie	*Ibid.* vol. xvi. p. 318	...	...	*	...	...
		Texas	Shumard	Bull. Soc. Géol. France, 2e serie, vol. xviii. p. 216.	...	*	...	...	...
					2	6	15	17	17

TABLE B (*continued*).

Roof.	Floor.	Locality.	Author.	Reference.	Roof and Floor: Conformably Inclined.	Roof and Floor: Horizontal.	Roof and Floor: Unconformably Inclined.	Floor Inclined.	Roof Horizontal.
					2	6	15	17	17
Coal-measures	Primordial	Texas	Shumard	American Journ. of Science, 2nd series, vol. xxix. p. 124.	*	...	...	...	...
Coal-measures	Longmynd	Shropshire	Ramsay	Lecture at Royal Instit. 1858.	...	...	*	...	...
Millstone-grit	Silurian	Alabama	Tuomey	Geol. Report, Alabama, pp. 37, 38.	...	...	*	...	...
Millstone-grit	Silurian	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. p. 97.	...	...	*	...	...
Carboniferous	Silurian	Sardinia	Della Marmora	*Ibid.*	...	...	*	...	...
Carb. Limestone	Metamorphic	Rocky Mountains	Hall	Tract on Mississippi Limestone, p. 19.	...	...	*	...	...
Chemung Group	Silurian	Missouri	Shumard	Geol. Report, Missouri, p. 184.	...	...	*	...	...
Devonian	Primordial	Spain	C. de Prado	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 517.	*	...	...	...	...
Old Red Sandstone	Lower Silurian	Czarskoe-celo, Russia	Murchison	Geology of Russia, vol. i. p. 32.	...	*	...	...	...
Devonian	Metamorphic	Basse Loire	Bureau	Bull. Soc. Géol. France, 2e série, vol. xviii. p. 789.	*	...	...	...	...
Lower Helderberg	Utica Slate	Montreal	Hall	Palæontology of New York, vol. iii.	*	...	...	...	...
Middle Silurian	Granite	Sardinia	Della Marmora	Voyage en Sardaigne, vol. i. pp. 60 *et seq.*	...	...	*	...	...
					6	7	22	17	17

the effects of the elements and of time, are obvious; so that, without dwelling on them, I will proceed to remark on the various positions they assume towards each other. These relations have been stated by the original observers in fifty-two cases, and they have been now collected, for examination and use, into the form of a Table (B), which contains their locality, the horizon which they occupy, the authority, and, lastly, the positions of basement and roof.

Table B shows that all the gaps are the products of disturbance. In the six cases where the top and bottom strata are at the same time conformable and inclined, the force must have been exerted obliquely and over a large area (Texas to Missouri). In the seven cases where they are both horizontal, the movement must have been vertical, and have affected a considerable region. In the twenty-two cases where the roof is unconformable to the floor, and both are inclined, there must have been more uplifts than one—an action that has given rise to the "complex mountains" of Sismonda and Studer.

In seventeen cases the floor is inclined and the roof is horizontal. Here the former represents disturbance; the latter, quiet deposition long afterwards. Two other columns might have been given, but are omitted because it is impossible for the condition to occur which they would represent, namely, for the roof of a gap to be inclined when its base is horizontal; for all upheavals are caused by a force acting from below.

These gaps or blanks are local, both in their origin and in their effects, because oscillation, their governing cause, is itself local and dependent on laws as yet undiscovered. Observation in the field has demonstrated that perturbation is local. We see this in the alternately fresh and marine deposits of Tertiary and Carboniferous times; and even in the celebrated disturbance on the River Onny (N. Wales), where the unconformity vanishes near at hand; and, furthermore, we see it in the Trias of Tuscany lying on Verrucano (Carboniferous), at the baths of San Julio and elsewhere.

If crust-movements be local, so also is the deposit of sediment, in its details, with epochal specialities. To these conclusions Elie de Beaumont*, Murchison†, Edward Forbes‡, John Phillips§, Barrande‖, D'Archiac, and others have arrived.

With such mere outlines as the foregoing, we must now rest on the great subject of "leaves torn out from nature's volume," as speaks "the old man eloquent" of Cambridge, begging permission, however, in conclusion, to add a few considerations on the importance of missing formations.

1. They constitute a breach in normal stratigraphic sequence resulting from plutonic influences—influences which, although worthy of the most serious consideration, have hitherto received little notice, save from Mr. Hopkins and Sir J. Herschel.

Some idea of their frequency and extent may be gathered from

* Bull. Soc. Géol. France, 2e série, vol. xi. p. 315.

† Quart. Journ. Geol. Soc. vol. v. p. 625; vol. vii. p. 18; vol. viii. pp. 180, 191.

‡ *Ibid.* vol. x. pp. 77, 78.

§ Geol. Survey Memoirs, vol. i. p. 144.

‖ Bull. Soc. Géol. France, 2e série, vol. xi. p. 311.

the foregoing pages; and still more forcibly from the fact, not confined to one region, that 1188 Palæozoic faults (a kindred phenomenon), each half a mile, 3, 10, 20, or 30 miles long, have been seen by the officers of the Geological Survey within the little area of Wales, and striking out in every direction. (See Geological Survey Maps, sheets 36, 37, 59, 60, 74, 75, &c.)

2. We are taught by missing formations that there always have been areas of dry land, because there always have been gaps, and much alike in character; some of the most distinct and protracted of these are Silurian, a formation about whose emergence anywhere there has hitherto been some uncertainty.

3. They yield us, in the vast Laurentian spaces, European and American, the remarkable spectacle of the most ancient land known, witnessing, itself little disturbed, for a length of time which no man can measure, the successive immersions and emersions going on around them, with all their strange and beautiful results. Agassiz, Logan, and others have recognized the greatness of this fact.

4. The great Russian double gap, where the Oxfordian stage (Jurassic) is interposed, more or less directly (and midway), between the widely separated formations, Carboniferous and Cretaceous, is worthy of special attention.

5. Gaps show us multitudinous discontinuities in deposition; seldom from faults, fractures, or igneous outbursts, but simply from oscillations on broad bases, accompanied by the submarine changes which we detect by reference to the laws affecting the distribution of organic life and the nature of the sediment.

6. These gaps occasion a rearrangement of mineral substances, and of organic existences, in favour of the new formation in the act of being deposited in the vicinity, as well as that change of general conditions which must follow emergence.

7. In one direction they are useful in the production of variety; thus preventing that monotony to which nature seems always opposed.

8. In another direction they greatly retard the multiplication and diffusion of life by converting into dry land, or shallows, many wide seas, whose shores and bottoms are the peculiar nurseries of marine creatures.

9. They have caused great destruction of life by disturbing conditions then existing, such as pressure, light, heat, currents, and the like, all necessary to the welfare of plants and animals. In the disturbance which took place in France at the end of the Liassic stage 300 species of Radiata and Mollusca perished *.

10. Being extraordinarily numerous, they lessen the importance of the great rule of gradation from stage to stage in the sedimentary column.

11. At these gaps there is perfect independence, a thorough severance, of the two contiguous beds or formations. Often not a connecting link is left, the floor strewn with the long-since dead being merely the support of the incumbent mass, and nothing more. An impassable barrier has thus been formed to the recurrence or

* D'Orbigny, 'Cours de Paléont.' vol. i. 2^{e} partie, p. 475.

transmission upwards of living beings, improved or unimproved, over surfaces vast and almost innumerable *.

12. The geological record is much obscured by these gaps, and in parts obliterated. The readings must be taken up in different places—obtaining general results only; and this is best done, perhaps, with the aid of the fossils. If these be few and simple (I am not speaking now of individuals), the duration of any given epoch has been short; while a highly elaborated and plentiful population indicates prolongation of time.

13. These gaps or blanks by their magnitude and number become a great feature in the earth's crust, expressive of unity of design in time and space.

March 23, 1864.

Sidney Beisley, Esq., The Cedars, Lawrie Park, Sydenham; The Rev. Henry H. Winwood, M.A., Cavendish Crescent, Bath; James Samuel Cooke, Esq., C.E., 12 Abingdon Street, Westminster; Robert Damon, Esq., Weymouth; The Rev. Dr. Dendy, 12 Vicarage Gardens, Kensington; and John Whitfield, Esq., Mem. Inst. C.E., 89 Great Portland Street, W., were elected Fellows.

The following communications were read:—

1. *On some* New Fossils *from the* Lingula-flags *of* Wales.

By J. W. Salter, Esq., F.G.S., A.L.S.

(Plate XIII.)

When the imperfect fragments of a great Trilobite were discovered by myself in the Lingula-flags of St. David's, and brought before the Society in February 1863 (Quart. Journ. Geol. Soc. vol. xix. p. 275), I had no reason to suppose there was a chance of obtaining more specimens. The occurrence of so conspicuous and characteristic a genus as *Paradoxides* in our Primordial zone was, however, worthy of record, though the description was necessarily incomplete.

But by the cooperation of Professor Griffiths, of Liverpool, and particularly the zealous examination of the beds by Mr. Henry Hicks, surgeon at St. David's, we are now in possession of much more abundant and perfect materials.

Mr. Hicks's discoveries have really made a large addition to the Primordial fauna. It has been hitherto a scanty one in Britain, perhaps for the reason only that we have had very little opportunity of working at the formation. And yet, in this favoured spot near St. David's, we have suddenly come upon a collection of new species, and the locality promises many more.

We have obtained new genera, all of a Primordial character; and among them a new Sponge, an organism new to the Primordial zone; for the Protozoa have not hitherto been found in strata certainly older

* See the striking instance of independence in the Northern Alps, as indicated by the grand rupture and hiatus between the Nummulitic (Eocene) formation and the younger Molasse and Nagelflüh, as explained by Sir R. I. Murchison in his paper on the Alps, Quart. Journ. Geol. Soc. vol. v. p. 304.

than the Lower Llandeilo Flags and Caradoc Sandstone, with one, perhaps doubtful, exception hereafter mentioned.

I beg leave to offer an amended description of the large *Paradoxides*; for there are now the means, through nearly a hundred specimens, of making it complete. These better specimens show the eye to have been more forward than was previously supposed, and supply the great head-spines, the hinder thoracic rings, and the tail, which is of a very remarkable structure, and quite unlike that of any other species of the genus.

Fortunately I had, in the figure, distinguished those parts which were known from those that were hypothetical, and therefore there is little to alter, though much to add. I can, however, see no confirmation of the two obscure anterior furrows to the glabella, and omit them accordingly.

PARADOXIDES DAVIDIS, Salter, Quart. Journ. Geol. Soc. vol. xix. p. 275. Pl. XIII. figs. 1–3.

SPEC. CHAR.—P. *sesquipedalis et ultra, maximus, glabellâ parum clavatâ, genis latiore, sulcis duobus solum perfectis, reliquis obsoletis. Oculi antrorsum positi. Thorax articulis* 18, *axe lato. Pleuræ subrectæ, apicibus recurvis, anticis brevissimis abrupte flexis, medianis longioribus arcuatis, postremis valde retrorsum flexis, fere parallelis, ultimis longissimis. Cauda mira, parte centrali oblonga truncata, gladiis lateralibus longissimis. Caudæ axis obscurus,* 2–3-*annulatus.*

Of the head we have now many specimens, and some of the fragments betoken a fossil not less than 16 or 18 inches long. One or two heads are perfect, and show that it was semicircular, with very large, thick, cylindrical, and tolerably straight spines. The glabella is rather long, reaching and overhanging the front margin, broader, but not suddenly so, in front, half its length being occupied by the great front lobe.

There are obscure traces in some specimens of short anterior furrows, but I cannot be sure of more than the two complete posterior ones, which bend backwards in the middle, and are equally strong with the neck-furrow. The eye is far forward, in advance even of the second or upper glabella-furrow; it is near the glabella—not half its length distant from it.

The cheek is coarsely granular, except towards the outer angle, and abruptly contracted at the base of the great cylindrical spine.

The labrum is expanded at the base, and has a truncated end, with subspinous lateral angles. It is, as usual, separated by scarcely any suture from the hypostome, or rather it is connate with it (fig. 1 *a*).

I cannot count more than eighteen rings to the body, and believe this to be the full number. The axis is very wide (in the largest specimen 1½ inch) and convex, fully as wide in front as the pleuræ, spine included, and so for the eight or nine front segments. The apex of each pleura in these is abruptly turned back, with a short sharp mucro; and there is no enlargement of the second or third pleura—a character of importance in this genus. All have a deep groove, which is considerably oblique, and reaches the hinder margin just at the base of the spine in all the pleuræ. But from the eighth or ninth segments the pleuræ lengthen and the axis gradually tapers. The hindmost axial ring is about half the width of those in front, and scarcely one-fourth as wide as its long pointed pleuræ.

All the middle pleuræ have a strong curve backwards from the fulcral point, but at the same time arch outwards, and gradually, as they approach the tail, close in upon it until the hindmost are parallel with it. These hinder pleuræ are greatly lengthened, and are of two forms in two distinct varieties (possibly sexes ?). In one form (fig. 3) the penultimate pleura is developed into a shorter spine than the preceding, and the last is suddenly abbreviated and incurved. This may be by abortion of the segments. In another the increment is regular, but the last spines are not extravagantly developed. In a third variety the ultimate and penultimate pleuræ are greatly extended (fig. 2), and this is accompanied by a corresponding dilatation and lengthening of the caudal portion next to be described.

The tail in this species (fig. 2*a*) is most remarkable, and for some time I was inclined to believe that its outer segment was the ultimate pleura of the body. In fact, the front caudal ring is a slightly metamorphosed body-joint, and is not very strongly connected with the tail-piece ; but it nevertheless belongs to it.

The tail, exclusive of the great sabre-shaped lateral spines, which are three or four times its length, is an oblong convex plate, with a short conical broad axis occupying about two-thirds of its length, and annulated by two or three incomplete rings. The extremity of this plate is broad and sharply truncate, contrasting with the parabolic contour of its axis, which is not so long as broad. The sabre-shaped appendages are broader as well as longer than the last pleura of the body-rings, and bend inward strongly at first beneath the tail, afterwards diverging again at the tips. In this variety (fig. 2) they are, in a moderate-sized specimen, four inches long. They are connate with the central plate of the tail, though separated from it by a deep groove, except at the actual base, where the character of a pleura is maintained by the usual pleural groove running out into it. The nearest approach to this structure is made by the *Paradoxides Bohemicus*. But in that species the enlarged hinder appendages are true pleuræ, according to Barrande's figure, and the tail itself is destitute of all appendages. Moreover, in that allied form the second pleura of the body is enlarged ; so we have additional characters for the separation of the present species.

Paradoxides Davidis nearly equals in dimensions the great *P. Harlani* from Massachusetts, and exceeds the large Newfoundland species described by me under the name of *P. Bennettii* *.

Locality, Lower Lingula-flags, of Porth-y-Rhaw and Solva Harbour, both near St. David's, South Wales.

With *P. Davidis*, which is really a common fossil at this particular locality, there have been found several other new species of Trilobites, the chief of which are briefly described in the pages following.

* Quart. Journ. Geol. Soc. vol. xv. p. 553.

Anopolenus, gen. nov. [Olenidæ.]

Gen. Char.—Depressed; the head broad, without eyes or facial suture. A broad slightly clavate glabella, with three complete transverse lobes and one incomplete lobe on either side. The cheeks obtusely triangular, rugose, strongly margined. Body of many segments, certainly more than eleven, with obtuse pleuræ square at the ends, and with the fulcrum close to the axis. Tail transverse, of few segments, with a broad serrate limb, and a wide axis of three or four rings.

Under this name I have to introduce to notice a singular Trilobite, which resembles the *Atops* of Emmons's figures *, an elongated expanded glabella overhanging the front; and it has no transverse furrows completely across. It is nearer, in all probability, to *Sao* and *Conocephalus,* while *Anopolenus,* however abnormal, is one of the close allies of *Paradoxides.*

Anopolenus Henrici, spec. nov. Pl. XIII. figs. 4 & 5.

We have only a few specimens, but the form is too peculiar to admit of a doubt as to its being a new and very distinct genus. It was found, with nearly the whole of the specimens described in this paper, by Mr. Henry Hicks, and I wish to record his services to palæontology in working out this fauna.

A species of *Conocoryphe* is also a new form, and may very possibly belong to a new genus.

Conocoryphe? variolaris, spec. nov. Pl. XIII. figs. 6 & 7.

We have only the head and body-rings of this curious species, which could not have been much more than an inch long. The head is wider than the body, semicircular, and with the glabella deeply divided from the cheeks and, as it were, sunk in them.

The glabella is parabolic and convex; two obscure lateral furrows indent the sides, but very slightly. The cheeks are broad, nearly as convex as the glabella, and bear a very small eye, rather remote from the glabella, about half its full diameter apart from it. The facial suture curves out above the eye, and beneath it again outwards to near the very shortly spinous angle. The head is marginate all round. A strong coarse tuberculation covers the surface of the glabella and the cheeks. The tubercles are so prominent and sharp as to be more like spines.

Nine body-rings are all that are preserved. They have a narrow axis, and deeply sulcate pleuræ bent down strongly at a point beyond the fulcrum. The front half of the pleura is the more convex, and has three or four strong conspicuous tubercles on it. In this respect and in the general form and ornament of the head there is much resemblance to *C. Ribeiro,* Barr., a species found in the Primordial schists of Spain †. That species has, however, an ocular ridge and larger eyes; but the two forms are very closely related. If it were not for the existence of this Spanish species, I should have more

* "Taconic System," 'American Geology,' reproduced by M. Barrande in the Bulletin Soc. Géol. France, 2e série, vol. xvii. pl. 5. figs. 1–3.

† Bull. Soc. Géol. France, 2e série, vol. xvii. pl. 6. figs. 7–12.

doubt about the genus. The small eye and the want of an ocular ridge render it very unlike *Conocoryphe*. In some respects *C. variolaris* resembles the genus *Sao*, in others *Arionellus*, and I think it unites characters found in both these genera. But as there is a distinct front margin, and as the glabella-lobes are like those of several species of *Conocoryphe* (*Conocephalus*), while the species has neither the large eyes of *Sao* nor the reduced glabella of *Arionellus*, I prefer to leave it with the first-named genus. Barrande's acuteness has not missed the relation which really subsists between two genera so different in appearance as the two last mentioned.

Locality, Porth-y-Rhaw.

HOLOCEPHALINA, gen. nov. [CONOCEPHALIDÆ.]

GEN. CHAR.—Head transverse, semicircular, with a very small and obscure glabella, without lobes, with wide free cheeks, and a wide front margin. The facial suture and the eye are placed at almost the extreme angle of the head, which is shortly spinous.

There are nine (or more) body-rings, grooved and facetted.

Tail ——?

Distinct from all the genera yet described by its form and the extreme position of the facial sutures and eyes. It has, however, affinities with *Arionellus*, in the small obscure glabella; and that genus shows a strong tendency to have the suture marginal, and more so in the adult than in the young state. It is not, however, nearly so marginal in any species of *Arionellus* as it is in *Holocephalina*.

HOLOCEPHALINA PRIMORDIALIS. Pl. XIII. fig. 9.

This species is less than an inch in length; and as at present only a single specimen has been observed, the characters of the species will be those of the genus.

Locality, Porth-y-Rhaw.

AGNOSTUS PRINCEPS, Salter. Pl. XIII. fig. 8. Memoirs Geol. Survey, vol. iii. (ined.) pl. 5. fig. 1.

This species will be figured and described in the forthcoming volume of the Geological Survey Memoirs on North Wales, by Prof. Ramsay and myself.

Locality, Porth-y-Rhaw. Abundant.

MICRODISCUS PUNCTATUS, spec. nov. Pl. XIII. fig. 11.

Dr. Emmons described, from his Taconic strata (see 'American Geology,' vol. i. p. 116. pl. 1. fig. 8), a minute form, which, from its association with Graptolites and Mollusca, Barrande thinks may be the young state of a *Trinucleus* or some such Lower Silurian genus. This is quite possible. But, at least, Emmons's figure is singularly like the small fossil here figured, and which Mr. Hicks finds abundant in the lower strata of the section at Porth-y-Rhaw. I do not feel inclined to institute a new genus for this while there is a probability it may be the *fry of some larger Trilobite*. The characters may stand thus in brief:—

Head without eyes or facial suture; margined, the glabella and side-lobes very prominent, punctate. An enormous nuchal spine. Body-rings 4. Tail equal to the head, with a strong 7-ringed axis and smooth punctate sides, margin distinct.

LEPERDITIA SOLVENSIS, Jones, Ann. & Mag. Nat. Hist. 2nd ser. vol. xvii. Feb. 1856, p. 95. pl. 7. fig. 16.

This curious little bivalved Crustacean was formerly thought to belong to the Llandeilo formation of Wales; but the beds at Solva are now proved to belong to the Lingula-flags. We must add, therefore, the bivalve Phyllopods to the older fauna.

Locality, Solva Harbour, west side, in Lingula-flags.

THECA CORRUGATA, spec. nov. Pl. XIII. fig. 10.

The characters of this small species reside in the strong rugose lines of growth. Except in these, it is not unlike some of the species of the Tremadoc slate. It is quite distinct from any published form.

Locality, Porth-y-Rhaw, abundant in lower beds.

PROTOSPONGIA FENESTRATA, gen. et spec. nov. Pl. XIII. fig. 12.

The Sponge which is here introduced to notice is remarkable for the size of the spiculæ, which however do not exceed in magnitude those of the *Astræospongia* of Ferd. Roemer—a sponge figured by that author in his work on the Upper Silurian Fossils of Western Tennessee, pl. 1. fig. 6.

Nor do they much exceed in size those described, but not figured, by Prof. McCoy in his 'Synopsis of the Silurian Fossils of Ireland,' p. 67. The specimen so described is in Sir R. Griffith's cabinet, and is well worth the study of the naturalist. The spiculæ are even larger than those of our fossil, and have six rays (*Acanthospongia* is the name bestowed by McCoy), while ours have, to all appearance, only quadrate spiculæ, and all on one plane, that of the general exterior surface.

GEN. CHAR.—General form? The skeleton is loosely reticular, formed of very large cruciform spiculæ, the branches of which cross each other at an angle of 80°, and only in one plane, no ascending or descending branches rising from the point of conjunction.

The skeleton thus constituted is far from being uniform. Some of the branches are double or treble the size of the others, appearing as if three or more spiculæ had become connate. The larger branches maintain the same angles as the smaller, the latter filling in, as it were, the interstices between the larger, which are very slightly tapering, and often measure nearly $\frac{1}{4}$ inch in length. The smaller branches vary from one to two lines or less in length. The angles occasionally vary, but not much so; in our figure they are more rectangular than usual.

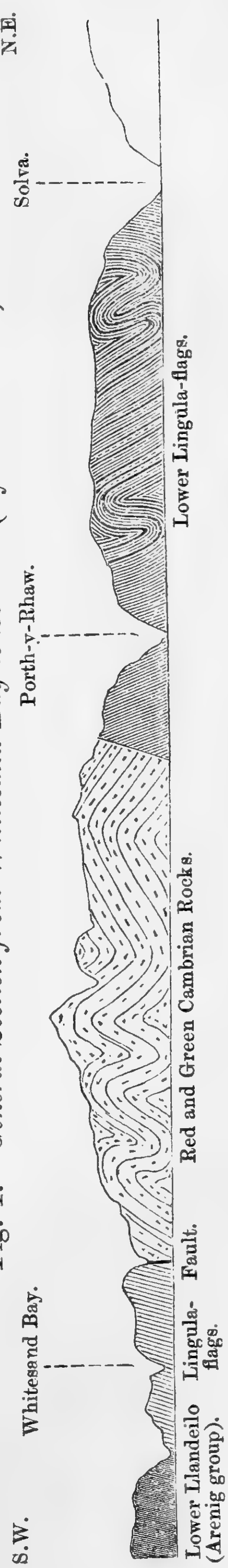
The only Silurian Sponges with which I am acquainted in Britain, which show decided spiculæ, are those above mentioned, and the *Amphispongia*, a form resembling *Grantia*, and described by myself*, from the Pentland Hills. These have both of them spiculæ in

* Mem. Geol. Surv., Explanation of Edinburgh Sheet, &c., pl. 2. fig. 3.

which the branches are arranged in more than one plane, and hence there is no danger of confounding the Primordial form with those Silurian genera *.

There are many unpublished Spongiadæ from true Silurian Rocks †; and it is at least satisfactory to find that these had their antecedents in a formation whose much greater antiquity is now well established. The fauna of the Lingula-flags is even yet a scanty one. In some few of its genera it shows an approximation to Lower Silurian forms; and some Shells and a Cystidean are of genera common to both formations. But the Crustacea here, as elsewhere in the Palæozoic rocks, are our surest indices of age; and the entire distinctness of the Trilobite fauna overbalances the fact that species of *Orthis*, of *Discina*, of *Theca*, and of *Trochocystites* are found both in Silurian strata and in the great Primordial formation which lies near the base of the fossiliferous rocks of Wales. With the exception of *Agnostus* and *Leperditia*, not a single Crustacean genus is known to pass from

Fig. 1.—*General Section from Whitesand Bay to Solva.* (By J. W. Salter.)



* In a letter from Dr. Bowerbank, to whom I sent specimens of *Protospongia*, he refers to his recent genus *Spongionella* (Phil. Trans. 1862, plate 74. fig. 10) as the nearest ally. The pyritized state of the fossil favours the view which he takes, that this is one of the true horny sponges allied to the genus just quoted, sponge-fibre decomposing but slowly. The remains here figured are not, in Dr. Bowerbank's view, the spiculæ, but the sponge-fibre itself replaced by pyrites; and, if so, the size of the fibres would be nothing remarkable, since it may be paralleled in many recent species. While I do not share Dr. Bowerbank's opinion (I believe these are true spiculæ), I feel bound to give his authority for a contrary view, the more so as there seem to be several Silurian and other palæozoic forms which may be better explained in this way, such as *Ischadites*, *Tetragonis*, &c. The remarkable genus *Archæocyathus*, Billings (Geology of Canada, pp. 283, 285, 286), described in 1861, has no relation to our fossil, and was probably calcareous. There is, I think, much doubt if the limestones there described truly belong to the Primordial group, though included with the Potsdam Sandstone. *Eospongia*, published in the same year, does not need comparison.

† I may mention here that a fine species of *Astylospongia*, very like *A. incisolobata*, Roem. (pl. 1. f. 3), was found by myself, years ago, at Sholes Hook, near Haverfordwest, in the Caradoc strata. It is in the Museum of Practical Geology. The genus is new to Britain.

the one to the other. Even of these genera that do transgress the line, the Primordial and Silurian rocks contain distinct species; while the intervention of the whole of the Tremadoc rocks, containing a remarkable assemblage of fossils distinct from both, easily explains the meaning of this wide difference in the fossils, and indicates that the epochs of the Llandeilo and Lingula-flags were separated by an enormous period of time.

Fig. 2.—*Geological Sketch-map of Porth-y-Rhaw Harbour.*

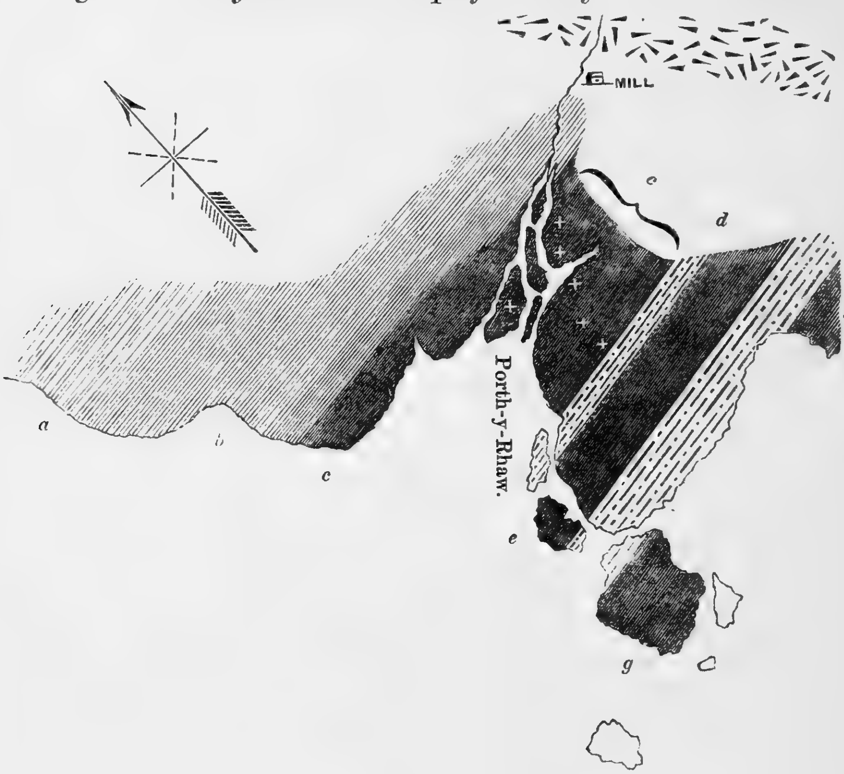
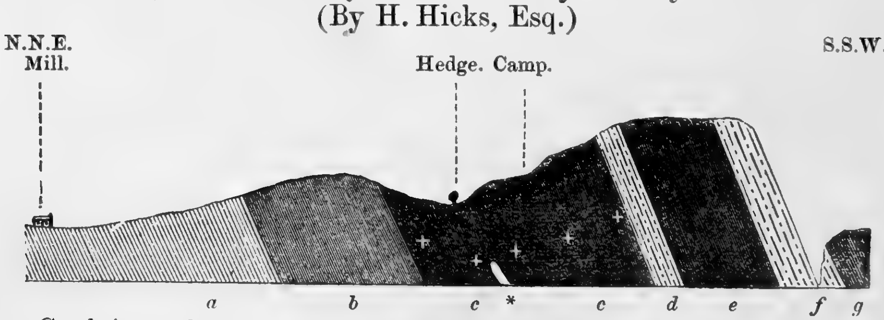
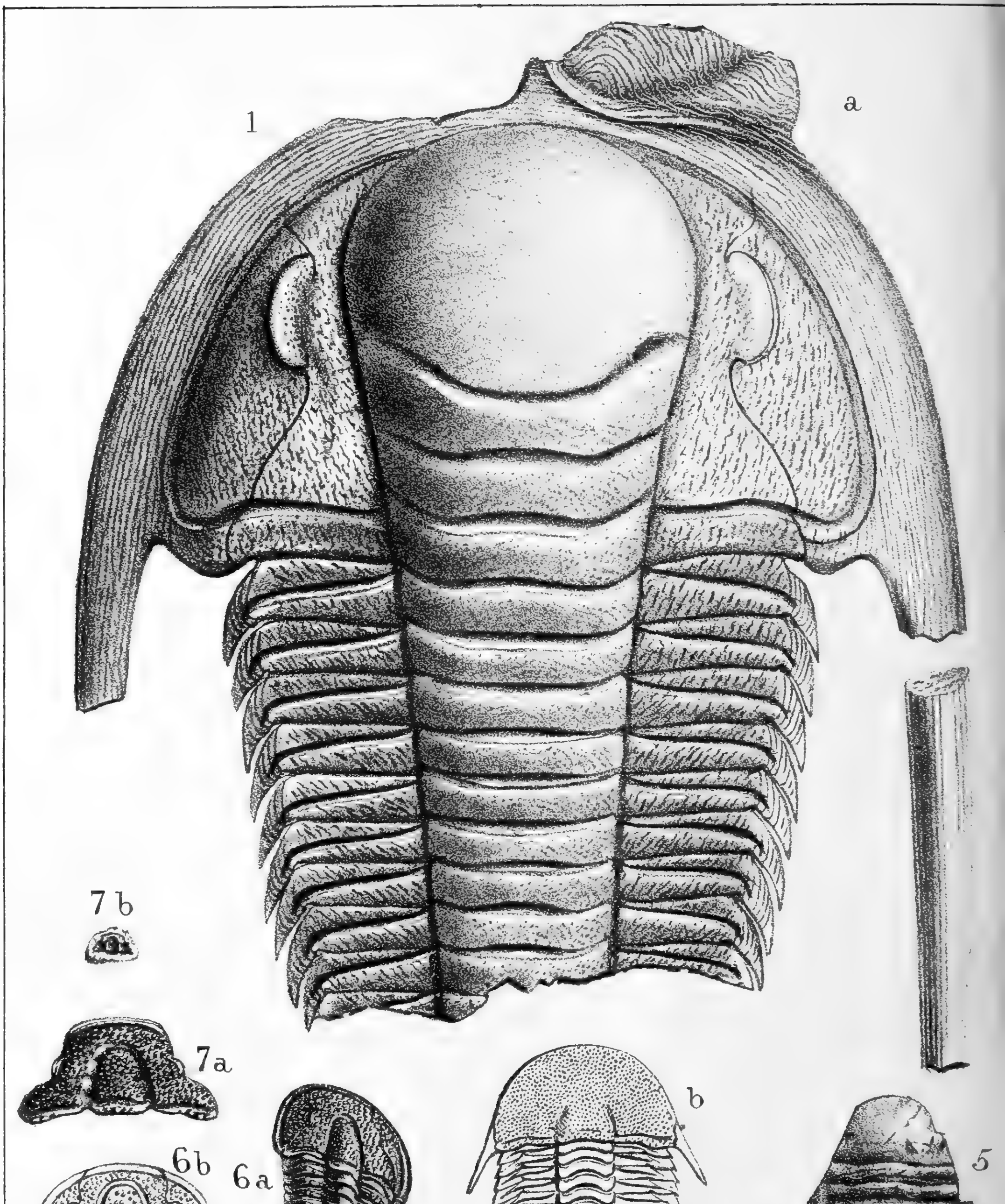


Fig. 3.—*Section of the East Side of Porth-y-Rhaw.*
(By H. Hicks, Esq.)



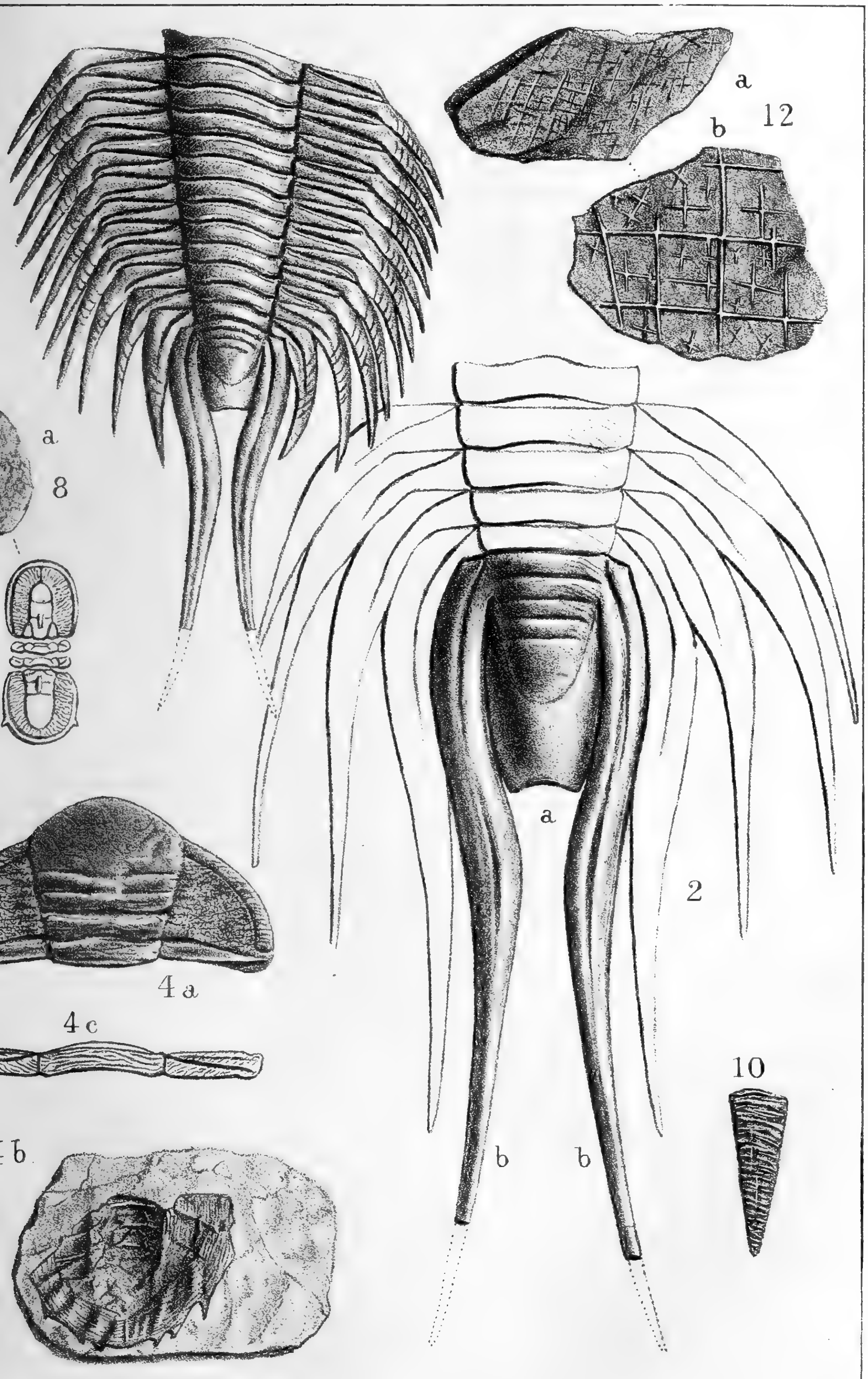
a. Cambrian rocks.
b. Transition beds.
c, e, g. Lower Lingula-flags (fossiliferous).
* Cavern.
d, f. Volcanic tuff.

In addition to the general section on page 239, which is not true to scale, I have given above a measured map and section of the fossili-



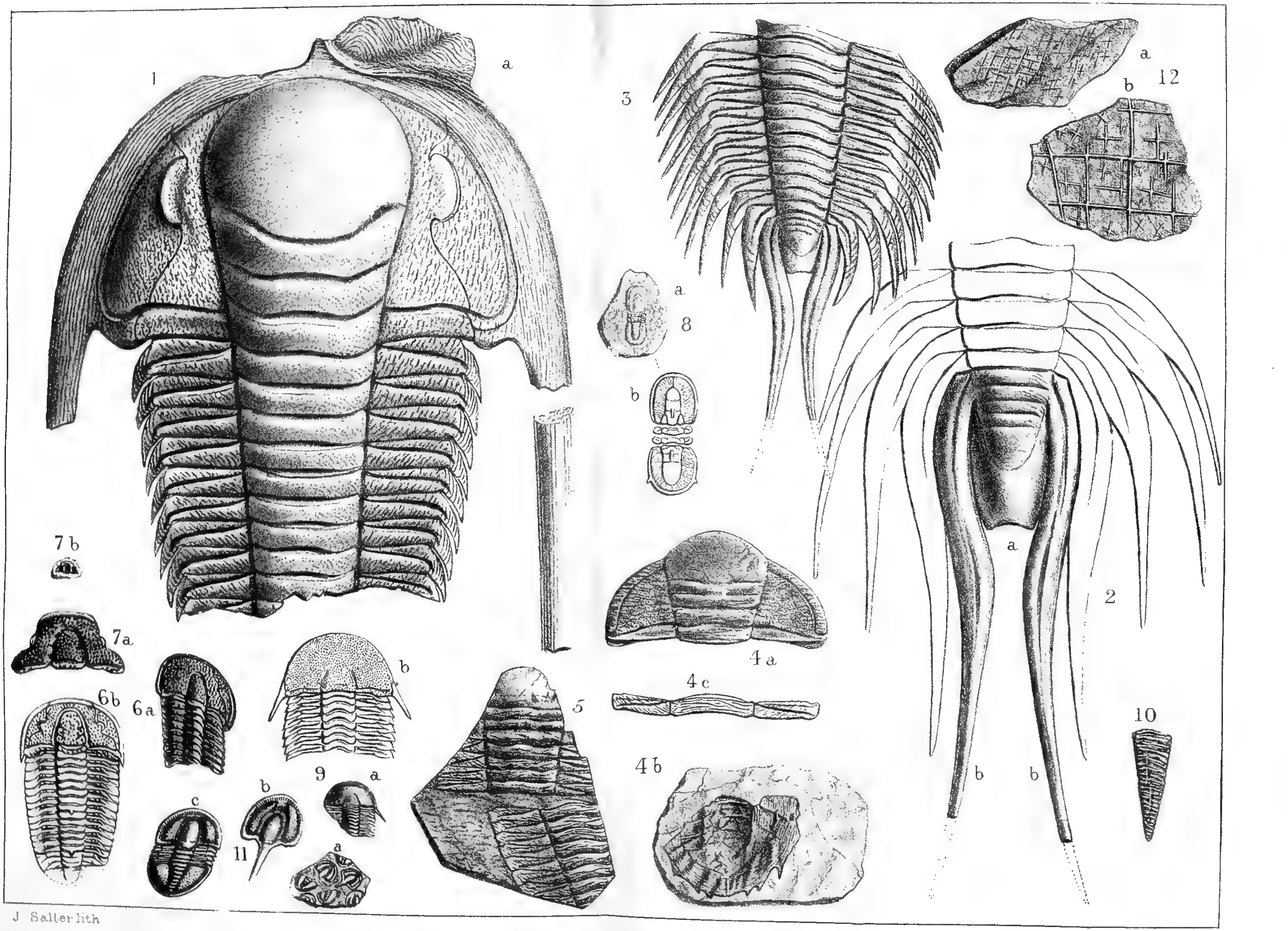
J Salter lith

FOSSILS FROM THE LOWER LIN



M. & N. Hanhart, imp

-FLAGS OF PORTH-Y-RHAW.



J Salter lith

M & N Hanhart imp

FOSSILS FROM THE LOWER LINGULA-FLAGS OF PORTH-Y-RHAW.

ferous beds, taken carefully by my friend Mr. Hicks, who has noted the exact distribution of the fossils in the several beds, and quite lately discovered new forms, which I hope to examine *in situ* and describe for the next volume of the Journal.

In a short paper, read last winter by Mr. Henry Hicks to the Geological Society of Liverpool, it was remarked that the fossils occurred in distinct beds. The fry? of the Trilobites and the *Lingulella Davisii*, both of very small size, occur lower down than the great Trilobites, and the *Theca* lowest of all, to within 100 feet of the grey Cambrian rock on the west side of the harbour, and fully 200 feet lower than the bands of the *Paradoxides*. The beds which contain the *Lingulella*, moreover, contain carbonate of lime in abundance, so much so as to produce strong effervescence with acids. This is not the case in the other beds, but is worthy of notice, as calcareous matter is very scarce in the Primordial zone in Britain, though abundant in Sweden in rocks of like age. There are also beds of contemporaneous trap, as shown in Mr. Hicks's measured section of Porth-y-Rhaw, given above (p. 240). Interbedded trap has not previously been described from the Lingula-flags, though I have seen it occurring rarely near Criccieth in North Wales.

EXPLANATION OF PLATE XIII.

Illustrative of Lower Lingula-flag Fossils.

Fig. 1. *Paradoxides Davidis*, Salter. Half-grown specimen of the natural size (left side restored from specimens showing the whole of the right side): *a*, the labrum, attached by a soldered suture to the hypostome, and bent back forcibly from the under side (cabinet of Mr. J. E. Lee).

2. ——. Tail of ordinary variety, showing the great sabre-shaped processes, *b*, *b*, with the body-rings in outline (British Museum).

3. ——. Variety with an abbreviated hinder pair of pleuræ to the body (this specimen has unfortunately been lost).

4. *Anopolenus Henrici*, gen. et spec. nov.: *a*, largest head known (Brit. Mus.); *b*, tail (Mr. H. W. Edgell's collection); *c*, body-ring.

5. ——. Body, rings, and part of head (Brit. Mus.).

6. *Conocoryphe? variolaris*, spec. nov.: *a*, natural size (Brit. Mus.); *b*, outline restored from a less perfect specimen, but showing fourteen body-rings and a portion of the tail.

7*a*. ——. Head (Brit. Mus.).

7*b*. ——. Young specimen (Brit. Mus.).

8. *Agnostus princeps*: *a*, natural size (Mr. Salter's cabinet); *b*, outline restored from good specimens in Mus. Pract. Geology.

9. *Holocephalina Primordialis*, gen. et spec. nov. (Brit. Mus.): *a*, natural size; *b*, enlarged to show the full form.

10. *Theca corrugata*, spec. nov. (Brit. Mus.), natural size.

11. Fry of some larger Trilobite, ? *Microdiscus punctatus*, spec. nov: *a*, head and tail-pieces, abundant in the Slates of Porth-y-Rhaw (Brit. Mus.); *b*, head magnified; *c*, perfect form (Mr. Hicks's cabinet).

12. *Protospongia fenestrata*, gen. et spec. nov. (Brit. Mus.): *a*, natural size; *b*, spiculæ magnified four diameters. The branches cross at rather too obtuse an angle; they should not be more, on an average, than 80°.

2. *On the* Millstone-grit *of* North Staffordshire *and the adjoining parts of* Derbyshire, Cheshire, *and* Lancashire.

By E. Hull, Esq., B.A., F.G.S., Geologist; and A. H. Green, Esq., M.A., F.G.S., Assistant Geologist of the Geological Survey of Great Britain.

(Plate XIV.)

Contents.

§ 1. *Introduction.*

Around the junction of the counties of Staffordshire, Derbyshire, and Cheshire lies a tract of rough moorland, which, from the opportunities it affords of studying the lower rocks of the Carboniferous system, would seem to deserve more notice than it has hitherto met with at the hands of geologists.

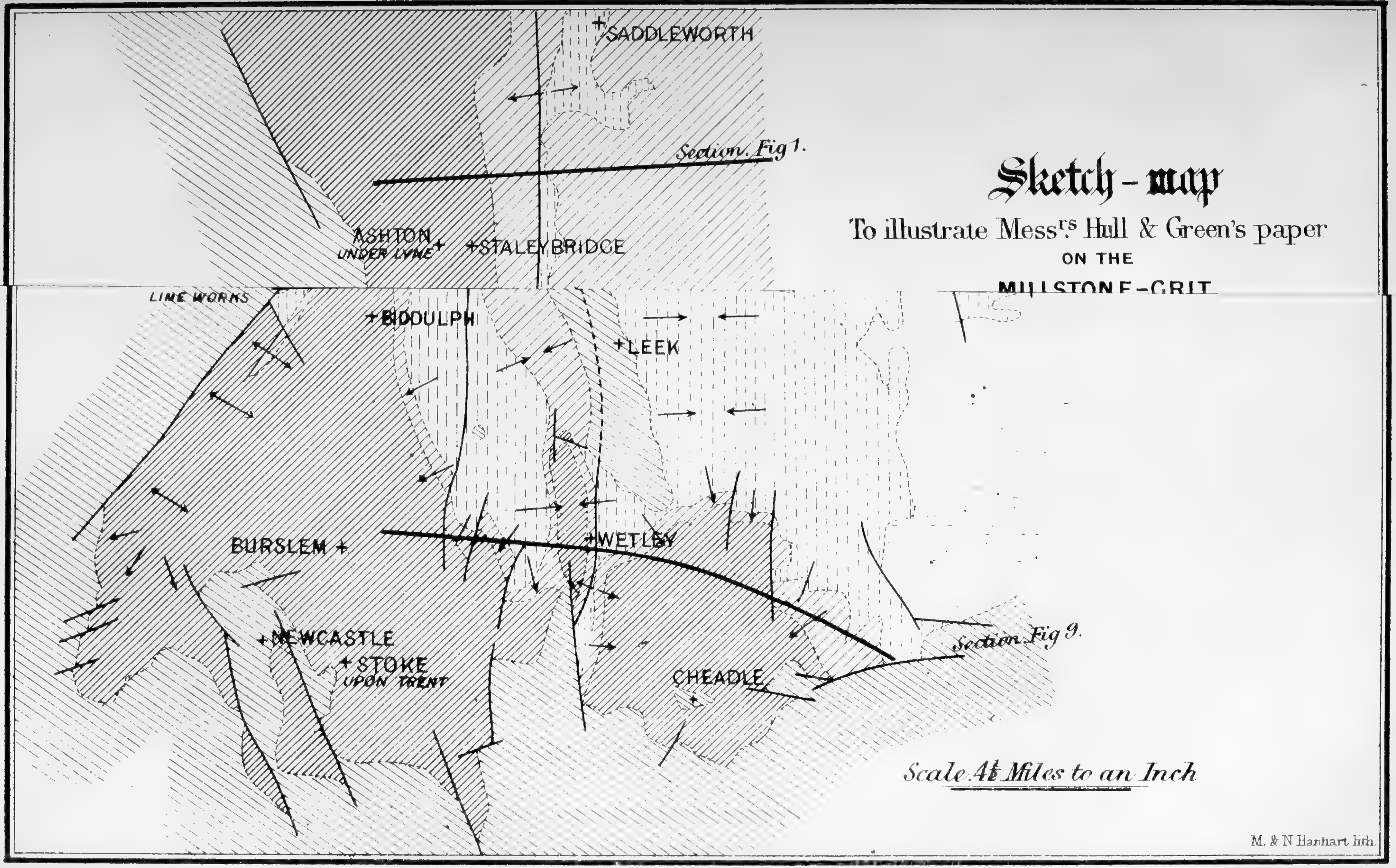
The authors of the present paper have been, during the last two years, engaged in mapping this country for the Geological Survey of Great Britain, and, with the permission of the Director-General, Sir R. I. Murchison, now come to lay some of the results of their observations before the Society.

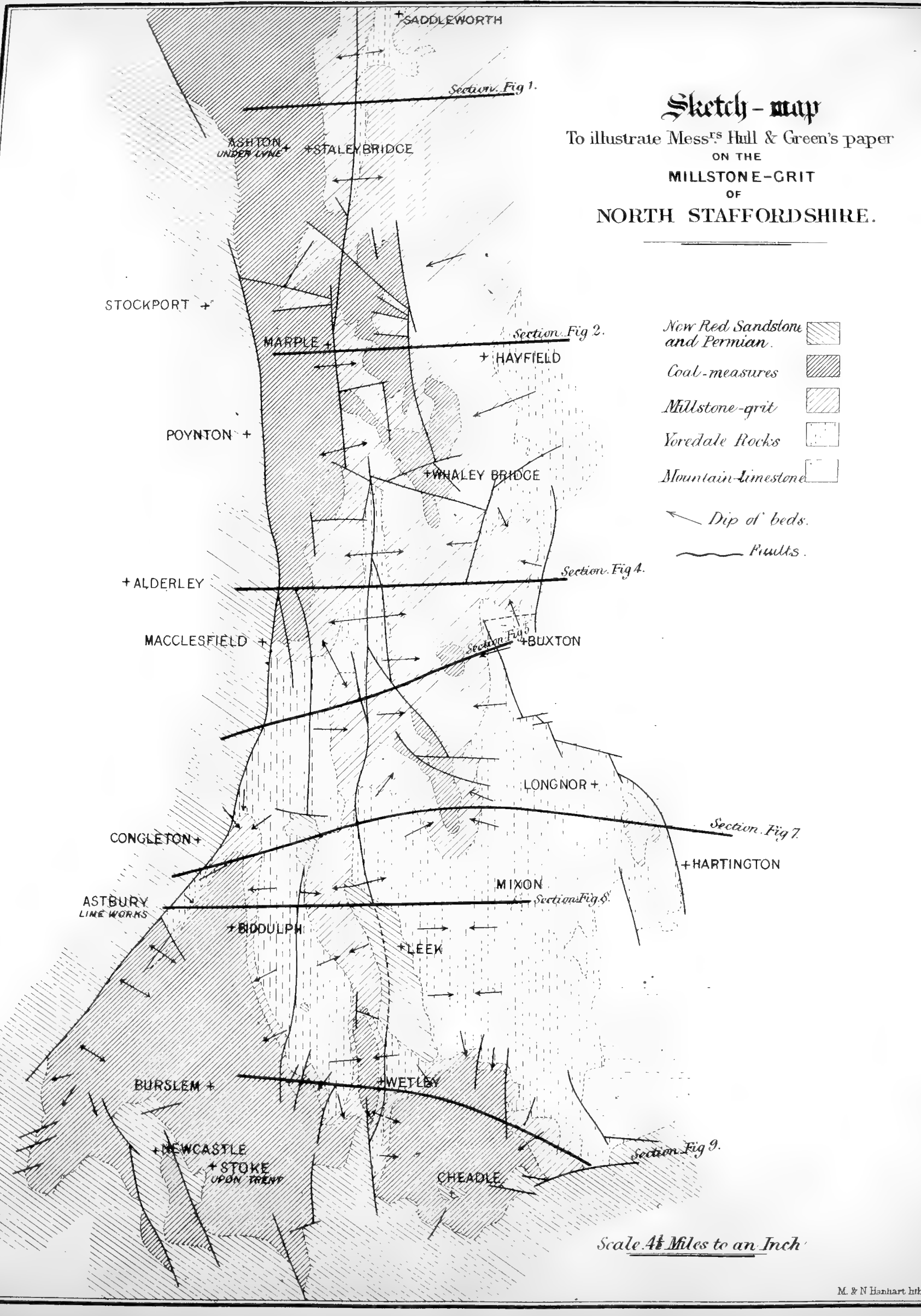
The main object will be to trace the thinning away, step by step, of the Millstone-grit from Lancashire to the borders of the North Staffordshire Coal-fields; but a few other points bearing on the geology of the district will be shortly noticed.

The country over which the observations extend begins at Saddleworth valley on the north, and stretches on the one side through Macclesfield and Congleton to the Pottery Coal-field, and on the other, past Buxton and Leek, to Cheadle in Staffordshire.

It is bounded on the west by a line of fault, known as the "Red Rock Fault," which throws down different members of the New Red Sandstone, on the west, against the Carboniferous rocks which cover the country to the east. This fault has a probable maximum throw of over 8000 feet south of Congleton, where it brings the Mountain-limestone against the Lower Keuper Sandstone, or Waterstones, of the Trias.

The chief geological features may be described in a few words. On the extreme east, and lying to the west of the High Peak and


Sketch-map
To illustrate Messrs. Hull & Green's paper
ON THE
MILLSTONE-GRIT
SADDLEWORTH
Section. Fig 1.
ASHTON UNDER LYNE
STALEYBRIDGE
LIME WORKS
BIDDULPH
LEEK
BURSLEM
WETLEY
NEWCASTLE
STOKE UPON TRENT
CHEADLE
Section Fig 9.
Scale 4½ Miles to an Inch
M. & N Hanhart lith.


Sketch-map
To illustrate Messrs Hull & Green's paper
ON THE
MILLSTONE-GRIT
OF
NORTH STAFFORDSHIRE.
New Red Sandstone and Permian.
Coal-measures
Millstone-grit
Yoredale Rocks
Mountain-Limestone
Dip of beds.
Faults.
SADDLEWORTH
Section. Fig 1.
ASHTON UNDER LYNE
STALEYBRIDGE
STOCKPORT
MARPLE
Section. Fig 2.
HAYFIELD
POYNTON
WHALEY BRIDGE
ALDERLEY
Section. Fig 4.
MACCLESFIELD
Section Fig 5
BUXTON
LONGNOR
CONGLETON
Section. Fig 7.
HARTINGTON
MIXON
ASTBURY LIME WORKS
Section Fig 8.
BIDDULPH
LEEK
BURSLEM
WETLEY
NEWCASTLE
STOKE UPON TRENT
CHEADLE
Section Fig 9.
Scale 4¼ Miles to an Inch
M. & N. Hanhart lith.

limestone district of Derbyshire, is a long synclinal, to the northern part of which Farey has given the name of the "Goyt Trough." This hollow runs due south from Mottram, near Staleybridge, by Whaley Bridge and the east of Leek to the Cheadle Coal-field, beyond which the Carboniferous rocks sink beneath the New Red Sandstone. It is, for the most part, bounded on either side by ridges of Millstone-grit, and is broken into several subordinate basins, in which lie patches of Lower Coal-measures.

To the west of the Goyt Trough the beds rise into a sharp saddle, along the whole or greater part of which runs a line of fault; these we will call the "Saddleworth and Saltersford Anticlinal" and the "Anticlinal Fault," respectively. We have traced this line of disturbance from the northern end of Saddleworth valley, southwards by Staleybridge Moor, the River Goyt at Marple, and Disley, into Saltersford valley, along which it ranges; and onwards by Forest Chapel, until it is lost on the north-west of Leek, below the patch of New Red Sandstone that there fills in the Churnet valley. To the south of this outlier, an anticlinal fault on the east of Wetley Rocks belongs most likely to the same line of fracture.

Beyond the anticlinal fault we have, on the extreme north of our district, the eastern edge of the Lancashire Coal-field. A long strip of Coal-measures, branching as it were from the main field, runs down by Hyde and Poynton to Macclesfield: it is bounded on the east and south by the ridges of the Millstone-grit, which rise in these directions from beneath the Coal-measures, and it stretches on the west up to the "Red Rock Fault."

Along the same line, further to the south, lies the large Coal-field of the Potteries, the northern part of which is known as the Biddulph Trough.

Between the Biddulph and Goyt Troughs, and to the west of the Anticlinal Fault, lies a shallower basin, beginning north of the village of Rushton, and running along Rudyerd Reservoir to the little Coal-field of Wetley and Shafferlong. This we will call the Rudyerd Basin. The rest of the district is mainly occupied by Yoredale Rocks, thrown into countless folds, and much broken by faults.

Two little patches of Mountain-limestone peep up through the overlying beds; at Mixon, east of Leek, and at Astbury near Congleton.

The Millstone-grit has a scenery of its own, marked by long lines of terraced or steeply scarped hills, which contrast strongly with the undulating plain of Cheshire on the one hand, and the rounded outlines of the limestone-hills on the other. We continually see the same form of outline, consisting of a gently rising surface of moorland, broken off along a line of sharp cliff, as characteristic of the landscape of this formation. By these physical features the composition and arrangement of the strata are marked out with wonderful clearness, the summits of the ridges and escarpments being invariably composed of grit or sandstone, and the flanks of the hills and the valleys of shale; and as the steep face of the escarpment always tends to run in the line of strike, and looks in the direction opposite to the dip, the observer can often, from some commanding point, trace out the geological structure of the country around by the aid of its surface-configuration alone.

In order to determine with accuracy the relationship to each other of the different beds which form the escarpments of the district, we began, with the express wish of Prof. Ramsay, to trace out separately each bed of grit, from the base of the Lower Coal-measures downwards; hoping that, in a country where the features were so obvious and so seldom hidden by drift, we should be able to ascertain, with certainty, the range of each bed, and note the changes in its thickness and quality, which previous observation, and the description by Prof. Phillips of the grits in the neighbouring district of Yorkshire, led us to look for *. Mr. Binney has endeavoured, with much success, to identify the grits and coal-seams of Lancashire and parts of Derbyshire; while Farey had, with wonderful diligence and judgment, attempted the same feat many years ago; but, except by tracing each band of grit step by step, it was impossible for any one, however sagacious, to feel sure as to the identity, at points widely distant from each other, of beds parted by faults and changed in look by the changes in quality to which sandstones are liable.

We now propose to begin with the Millstone-grit as it is seen on the borders of Lancashire and South Yorkshire, and to describe a series of sections taken at intervals over the district from north to south, which will serve to show a general thinning away of the series towards the south or south-west. The general attenuation of the sedimentary rocks of the Carboniferous series in this direction has been pointed out by one of the authors in a former paper †. The present has for its object to give the details for the Millstone-grit over a small definite tract of country.

§ 2. *Lower Coal-measures, and Upper Limit of the Millstone-grit.*

Before entering on our immediate subject it will be advisable to give a short description of the overlying Carboniferous rocks, so as to define clearly what we take to be the upper limit of the Millstone-grit.

The Coal-measures of Lancashire are divisible into three stages, namely,

The Upper, consisting of purple and grey shales and sandstones with thin beds of limestone and coal. Thickness, 2000 feet.

The Middle. From the Pendleton Four-foot down to the Arley Mine, or a little lower; they consist of shales and sandstones, and contain all the thick coals. Thickness, 3000 feet.

The Lower or *Gannister* beds. From the Arley Mine to the Rough Rock; they consist of micaceous sandstones and shales, with three or four thin beds of coal. Thickness, 1800 feet.

The coals of the Lower Measures are, in descending order:

1st. The Forty Yards Mine, known at Up-Holland, Chorley,

* Geology of Yorkshire, Part 2, 1836, pp. 58 *et seq.*

† Hull, "On Isometric Lines, &c.," Quart. Journ. Geol. Soc. vol. xviii. p. 127.

Rochdale, Bacup, Helpet Edge, and Dukenfield*, and perhaps the Great Smut of Kerridge and Macclesfield.

2nd. At a distance of from 40 to 64 yards below the last, the Upper Foot Mine or Bullion Coal, having a black shale roof with calcareous nodules, containing *Goniatites Listeri, Aviculopecten papyraceus*, &c. It is worked at Burnley, Rochdale, Helpet Edge, Dog Hill, Oldham, and Staleybridge.

3rd. At a distance of 10 or 12 yards below the Lower Foot comes the Gannister Coal, with a black shale roof, and a floor of extremely hard siliceous rock, full of Stigmaria. It is worked at Burnley, Blackburn, Rochdale, Darwen, Halliwell, Bury, Oldham, and Staleybridge.

4th. Below the Gannister, at a distance of 10 yards, lies the Lower Foot Mine, often absent. It has been worked at Affeside, Quarlton, and Helpet Edge.

5th. The next seam is the Lower Yard or Bassy Mine, lying 18 yards below the Lower Foot. It has been worked at Up-Holland, Harrock Hill, Sharples near Bolton, Helpet Edge, Broad Bottom, Compstall, and New Mills. Shales and a thick bed of hard, fine-grained grit, called by Mr. Binney "The Woodhead Hill Rock," lie below this seam.

A group of four or five thin coals, corresponding in the main with these seams, is found in the Goyt Trough about Whaley Bridge and Goldsitch Moss; in the Cheadle Coal-field about Ipstones and Froghall; and in the Macclesfield Measures at Bakestone Dale, Bollington, Kerridge, and Roewood near Macclesfield.

Lastly, at a distance of 38 yards below the Bassy Mine lies a coal, known as the "Featheredge," "Three Quarters," or "Sandrock" Coal in Lancashire, and the "Big," "Brick," or "Limekiln" Coal about Macclesfield and in the southern part of the Goyt Trough. Its roof is mostly black shale, and under its floor is a coarse grit or conglomerate, known as the "Rough Rock." Here and there, however, the Rough Rock forms both the roof and floor. Whether such was always the case, or whether the grit roof has in places been removed by denudation and its place been taken by shale, cannot be said: the frequent absence of the coal itself is somewhat in favour of the latter hypothesis. In either case we take the top of this Rough Rock for the upper boundary of the Millstone-grit, under which head we include the following series of beds.

§ 3. *Subdivision of the Millstone-grit Series.*

1st Grit. The Rough Rock. A coarse massive grit, crumbling under the action of the air, on account of the decomposition of felspar, which it contains in large quantity.

Shales, with a thin coal at the bottom west of Buxton, lie below the Rough Rock.

* The localities for these seams are taken chiefly from Mr. Binney's valuable papers, "On the Lancashire and Cheshire Coal-field," Trans. Geol. Soc. of Manchester, vol. i.; and "On the Fossil Shells of the Lower Coal-measures," *ibid.* vol. ii. part 7.

2nd Grit. The Haslingden or Lower flags of Lancashire. Mostly a brown, fine-grained, flaggy sandstone, but here and there coarse and massive in the upper part.

Shales with two or three thin coals, the Brooks bottom coals of Lancashire, come next. The lowest of these, which often rests directly on the grit below, is found here and there over the whole of the district. It has been worked, among other places, on Sponds Hill, east of Pott Shrigley; under Great Low, near Bollington; at Tegg's Nose, near Macclesfield; Thatch Marsh, near Buxton, where it is 4 ft. 6 in. thick; Harper's End, north of Leek; on Congleton Edge; at Bagnall, five miles S.W. of Leek; and at Foxt, four miles N.N.E. of Cheadle.

3rd Grit. A very coarse massive grit and conglomerate, mostly red. It may well be called the Escarpment-grit, the edges formed by its outcrop being the finest in the country, and often running for miles in an unbroken wall of rock.

Shales, with one or two very thin coals in Lancashire, one close to the bottom, separate this from the next grit.

4th Grit. Main Millstone or Kinder Scout Grit. A thick mass of very coarse gritstone and conglomerate, in two or three beds separated by shale. To the south this bed falls away very suddenly, and passes into two sandstone-beds with a thick shale between; these we shall speak of in their place as the fourth and fifth grits.

Our classification is the one adopted by the Geological Survey, and is similar to that given by Professor Phillips in his 'Geol. of Yorkshire.' Other authors, including Farey and Mr. Binney, place both the Rough Rock and the Flags below in the Lower Coal-measures. This is, however, only a matter of words. The main features of the Carboniferous system in the centre of England seem to be a prevalence of coal in the upper, of gritstone in the middle, and of limestone in the lower portion; and these pass step by step one into the other; the coals get fewer and thinner downwards, and the flagstones of the Lower Coal-measures form a step to the gritstones below; while the lime-cemented sandstones in the middle of the Yoredale Rocks and the thin limestones at their base lead us on to the thick mass of the Mountain-limestone. Also the whole series, especially the two lowest members, thins away to the south.

If we keep these main facts in view, it matters little where we draw the lines of artificial, though useful, division. To the field-geologist, however, it is a great help to take the Rough Rock for the upper bed of the Millstone series; by its coarseness and the marked feature which it mostly makes in the landscape, it is easily traced, and it makes an excellent geological horizon, being, with one exception, present over the whole of the district. It must be recollected, too, that in the south of our district the Rough Rock forms one-half of the Millstone-grit, and in Leicestershire is probably the only bed present, so that Mr. Binney's classification would sadly impoverish the one district, and deprive the other of the Millstone-grit altogether.

As to the lower boundary there is luckily but one opinion. The fourth grit is in Lancashire the thickest, coarsest, and most massive of all the gritstones; and the sandstones below it are all thinner-bedded and finer in grain. It makes, therefore, a natural base to a series whose character is indicated by its name, and as such it has always been looked upon by all authors, from Farey* downwards.

In the south of the district, however, the bed falls off in character, and is at last represented by two sandstones, with a thin bed of shale between them. Looking at these beds by themselves, there is nothing to entitle them to be called Millstone-grit at all; and it is not from their own importance, but only as the representative of the more striking masses in the north, that they can claim the prestige of marking the base of the formation. An observer who looked only at a district where the fourth grit wears so feeble a form, and had not traced it step by step up to its full development, would be likely to take the lowest coarse grit in the neighbourhood for the base of the formation; and into this mistake Farey seems at times to have naturally fallen, and to have looked upon the third grit of Combs Moss, for instance, as the equivalent of the Kinder Scout bed, because each was the lowest coarse grit in the country round†.

The fourth grit thins away altogether before reaching the borders of the North Staffordshire Coal-fields, and the bed above is then taken for the base of the Millstone series.

§ 4. *Yoredale Rocks.*

Between the lowest grit and the Mountain-limestone lies a group of shales and sandstones, with thin limestones at the bottom, the Yoredale Rocks of Professor Phillips.

These beds, in the country we are describing, admit of the following threefold division:—

(A.) Shales with a thick bed of sandstone (the "Shale-grit" of Farey‡), and perhaps a few thin limestones.

(B.) Sandstones, for the most part thin-bedded and close-grained, with black shales. This group we shall speak of as the "Yoredale Quartzites."

(C.) Black shales, with thin, black, earthy limestones towards the bottom §.

Were it not that the Kinder Scout Grit makes so natural and so generally received a base to the Millstone-grit, the first of these groups might well have been placed in that formation rather than among the Yoredale Rocks. The sandstone, though fine-grained, is

* Hist. of Derbyshire, vol. i. p. 220. † *Ibid.* p. 170.

‡ As we speak of the whole group as the Yoredale Rocks, we shall call this bed the "Yoredale Grit."

§ Farey, in his account of the Yoredale Rocks, mentions what he calls three "anomalies" as occurring in them: a bed of fine sandstone, the Shale Grit; beds of hard cank-like sandstone; and thin beds of dark-blue or black limestone (Hist. of Derbyshire, p. 228). These three "anomalies" form the distinguishing features of the three groups in the above scheme.

massive, and is in character more like a millstone-bed than the close-grained quartzose rocks of the second group; like the grits, too, it thins away to the south—at least it cannot be traced beyond certain points. It may be, however, that it passes into a rock indistinguishable from the sandstones of the group below. Some sections between Buxton and Leek are in favour of this view.

The sandstones of the second group may always be known by their firm close grain, which seems to be owing to a plentiful siliceous cement. They never tend to become crumbly from weathering, as is the case, more or less, with all the millstone-grits; and their fracture is clean and bright, while the freshly broken surface of the gritstones is rough. As a rule, they are thin-bedded and fine-grained; but massive conglomerates* are seen here and there. These, however, have the same firm cement as the other beds, and thus differ widely from the conglomerates of the Grit-series. In places, as on Gun Hill, near Leek, these beds are very hard subcrystalline quartz-rocks; and this seems to be the shape they mostly take where much contorted, as if pressure had developed in them a semicrystalline structure. Some beds of this group have at times a calcareous cement.

The term "Limestone-shale," which is often given to the whole group, belongs properly only to the lowest division, which is made up almost entirely of black shales, with thin earthy limestones in the lower part. The latter seem to become more plentiful and purer towards the bottom, and vary from black earthy beds to pure grey crystalline limestones, with many fossils.

We shall now pass to the detailed accounts of the several districts into which the country under consideration may be suitably divided.

§ 5. *Description of the Sections.*

a. *Saddleworth Valley. Position of Rocks at the surface.*—This valley trends north and south, and, as stated by Professor Phillips, is occupied by Limestone-shale, or, rather, the Yoredale Rocks—an equivalent and much preferable term, due to this author, which we shall henceforth exclusively adopt. The Yoredale beds consist principally of black and grey shales, with a thick bed of rather massive sandstone—the "shale-grit" of Farey. On both sides the valley is bounded by high ridges of the Kinder Scout Grit, dipping in opposite directions from the axis of the Saddleworth anticlinal. The change of dip takes place along a fault which breaks through the escarpment at the northern apex of the valley, and ranges southward, throwing off the beds at high angles on either side as far as the entrance to Greenfield Valley. Here it joins another great dislocation, and then ranges along the base of a series of bold bluffs formed of the Scout Grit to Harrop Edge (see fig. 1). All along this line (a distance of ten miles) the structure of the beds is very different on each side of the anticlinal. West of it the dip is for

* Farey seems to have noticed such beds (see 'History of Derbyshire,' p. 228).

the most part rapid, and the several members of the Millstone and Gannister series plunge beneath the Lancashire Coal-field. On the opposite or Yorkshire side, however, the strata evince no such precipitancy. The Kinder Scout Grit lies nearly horizontal, and rises into tabular moorlands, to a height of nearly 2000 feet above the sea-level. A little further on, the grits begin to dip towards the east, at first leisurely, then more rapidly, until *they* also are lost beneath the Coal-measures of Yorkshire. The section (fig. 1) on p. 251 will illustrate this peculiarity.

Petrological details. Yoredale Beds.—The lowest beds of this series exposed are close to the fault. They consist of shales a little below the Yoredale or Shale-grit. This latter is shown near the entrance to the tunnel, and in quarries on both sides of the fault. It consists of rather massive greyish sandstone, sometimes coarse, but seldom a conglomerate like the Kinder Scout Grit; over it comes a thick series of black and greyish-blue shales, which extend up to the base of the Millstone ridges. The thickness of the series of beds here shown is not less than 1200 feet, and the basement-beds are nowhere brought to light. Hence it is probable that the Yoredale beds are here altogether not less than 2000 feet in thickness.

The Kinder Scout Grit, or Fourth Grit, consists of two or three beds of very massive grit or conglomerate, separated by shales, altogether attaining a thickness of not less than 600 or 700 feet. It often contains pebbles of white quartz the size of a pigeon's egg, but no larger, and is traversed by planes of current-bedding, which dip towards the W.S.W. It forms the ridges of Harrop Edge, Millstone Edge, Diggle Edge, Charnel Rocks, Warlow Pike, Harridge Pike, Tintwistle Knar, and Roe Cross, and is largely quarried for foundation-stones, &c.

Third Grit.—At the top of the fourth grit there is sometimes a little coal, and then a thick series of shales and flags, forming the flanks (as we suppose at present) of Pule Hill. At Mossley these shales are 400 feet in thickness, and are surmounted by the third grit, which at Pule Hill forms a sharp and serrated ridge, and south of Mossley is well shown on the banks of the Tame. The upper beds are massive and coarse, the lower flaggy. The third grit may be seen west of Friar Mere, at Lidgate, Mossley, and in quarries alongside Staley Lane; also at Hollingworth and Hadfield. The thickness varies from 300 to 450 feet.

Second Grit.—Above the third grit occurs a series of generally black shales, with a stratum of rock*, and a coal-seam which is worked at Mossley and Mottram. The thickness of this shale series is about 500 feet at Mossley, and it is surmounted by the flagstones which form the second grit of our classification. In this part of the district these flags† (which, further south, form a distinct geological horizon) are here in close connexion with the first grit, or "Rough Rock," and can only be considered as a lower member of it. They are, however, very constant in this position, and may be traced along

* Called "Scout Rock," near Staleybridge; not "Kinder Scout Rock."
† Called by Mr. E. W. Binney "The Haslingden Flags."

Badger Edge, near Delf, and Brown Edge and Early Bank, near Staleybridge. Further south the shales which intervene between the second and third grit thicken out, and each of these beds assumes a more individualized character.

First Grit, or Rough Rock.—This is a coarse grit and conglomerate, nowhere very thick in this neighbourhood, and east of Staleybridge totally disappearing for a short space. South of Mottram, however, it again appears in force. It may be traced along Bowstead Edge to Knot Hill, then from Grotton Head along High Knowles to Luzley, where it thins away. Along this range it dips beneath the shales of the Lower Coal-measures. We may place the average thickness of the first and second grits in this district at 150 feet. We thus get the thickness of the entire series as follows:

Staleybridge District.

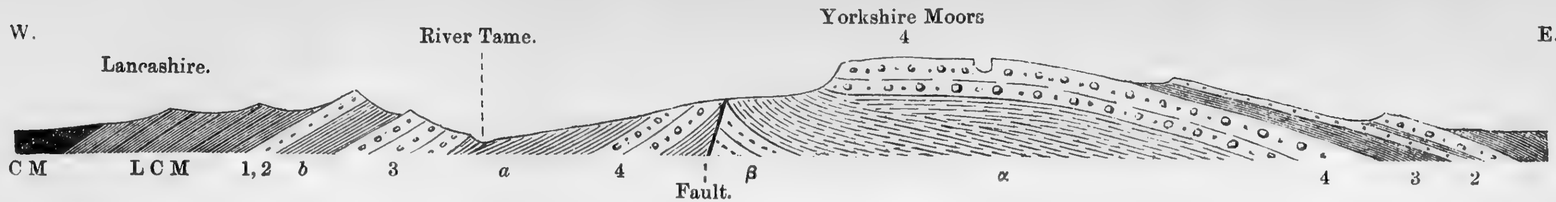
	feet.
First and Second Grits	150
Shales (with coal)	500
Third Grit (300 to 450)	400
Shales	400
Fourth Grit, in two or three beds (600 to 700)	650
Total	2100

b. *Mottram and Glossop District. Position of Rocks at the surface.*—In this neighbourhood the Goyt Trough has its northern termination; the beds of the Millstone series, above the Kinder Scout Grit, gradually rising and cropping out to the northwards as well as to the eastward and westward. South of Mottram the symmetry of the trough is much interrupted by faults, which give origin to local rolls of the strata; and so it is not until we have passed south of New Mills that the beds resume their centroclinal arrangement.

The other main feature, namely, the Saddleworth anticlinal, also loses its normal character, and at Compstall passes altogether into a fracture; and it is not until we reach Disley that the change of dip becomes very clearly developed. These features will be understood by the section (fig. 2), which is continued eastward across the Peak, in order to show the general arrangement and connexion of the beds.

The Kinder Scout, or fourth, Grit forms a range of moorland hills extending from Glossop and Hayfield eastward across the watershed of England, and embracing in its centre the table-land of The Peak. The beds rise to the eastward with great regularity, gradually flattening towards the axis, and then roll over on the eastern dip. Along the western side of the axis, to which we shall for a moment confine our attention, the Kinder Scout Grit dips below a series of sharply chiselled escarpments formed of the upper members of the Millstone-series, ranging in a nearly true north and south direction from Glossop to Combs Moss, above Buxton. Between the Scout Grit and the Third Grit there is generally a rather wide valley, formed of a very thick series of shales, surmounted by a cliff; then

Fig. 1.—*Section from the Lancashire Coal-field to the Yorkshire Moors.*

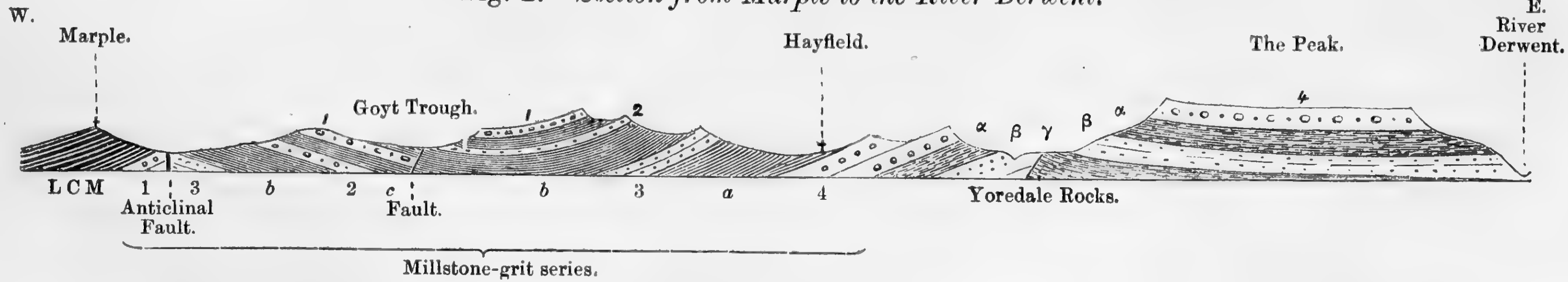


C M. Edge of the Lancashire Coal-field.
L C M. Lower Coal-measures, or Gannister beds.

Millstone-grit series.
- 1, 2. First and Second Grits.
- *b*. Second Shale-series.
- 3. Third Grit.
- *a*. First Shale-series.
- 4. Kinder Scout or Fourth Grit.

Yoredale Beds.
- *α*. Upper Shale.
- *β*. Yoredale Grit.

Fig. 2.—*Section from Marple to the River Derwent.*



L C M. Lower Coal-measures.
1. First Grit or Rough Rock.
c. First Shale-series.
2. Second Grit.
b. Second Shale-series.
3. Third Grit.
a. Third Shale-series.
4. Fourth or Kinder Scout Grit.

Yoredale Rocks.
- *α*. Upper Shale.
- *β*. Yoredale Grit.
- *γ*. Lower Shale.

a second lesser hollow rising into the cliff of the second grit; then another still smaller, crowned by the cliff of the first grit. This completes the series. These successive stages are well shown along the flanks of Crown Edge and Chinley Hill, the latter of which reaches an elevation of 1493 feet.

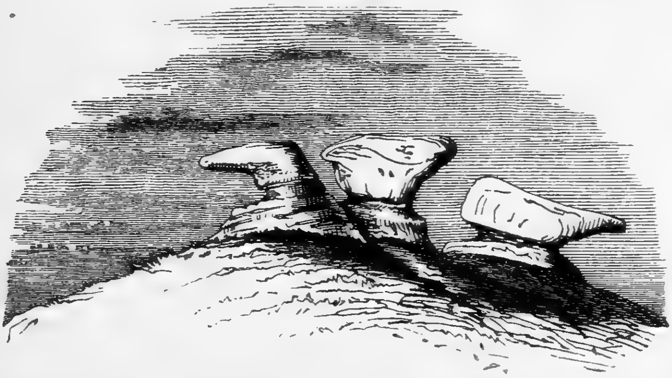
Petrological details.—The Kinder Scout Grit undergoes no change of character from that described at Saddleworth. The third grit, here known as the "Simmondley Rock," becomes very massive and coarse on Matley Moor, and is surmounted by the shales with the same coal-seam (apparently) that occurs at Mossley. The second grit here forms a distinct escarpment, and is extensively quarried for flagstones and tiles under Chinley Churn. The first grit becomes thick and massive; in some places, as at Mellor and Aspinshaw, containing the *Featheredge Coal*; in other places, as at Broadbottom and Crown Edge, this seam nowhere appears. The thickness of the series is greater here than at Staleybridge, owing to the increase of the first grit and the underlying shales, and may be estimated at 2800 feet. At New Mills the Rough Rock with the Featheredge Coal, and some of the inferior beds, rise towards the west on the opposite side of the trough, and at Disley, still further to the west, are thrown down by the anticlinal fault already described. From Disley westward the dip is steadily west, and we cross the full series of the Lower Coal-measures, which form the hilly tract of Lyme Park, and then reach the Poynton Coal-field, which will require a few words of description.

The eastern boundary of the Poynton Coal-field forms the arc of a circle, of which the "red rock fault" is the chord. It is, in fact, a limb of the great Lancashire Coal-field projected from its south-eastern extremity, and extends from Offerton Green to the north side of Stypherson Park, a distance of about five miles from north to south. At its broadest part it is about two miles across. Its eastern border is formed by the outcrop of the *Redacre Coal*, which is considered, with great probability, to represent the Arley Mine of Lancashire. It contains several valuable coal-seams, which are worked at Poynton and Norbury collieries; but a considerable part of the field is rendered valueless in a mineral point of view by the broken character of the strata.

In this district one or two seams in the Lower Coal-measures have been extensively worked; the principal of these is the *Bakestone Dale seam*, which represents the "*Lower Yard*" Coal (No. 5 of the series, page 245). Along with the Gannister Coal, this seam is worked at Disley, New Mills, and Whaley.

c. *The Peak District. Position of Rocks at the surface.*—The tabulated aspect of The Peak is very clearly indicated by the shading in the Ordnance Map; and its structure is illustrated in the general section above (fig. 2). This hill, which may aspire to the character of a mountain, as it reaches an elevation of 2000 feet, forms a very striking and bold feature from almost every point of view. It is somewhat in the form of a triangle, lying with its vertex pointing east, in the direction where the broad valley of Edale joins the narrow gorge of the Alport. Its base is formed by the cliffs of Kinder Scout; and its sides, which are extremely irregular in outline, by the similar cliffs overlooking the two valleys just named. Its upper surface is somewhat uneven, and is entirely composed of the Millstone-grit, which, for the most part, is buried beneath a thick coating of peat, fissured into innumerable gullies and clefts, which cause an excursion across a surface, which on the map appears a plain, to be in reality a succession of dips and emersions.

Fig. 3.—*Views of Rocks on the Peak.*



The grit, however, sometimes appears in little bosses, or it throws up groups of tabulated or fantastically-shaped stones, the forms of which I cannot but regard as the results of old marine denudation. In some places, especially near Edale Head, whole acres are covered by these groups or multitudinous assemblages of water-worn rocks. Amongst the various forms the table is common, but the smith's anvil seems to be a special favourite; nowhere else, as far as my acquaintance with these hills has extended, have I observed such numerous examples, in the same space, of seashore rocks.

The flanks of the valleys in the Peak country are also remarkable for enormous land-slips, the origin of which may in many cases be placed as far back as the final retirement of the sea at the close of the glacial period. Almost everywhere around the steep cliffs of the Peak itself these slips occur, and are easily to be accounted for when we examine the nature of the beds which underlie the Scout Grit forming the summit of the escarpment. The grit is here underlain by shales, which intervene between it and the *Yoredale Grit.* Hence the latter, being undermined by the retiring waters, or by atmospheric agencies, as the case may be, have yielded to the enormous pressure of the superincumbent millstones, which descended in masses from their original elevations. A similar arrangement of the beds has caused the landslips (or coast-slips) amongst the Oolitic escarpments of the south-west of England and the Chalk-downs, and indeed wherever solid rock forms a cliff resting upon strata of clay or shale. Alport Edge, on the eastern side of the valley, and Coombs Rocks, near Mottram, afford similar instances worthy of being noticed.

The valleys which form the lateral boundaries of the Peak are scooped down to the base of the Yoredale Grit, without penetrating to the limestone. This sandstone is here of considerable thickness, not less than 500 feet, often massive and compact.

The Yoredale Grit forms a series of table-lands of less elevation than The Peak, intersected by deep gorges all round The Peak, except on the west and south sides, where it forms the long round-backed ridge between Lose Hill and Mam Tor. To the east of Derwent Dale, however, the Kinder Scout Grit sets in with an easterly dip along the fine escarpment of Derwent Edge, 1773 feet in height, beyond which the ridges of the third, second, and first grits rise in succession, all the beds of which dip beneath the Yorkshire Coal-field.

d. *Whaley Bridge and Saltersford Valley. Position of Rocks at the surface.*—Along this section of country the structure of the beds is remarkably symmetrical. It may be described in a few words as a trough bounded on either side by anticlinals. The geological features which we attempted to describe, as expressed by two parallel lines of fracture in the Mottram and Glossop district, here resolve themselves into undulations. In order to understand its structure, we cannot do better than follow a line of section (fig. 4) from east to west, which we have here drawn through a distance of ten miles.

We commence on the Carboniferous Limestone a few miles north of Buxton, and not far from its extreme northerly extension. The limestone dips to the westward under the Yoredale series, here apparently thin, which is partially due to the presence of a fault. We then ascend the flanks of Combs Moss, and cross the representatives of the Kinder Scout Grit, and at the summit reach a small table-land formed of the third grit. This table-land, unlike that of The Peak, occupies the axis of a slight trough, instead of an anticlinal or saddle. Along the western flanks the beds rise to the west, and in the valley we reach the Yoredale Rocks forming an anticlinal with a fault. Having crossed this the dip is reversed, and we ascend to the ridge of Hazel Hurst, formed of the third grit dipping at a high angle to the west, and cross successively the remaining members of the Millstone-grit, until we reach the river Goyt, when we find ourselves in the axis of the Goyt Trough. On the west side of the valley we cross the same beds on the easterly dip, and descend into Saltersford Valley, along which runs the line of the great anticlinal fault. This valley is scooped far down into the Yoredale beds. On the opposite side of the valley the beds roll over, and maintain the westerly dip all the way to Bollington. Here the millstones dip beneath the Lower Coal-measures of Kerridge, and are ultimately cut off by the great "red rock fault" of Cheshire.

Petrological details.—In this district there is a remarkable change in the character of the Lower Millstones from that which they assume further north in the direction of Glossop and Saddleworth. In the first place, the whole series below the third grit is thinner, and along with this thinning of the beds the sandstones become finer and less massive. The Kinder Scout Grit along both sides of Saltersford Valley, and along the flanks of Combs Moss, is represented by one or two beds of rather fine grit, not more perhaps than 150 feet in thickness. These we shall henceforward speak of as the fourth and fifth grits. The Yoredale Grit is also less massive than in The Peak country. Even the third grit, which rises with a fine escarpment on both sides of the Goyt Trough, on the western side of the Saltersford Valley assumes for a time the character of a flaggy sandstone of no great thickness. The same is true, though in a less degree, of the remaining grits; so that between Glossop and Bollington, a distance of twelve miles from north-east to south-west, the whole Millstone-grit series may be said to exhibit a great degeneracy in many of its features, and to give clear indications of that general thinning away of the sedimentary materials which takes place in this part of England from north to south.

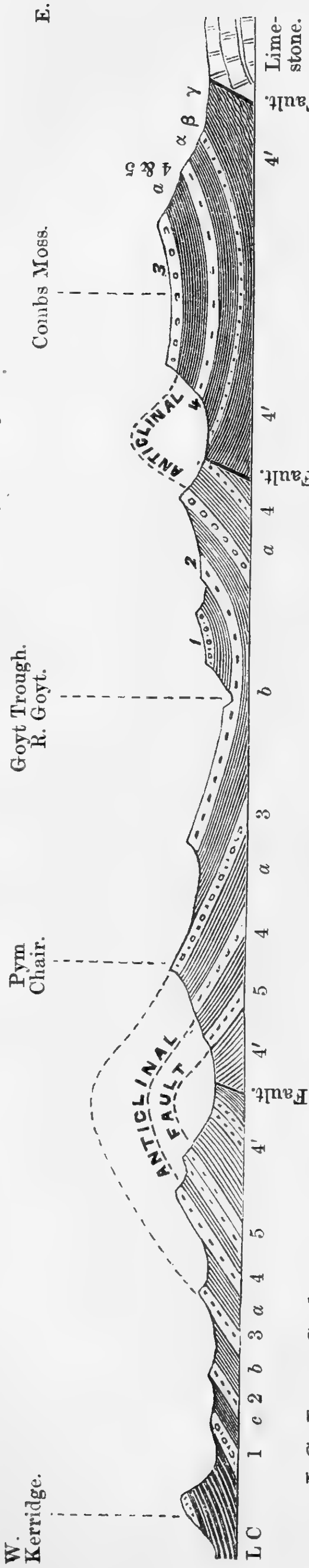
e. *West of Buxton. Position of Rocks at the surface.*—The town of Buxton stands on the Mountain-limestone, which is bounded on the west by a fault. Crossing this, we pass over first the upper part of the Yoredale Rocks, and then the outcrops of the several beds of the Millstone-grit as they rise one by one to the surface along the eastern edge of the Goyt Trough, forming a series of ridges, of which Axe Edge, 1809 feet above the sea, is the highest. We have here perhaps the most perfect of those lesser basins into which the Trough of the Goyt is broken up. Around a little outlier of Coal-measures in the middle, the grit-beds crop out in turn on all sides, and form a series of concentric rings, which, though broken through and shifted here and there by faults, keep upon the whole the most perfect regularity round three sides, at least, of the basin. A detailed map of this little basin, showing the range of each grit-stone, is given in fig. 6, and the section (fig. 5) on p. 256 runs across it.

On the other side of the trough we find the outcrop of the beds from the Rough Rock down to the fourth grit, below which the succession is broken by a fault ranging N.W. and S.E. across the basin.

The country in the angle between this and the Anticlinal Fault is also worth notice. It may be described as a plateau formed of the thick massive bed of the third grit, and cut through by the deep valley of Wild Boar Clough. On this plateau rests a long, narrow ridge, ranging N.N.E., around the flanks of which the second bed crops out; the whole is crowned by the sharp, conical peak of Shutlingslow, rising to a height of about 1700 feet above the sea, and bearing at the top a little outlier of Rough Rock. A slight anticlinal runs along the ridge, the beds on one side dipping to the east at about 10°, and on the other sloping gently towards the opposite quarter.

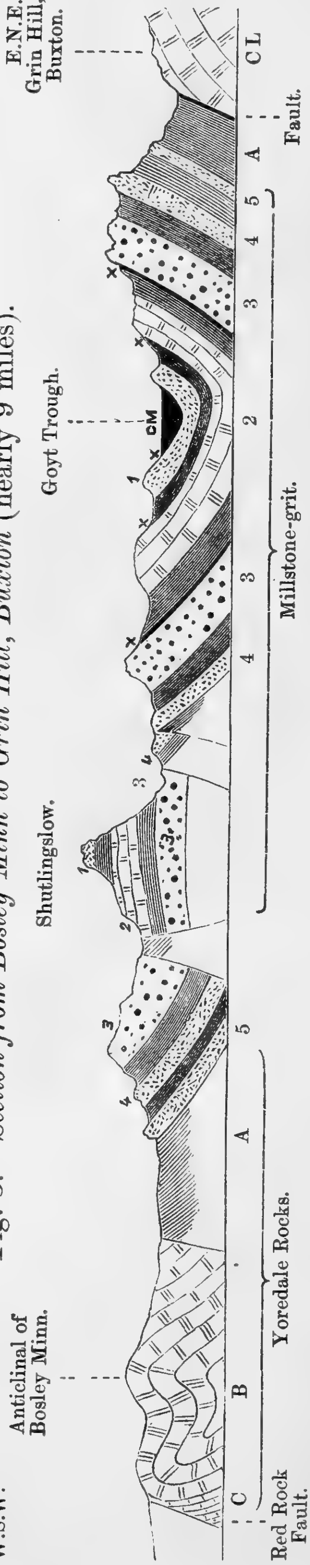
The Shutlingslow district is bounded on the west by the Anticlinal Fault, which brings up some shales and sandstones belonging most likely to the Yoredale group: these are soon cut off by a branch fault, beyond which the three lowest Gritstones again set in. The Third Grit, lying nearly flat, stretches westwards from the fault over a gently rolling moor, and ends in a steeply scarped cliff, below which the ground falls quickly away, and, the dip growing steeper to the westward, the fourth and fifth grits, and the upper part of the Yoredale Rocks, come out to day.

Fig. 4.—*Section across the District South of Whaley Bridge.*



L C. Lower Coal-measures.
1. First Millstone-grit.
c. First Shale series.
2. Second grit.
b. Second Shale series.
3. Third grit.
a. Third Shale series.
4. } Fourth and Fifth grits.
5. }
4′. Yoredale series. { α. Upper Shale. β. Yoredale grit. γ. Lower Shale.

Fig. 5.—*Section from Bosley Minn to Grin Hill, Buxton* (nearly 9 miles).

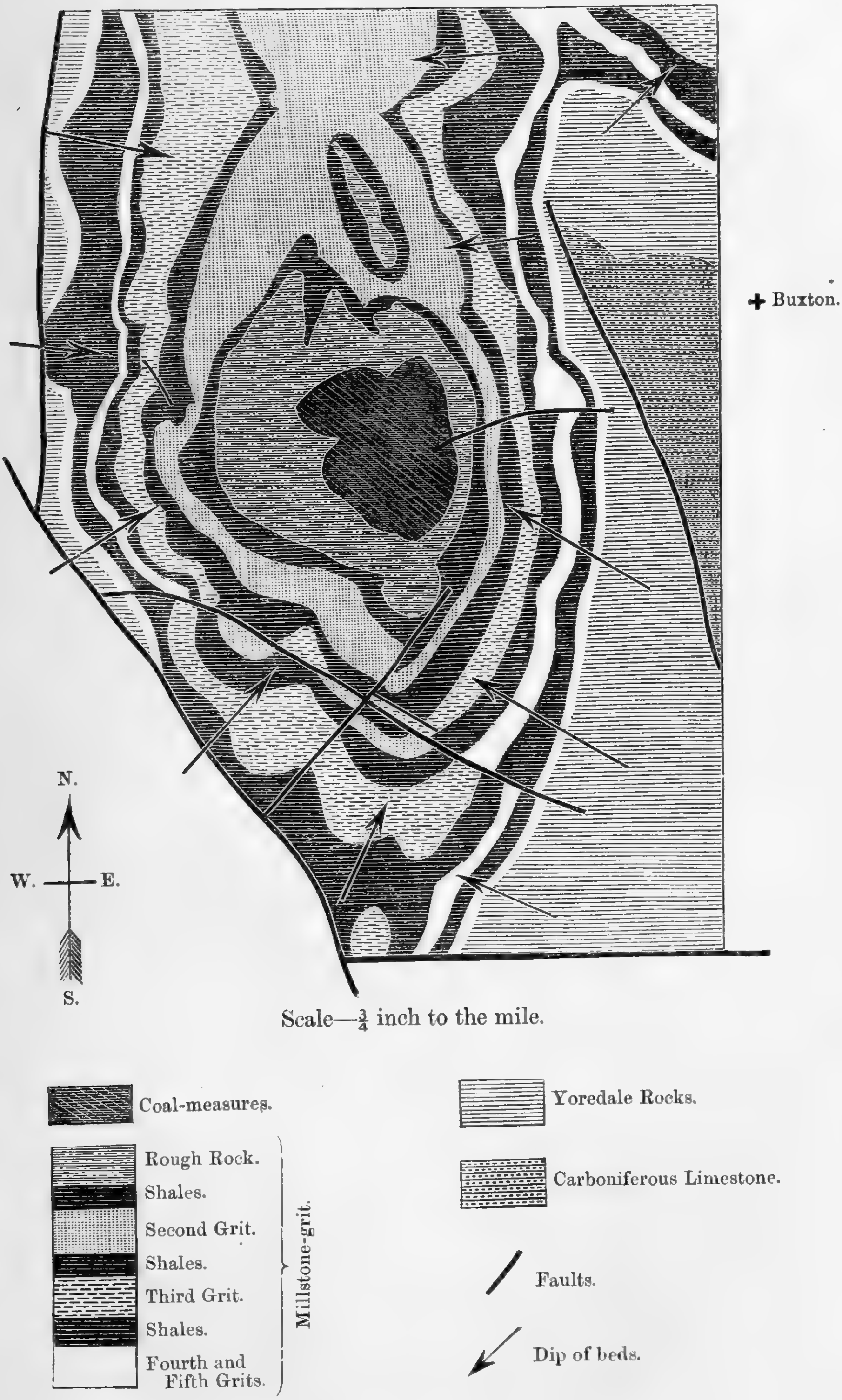


C M. Lower Coal-measures.
1. Rough Rock.
2. Second Grit.
3. Third Grit.
4, 5. Kinder Scout Grit.
} Millstone-grit.

A. Shale and Yoredale Grit.
B. Yoredale Quartzites.
C. Shale and thin limestones.
} Yoredale Rocks.

C L. Carboniferous Limestone.

Fig. 6.—*Detailed Map of a Part of the Goyt Trough, west of Buxton.*



This patch may be looked upon as the continuation of the western half of the Rudyerd Basin, the other half having been cut out by the Anticlinal Fault, which here runs lengthways along the middle of that synclinal.

The structure of the country becomes now for a while somewhat obscure; but a line of fault ranging south from the west side of Kerridge would seem to run somewhere hereabouts.

Between this and the red-rock-fault is a group of rounded hills, known as Bosley Minn, rising to 1000 or 1200 feet above the sea. They are formed of the Yoredale Quartzites, bent into several very sharp folds, and, it may be, broken up by faults. The beds seem, upon the whole, to have been thrown into a number of dome-shaped elevations; but it is all but hopeless to try fully to unravel the intricacies of this very disturbed district.

Petrological details.—On the east of the district the Yoredale Grit is a thick mass of fine, unevenly bedded flagstone, but without the massive form which it bore further to the north.

The Kinder Scout Grit is represented by the beds which we have spoken of as the Fourth and Fifth Grits; the latter is a fine-grained sandstone, thick-bedded and concretionary at Nithen End, near Buxton, and rather more flaggy on the flanks of Axe Edge: the fourth bed, which forms the top of that ridge, is a red, crumbly grit, not very coarse. This part of the series shows, then, as has been already stated, a marked falling off. The other grits, except that they are somewhat thinner, have not undergone any great change: the third is still coarse and massive, and still forms its usual fine escarpments.

The thickness of the Millstone Grit in this neighbourhood is about as follows*:—

Rough Rock	90
Shales	90
Second Grit	140
Shales	260
Third Grit	140
Shales	180
Fourth Grit	140
Shales	100
Fifth Grit	50
Total	1190

A little coal, which is not seen elsewhere, with a hard, Ganister-like floor, lies hereabouts on the top of the Second Grit. The coal lying on the top of the Third Grit has been worked on the west side of the trough, at Dane Thorn Colliery, where it was about 2 feet thick, and is now being worked on the east side at Thatch Marsh Col-

* The thickness of the beds above the fourth grit was proved in a tunnel driven through them near Buxton, for a section of which I am indebted to Mr. Willmot: the thickness of the fourth and fifth grits, and of the shales between, is estimated.—A. H. G.

liery; it there reaches a thickness of about 4 feet 6 in., which it keeps for some way to the south. Upon the Rough Rock lies the Featheredge Coal, reaching a thickness of from 5 to 6 feet, but of poor quality.

On the west side of the Goyt Trough the Fourth and Fifth Grits become still finer and more flaggy, but the three upper beds keep pretty much the same character. The Yoredale Grit seems to have thinned away altogether.

Upon Bosley Minn and the neighbouring hills the Yoredale Quartzites take the form of grey, fine-grained, very hard, quartz-rocks, with a calcareous cement in places. We have already mentioned that these beds elsewhere tend to put on this shape when they have been much contorted.

f. *Between Longnor and Congleton.*—Our next section starts in the valley of the Dove, on the Mountain-limestone, between Longnor and Hartington; crosses an outlier of Millstone-grit on Sheen Hill, and a very broken tract of the Yoredale rocks about five miles in width. It then passes over in turn the Goyt Trough, the Anticlinal Fault, and the Rudyerd Basin, and ends at the northern part of the Biddulph Trough near Congleton (see fig. 7).

Position of Rocks at the surface.—It is likely that the Mountain-limestone, which forms the eastern bank of the Dove, is here again bounded by a fault. On the west side of the valley the ground rises steeply to the summit of Sheen Hill; along the flank of the slope runs the outcrop of a sandstone-bed, which I take to be the Yoredale Grit; the hill itself is formed of the two lowest millstone-grits and the shale between, and is capped by a very small patch of the third bed. The Yoredale beds to the west cover the whole of the country up to the edge of the Goyt Trough. They are much tossed about and broken by faults, but the three groups can be well made out. The Yoredale Grit plays an important part on the east and north-east of Longnor; the Yoredale Quartzites are well shown on Lady Edge and the neighbouring hills; and the bottom shales and limestones will be found in many of the brook-courses along the deeper valleys.

In contrast to this troubled country, the Goyt Trough shows the most perfect regularity; a little coal-field, which has been worked about Goldsitch Moss, nestles in the middle, bounded on the north by a fault, and hemmed in on the east, south, and west by lofty ridges of the grit-rocks, the most noticeable of which is, as usual, that formed by the third bed. It is called The Roaches, and its highest point is about 1700 feet above the sea. To the west of this escarpment, after passing over the outcrops of the lower grit-beds, and the upper part of the Yoredale rocks, which form respectively the lower part of the range and the Meerbrook Valley, we find the Yoredale Quartzites rising gently to the summit of Gun Hill, when they roll over, and plunge steeply down to the west until they abut against the anticlinal fault.

Beyond the anticlinal fault is the Rudyerd Basin, lying between it and another break about a couple of miles to the west.

Fig. 7.—*Section from the Biddulph Trough to the River Dove* (16 miles).

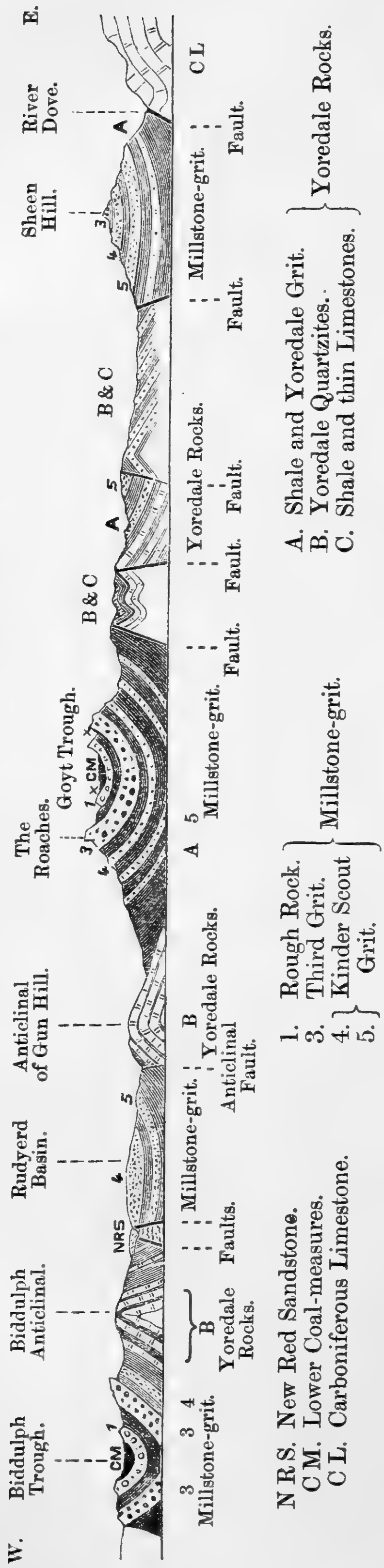
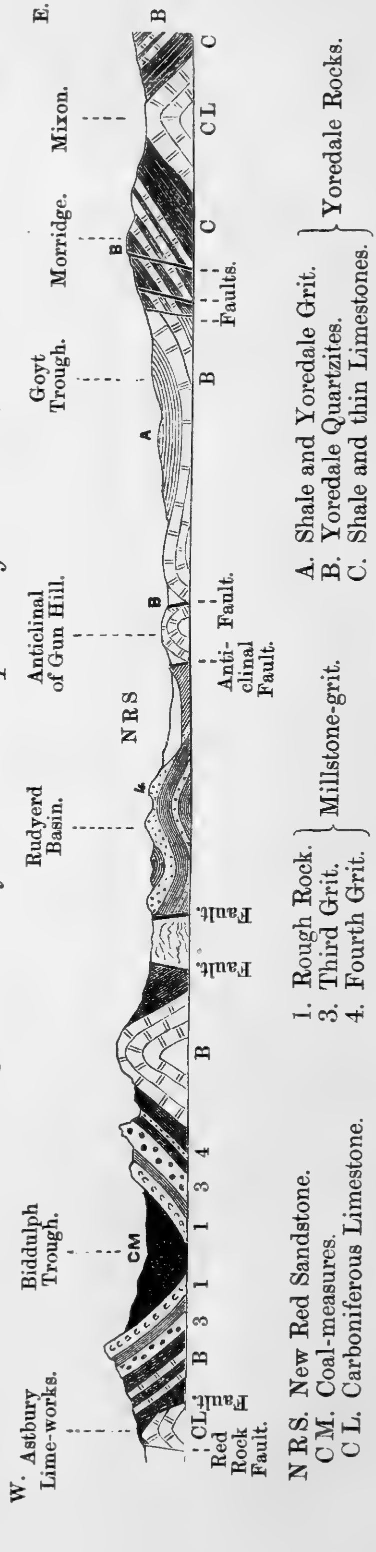


Fig. 8.—*Section from the Biddulph Trough to Mixon.*



Then follows another very sharp saddle formed of the Yoredale Quartzites, and beyond this the Biddulph Trough, containing here the Lower Coal-measures, and bounded by bold ridges of the Millstone-grit. Here again the third grit makes the most marked feature; it forms Cloud Hill, the extreme northerly point of the basin, from the top of which the long lines of its escarpment may be followed by the eye to Mow Cop on the west, and by Knipersley towards Bagnall on the east.

Petrological details. Yoredale Rocks.—We have here first to notice the nature of the Yoredale Quartzites on the sharp anticlinals of Gun Hill and Biddulph Moor. As was the case on Bosley Minn, the sandstones are very hard, close-grained, subcrystalline quartz-rocks. The quarries on Gun Hill show the actual turn of the beds: from their shattered state it is clear that they must have undergone great violence; the surfaces of the beds and a series of vertical joints running parallel to the dip are often marked by "slickenside," showing that in some cases a bed must have slipped upon the one immediately below it. On the Biddulph Anticlinal the rise of the beds is very sharp on either side: they have in places been reversed, so as to dip into the hill. In both these cases, then, we again find a subcrystalline structure in the rock, accompanied by signs of violent disturbance. The Yoredale Grit, as has been already mentioned, is found in force about Longnor: on the west side of the Goyt Trough it is present, but has become much thinner; while it is altogether wanting round the edges of the Biddulph Trough.

Millstone Grit.—A complete section of this series is given on either side of the Goyt Trough, and to this we will for the present confine our attention, leaving the grits of the Biddulph Trough to be taken in hand by-and-by.

The fifth or lowest bed is somewhat changeable in its character, but occurs mostly as a fine-grained sandstone, not very thick-bedded, with shale-partings.

The fourth is largely quarried beneath The Roaches: it is there a close-grained, thick-bedded grit, and it makes a good escarpment; but, like the fifth, it seems to be very changeable in its nature. Upon the whole, these beds are perhaps slightly thinner than at Buxton.

The third bed is still coarse and massive, often a conglomerate, of about the same thickness as at Buxton. The little coal lying on the top of the bed has been worked in one place.

It will be seen from the section (fig. 7) that the second bed is wanting. It may be followed southwards along the western edge of the Goyt Trough, without any sensible decrease in thickness, to the little hamlet of Hallgreave; it is there cut through by one of the feeders of the River Dane, and consists of 100 feet or more of flaggy sandstone. Our next section of this bed is about two miles to the east, in the River Dane at Gradbatch, where, about halfway between the Rough Rock and the third grit, we find about 30 or 40 feet of thin-bedded flags much mixed up with shale. This is the last certain trace we have of the second grit, though for some miles further south a few feet of flagstone and sandy shale are found on the horizon of this bed.

The Rough Rock calls for no particular notice: it is the usual coarse, crumbly gritstone, of about the same thickness as at Buxton.

The Coal-measures of the Goldsitch Basin contain the following series of coals:—

	ft.	in.		ft.	in.
Coal,—Silver-seam	1	4	to	1	6
Measures	60	0			
Coal,—Thin seam	1	4	,,	1	6
Measures	40	0			
Coal,—Thick seam	2	0	,,	2	3
Measures	60	0			
Coal,—Cannel	0	6	,,	2	0
Measures	10	0			
Coal,—Bassy (bad)	4	0	,,	6	0
Sandstone (Woodhead Hill Rock)	50	0			
Measures	250	0			
Coal,—Thick or Big seam	4	0	,,	6	0
Rough Rock.					

Of these, the first four represent most likely the Gannister and its companions in Lancashire, while the Big Seam is the Featheredge coal. The thicknesses are not to be depended on; they are given from the accounts of old colliers.

g. *The Biddulph and Rudyerd Basins.*—We will next take in hand, and compare with the normal section, the grits on each side of the Biddulph Trough, and in the Rudyerd Basin.

Position of Rocks at the surface.—The section (fig. 8) has been drawn across these basins, and shows also the position of the patches of Mountain Limestone which come to light at Astbury and Mixon. The line of this section lies about three miles to the south of that last described; it has the same geological features, and crosses nearly the same series of beds, except that in the Goyt Trough we have nothing higher than Yoredale Rocks.

Petrological details. The Grits of the Rudyerd Basin.—The banks of the pretty reservoir of Rudyerd are formed of the fourth bed. The rock is in character very like that quarried under The Roaches: a hard, close-grained, red grit, rather massive; it would seem, too, for a while to increase in thickness, but it soon dwindles down again; and though it may be followed along the eastern outcrop almost as far south as Cheddleton, no traces of it are to be found beyond that village. On the west side of the basin it is cut off by a fault, up to which it keeps a good thickness, but beyond which it is never seen again. The fifth runs in the shape of a fine flaggy sandstone on either side of the basin, and seems to thin away at last beneath the outliers of New Red Sandstone at Rushton, and north of Leek. Here, then, we have reached a point at which the thick massive Kinder Scout Grit, after having passed into a less striking gritstone, and then into a fine sandstone, at last dies out altogether.

The Third Grit occurs in this basin only in outliers; it is often very coarse and massive, but in places has already become a soft red sandstone.

Passing westward to the grits of the Biddulph Trough, we find there only a few very doubtful traces of the fifth bed. The fourth is quarried under Cloud Hill, where it has much the same character as at Rudyerd, but is not so thick. Hence it may be traced southwards for about three miles to Biddulph Moor, where it is seen in a brook-section to have become very flaggy. It must soon after this thin away altogether; for about ten miles further on we again get a good section across the valley below the escarpment of the Third Grit, and there nothing but shale is found between that rock and the Yoredale Quartzites of the Biddulph Anticlinal. Here again, then, we have reached a point on the southerly limit of the Kinder Scout Grit.

The third and first beds form bold and well-marked ridges on either side of the Biddulph Trough. They are both coarse, massive gritstones; but it is worth notice that in places they have exchanged characters, the third being crumbly and suitable for grinding down into sand, while the first is close-grained, and is used as a building-stone. The little coal lying on the top of the third grit has been worked on Congleton Edge. The thickness of the two grits, and of the shales between, is probably altogether not more than 300 feet; so that the Millstone-grit has here dwindled down to less than one-fourth of the thickness it has in Lancashire.

Yoredale Rocks.—The whole of this series is twice brought to the surface along the line of section we are now describing at Mixon, on the eastern side of the Goyt Trough, and at Astbury, on the west of the Biddulph Trough. The first section shows—

1.	Shales and a thick sandstone-bed	(A ?)
2.	Shale....................................	B.
3.	Coarse quartzose conglomerate...............	B.
4.	Shales	B.
5.	Hard close-grained quartzose flagstones and shales	B.
6.	Black shales with thin earthy limestones	C.

The sandstone-bed in No. 1 may be the Yoredale Grit of our general section, but its outcrop is so broken by faults, and so hidden by drift, that it cannot be traced up to the outcrop of that bed to the north.

The conglomerate (3) is found at the western foot of the long range of Morridge, and comes out again on Sharpcliff, about a couple of miles to the S.W.; it is most likely only of local occurrence. Nos. 4 and 5 form the greater part of the Morridge range, and would seem to be of great thickness; but this is probably due to their being repeated, once or oftener, by faults. Some of the lower beds of this group are sandstones with a calcareous cement, full of broken shells, and form a link between the sandstones above and the limestones of the group below. The latter are well seen on each side of the Mixon Carboniferous Limestone.

At Astbury we have, below the outcrop of the third grit on the west of the Biddulph Trough—

1. Shales	B.
2. Thin-bedded, hard, quartzose sandstones and shales.	
Upcast fault:—	
3. Sandstone and shale	
4. Black shales and thin earthy limestones	C.
5. Carboniferous Limestone.	

We have nothing that we can safely say belongs to the upper group, and certainly no trace of the Yoredale Grit; that bed has, therefore, either thinned out, or passed into a quartzose sandstone like those of the middle division. We find in No. 1 some thin coals, a thick bed of Gannister, and limestone-nodules with many fossils, all three being most likely local.

The beds in No. 2 have all the character of the Yoredale Quartzites.

At the bottom of No. 3 lies a little cannel coal, about a foot in thickness.

The series altogether is perhaps not less than 2000 feet thick.

The Yoredale Quartzites of Gun Hill and the Biddulph Anticlinal have been already described.

h. *The Pottery, Wetley, and Cheadle Coal-fields.*—We have now reached the southern limit of the country under consideration, where the Carboniferous rocks begin to be covered up by the New Red Sandstone of the central plain of England; and the section below (fig. 9) is the last to which we shall have to call attention.

Position of Rocks at the surface.—This section starts on the eastern edge of the Pottery Coal-field, shows the outcrop of the two beds, which are now all that is left of the Millstone-grit, and then crosses an anticlinal of Yoredale Rocks, beyond which lies the little Coal-field of Wetley, the southern end of the Rudyerd Basin. This basin is here bounded on the east by a fault, which we take to be the continuation of the Anticlinal Fault; beyond this the beds roll over, and form the gentle synclinal of the Cheadle Coal-field, which, lying as it does on the line of the axis of the Goyt Trough, may well be looked upon as one of the lesser basins of that great hollow.

Petrological details. Millstone-grit.—We have seen that in the district last described the Millstone-grit had come down to two beds only, the first and the third; these run on over the whole of the present district, but no longer with that marked character and bold look which made it so easy to recognize and trace them further to the north. They have become changeable, and upon the whole much finer, softer, and less striking; here and there, however, they seem for a time to recover their coarse and massive nature, and this is especially the case with the Third Grit, which still at times shows fine escarpments, as in the defile cut through it between Cotton and Oakamoor, round the village of Foxt, and about a mile west of Ipstones. These, however, are exceptions, not the rule.

At the south-west corner of the Cheadle Coal-field the third bed, if not actually gone, has so fallen off in thickness that we may look upon it as on the point of thinning away altogether. Unluckily the country is much covered up by drift, but at the last point where the

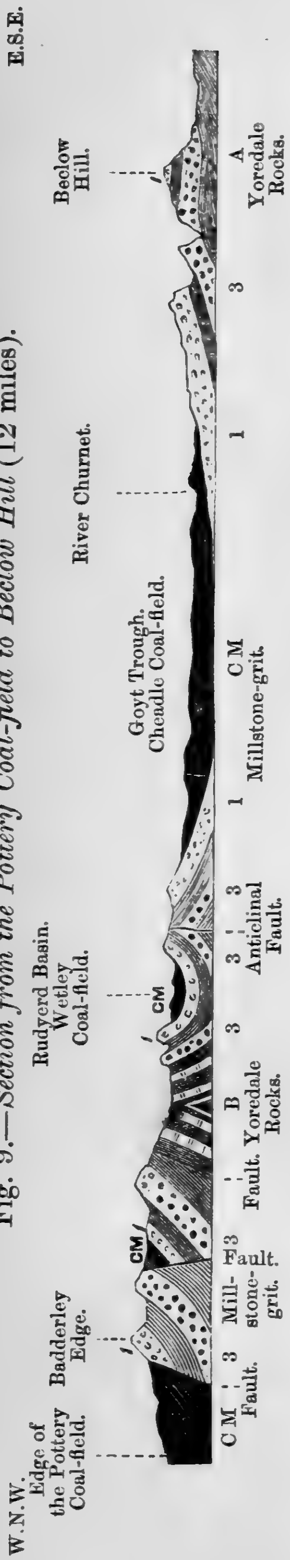


Fig. 9.—*Section from the Pottery Coal-field to Beclow Hill* (12 miles).

C M. Coal-measures.
1. Rough Rock. } Millstone-grit.
3. Third Grit. }
A. Shale and Yoredale Grit. } Yoredale Rocks.
B. Yoredale Quartzites. }

third bed was seen, it did not seem to be above 20 feet in thickness. The little coal on the top of this bed has been worked about half a mile to the east of Froghall.

Yoredale Rocks.—In the anticlinal space between the Pottery and Wetley Coal-fields no trace of the upper group is to be found. Close below the outcrop of the third grit come quartzose sandstones, with all the usual characters of the Yoredale Quartzites.

In this country, where the gritstones have become so thin and weakly, while the chief sandstones of the Yoredale series still keep up their thickness and character, a curious change has been brought about in the connexion between scenery and geological structure. In the northern districts, about The Peak for instance, it is the Millstone-grit that caps the loftiest hills and forms the boldest ridges, while the Yoredale Grits hold a lower place; here, on the other hand, the Millstone-grit makes but little show, and the Yoredale sandstones stand out well, and form all the most marked features in the landscape.

§ 6. *Summary.*

We have now traced the Millstone-grit from the borders of Lancashire and Yorkshire, where it contains five* thick beds of massive gritstone, and reaches a thickness of 2800 feet, to the borders of the North Staffordshire Coal-fields, where only two of these beds are left, and where the whole thickness is not more than 200 or 300 feet.

We find the Rough Rock (the uppermost bed, with one exception)

* The Kinder Scout Grit has at least *two* thick gritstones, with shale between.

present everywhere, and keeping pretty much the same thickness throughout, but losing altogether its coarseness and massive character in the south.

The Haslingden flags, the second bed, maintain their thickness and character unchanged, until they thin away somewhat suddenly, about five miles south-west of Buxton.

The Third Grit runs through the whole of the district; but from a thickness of more than 400 feet, which it reaches in Lancashire, it lessens down to about 100 in the neighbourhood of Congleton, and still further south seems to be on the point of dying out altogether. Though this bed becomes, without doubt, finer to the south, it keeps more than any other a certain massiveness of structure to the last.

The little coal on the top of the Third Grit is one of the most persistent beds in the series. Seldom reaching more than a foot in thickness, it is found here and there over the whole country.

The passage of the fourth or Kinder Scout rock from an enormous mass of gritstone and conglomerate, a thousand feet thick, into two beds of finer gritstone with a shale between, north of Buxton, has been pointed out, as also the further change which the latter undergo into still finer sandstones, and their total disappearance in the Biddulph and Rudyerd basins.

These general results are embodied in the set of vertical sections given in fig. 10.

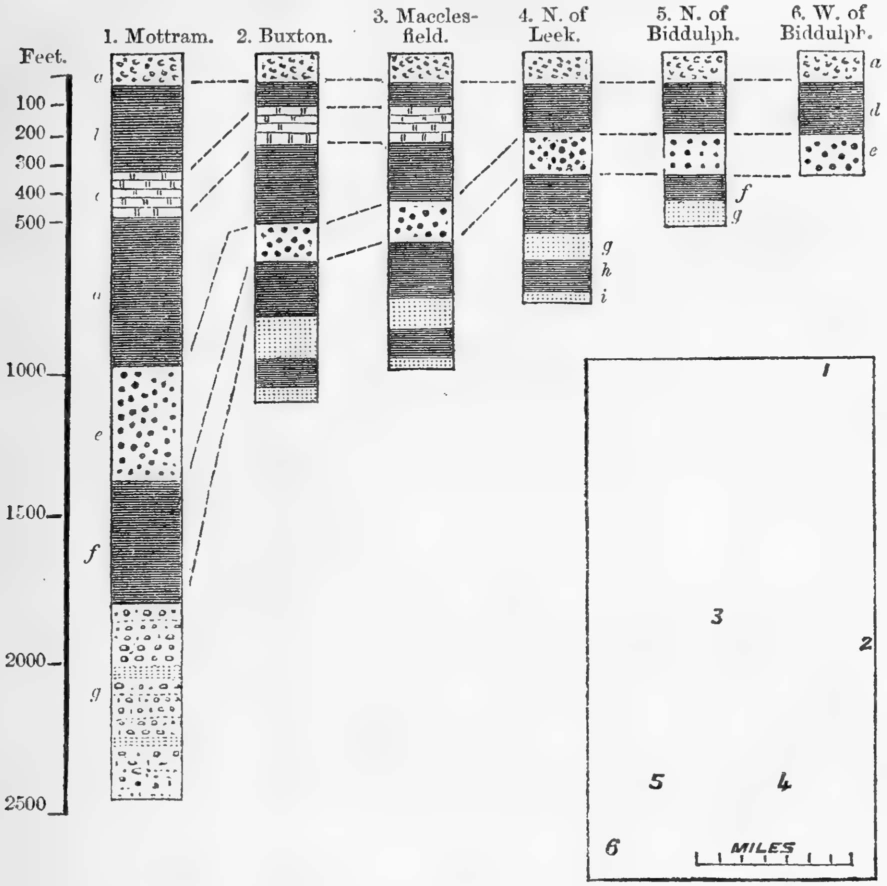
It is well known that the Millstone-grit is wanting in the South Staffordshire Coal-field *, and is only feebly represented in Leicestershire; a still further thinning away of the series must therefore take place, below the New Red Sandstone, between these places and the country under notice.

One other point calls for notice. On the top of each of the gritstone-beds there are traces, more or less distinct, of coal: the Featheredge coal on the Rough Rock, the little coal found near Buxton on the Second Grit, the coal just mentioned on the top of the Third, and the very thin seams of coal which, accompanied by Gannister or Gannister-like rock, often lie on the top of the Kinder Scout Grit in Lancashire. The rough thick-bedded grits, and the finely laminated shales that lie between them, must, of course, have been deposited under very different circumstances, and these coal-beds seem to point out that in the intervals during which the changes were being brought about, each grit-bed became in turn, for a time, almost a land-surface.

In the Yoredale series we have seen that the upper group dies away altogether. The Quartzites must also partake in the general thinning out, for they are wanting, most likely, in Leicestershire, and certainly in South Staffordshire; but in the just described country they do not show any very marked falling off. The lowest group is also wanting in South Staffordshire, and is only 30 or 40 feet

* This may, however, be due to the fact that that part of England was dry land at the early part of the Carboniferous period: see Hull, 'Coal-fields of Great Britain;' Jukes, 'On the South-Staffordshire Coal-field,' Memoirs of the Geological Survey of Great Britain.

Fig. 10.—*Comparative Sections of the Millstone-grit.*



Plan to show the position of the Sections.

a. Rough Rock.
b. Shales.
c. Second Grit.
d. Shales.
e. Third Grit.
f. Shales.

Fig. 1.

g. Kinder Scout Grit.

Figs. 2–6.

g. Fourth Grit.
h. Shales.
i. Fifth Grit.
} Equivalents of the Kinder Scout Grit.

thick in Leicestershire; but it is too sparingly shown in the district under consideration to allow of its change of thickness being traced with any certainty.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

EXPERIMENTAL RESEARCHES *on the* GRANITES *of* IRELAND. PART IV. *On the* GRANITES *and* SYENITES *of* DONEGAL; *with some Remarks on those of* SCOTLAND *and* SWEDEN. By the Rev. SAMUEL HAUGHTON, M.D., F.R.S., Fellow of Trinity College, and Professor of Geology in the University of Dublin.

[Read December 16, 1863.*]

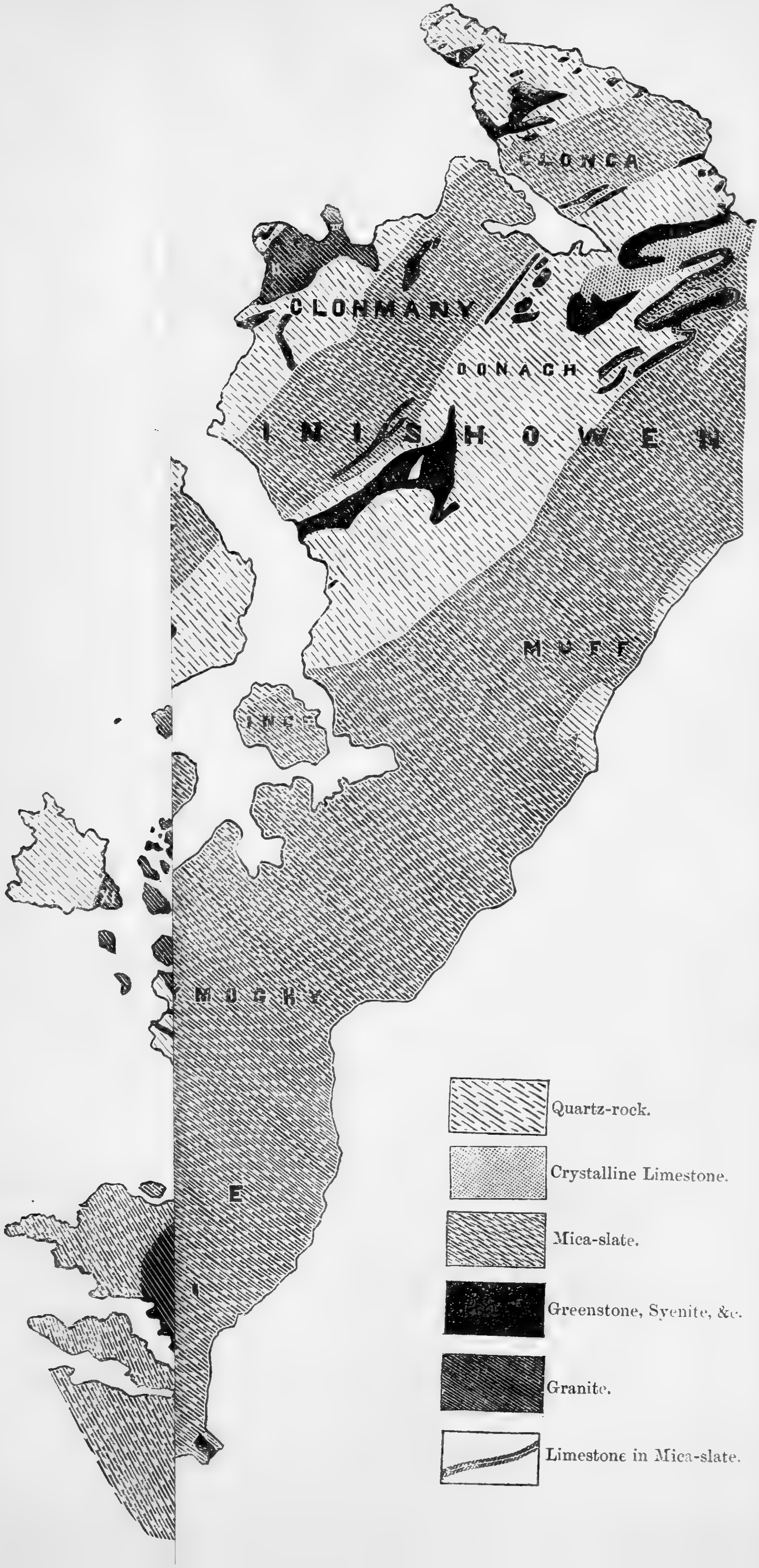
CONTENTS.

§ I. *Mineralogical Composition of the Donegal Granites.*

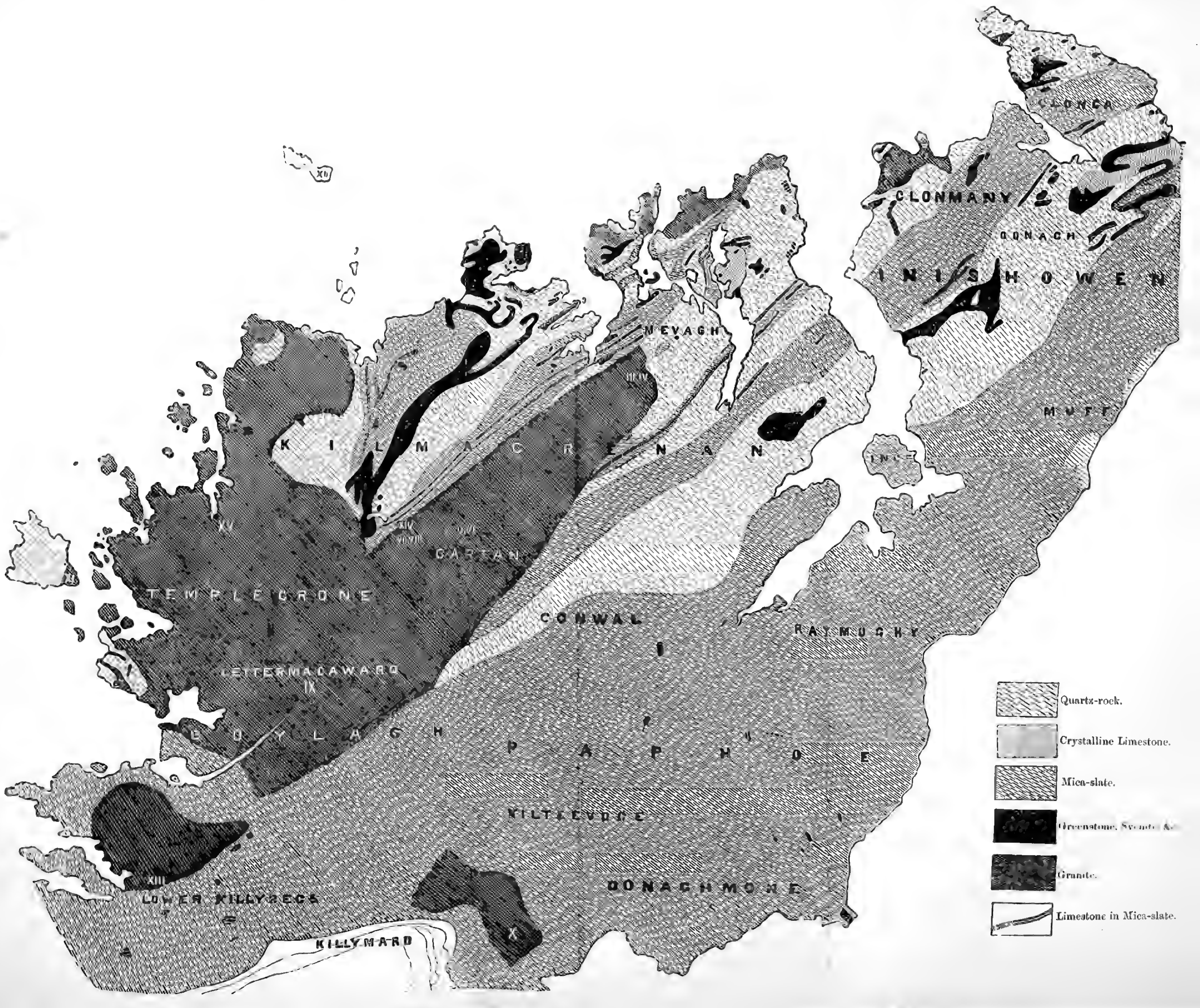
IN Part III. of these researches† I gave the analyses of fifteen Donegal granites, and an account of their constituent minerals, so far as I am acquainted with them; and at the close of the paper I endeavoured to calculate the mineral composition of the Doocharry Bridge granite, on the hypothesis that it is composed of the four minerals observed to occur in many of the Donegal granites, namely, 1, Quartz; 2, Orthoclase; 3, Oligoclase; 4, Black Mica. I now propose to discuss in detail the mineralogical composition of each of these fifteen granites, and in so doing to bring under the notice of the Society the method which I usually employ in the investigation of such problems; and from the results of this method of

* For the other communications read at this Evening-meeting, see p. 116.
† Quart. Journ. Geol. Soc. vol. xviii. p. 403.

[Q. J. G. S. vol. xx. To face p. 268.



Geological Sketch-map of Co. Donegal to illustrate the Paper on the Granites of Ireland by the Rev. Prof. Haughton.



investigation, I hope to be able to show that the mineralogical composition of a granite is a problem of much greater difficulty than is commonly supposed, and that the number of minerals entering into its composition is greater than that visible to the eye, or to be detected by physical characters.

In order to save the trouble of reference to my former paper, I here reproduce the Tables containing the chemical composition of the granites and of their four supposed constituents, together with the table containing the oxygen-proportions of those constituent minerals.

TABLE I.

Chemical Composition of Donegal Granites (Table IV. *loc. cit.*).

No.	Silica.	Alumina.	Iron, peroxide.	Iron, protoxide.	Lime.	Magnesia.	Soda.	Potash.	Manganese, protoxide.	Water.	Total.
I. Ardmalin	70·00	16·36	2·80	0·08	1·12	0·71	4·13	4·66	...	...	99·86
II. Urrismenagh	65·80	12·80	6·64	0·18	2·92	1·78	4·16	4·40	...	1·20	99·88
III. Glen	68·96	17·40	2·52	...	2·80	0·41	3·03	5·25	...	...	100·37
IV. Glen	58·44	20·00	6·44	2·05	4·72	1·57	3·81	2·82	...	...	99·85
V. Glenveagh	69·36	16·00	3·03	0·30	2·29	0·54	4·17	4·47	...	...	100·16
VI. Glenveagh	68·00	16·80	3·68	0·65	4·05	0·95	4·32	2·04	...	...	100·49
VII. Poison Glen	68·20	15·96	3·69	1·00	2·92	0·78	3·75	4·14	...	...	100·44
VIII. Poison Glen	70·64	15·64	2·64	...	2·47	0·15	3·81	4·53	...	...	99·88
IX. Doocharry Bridge	72·24	14·92	1·63	0·23	1·68	0·36	3·51	5·10	0·32	...	99·99
X. Barnesmore	73·60	13·80	2·00	...	0·79	0·50	4·29	5·22	...	...	100·20
XI. Arranmore	68·80	16·40	2·60	0·65	1·75	0·85	3·78	5·31	...	...	100·14
XII. Tory Island	69·20	16·40	2·09	1·00	1·03	0·85	4·20	5·22	...	...	99·99
XIII. Ardara...............	55·20	19·28	6·08	0·46	5·08	3·66	4·63	3·17	0·96	0·64	99·16
XIV. Dunlewy	75·24	13·36	0·60	...	2·25	0·14	4·86	3·27	...	...	99·72
XV. Annagary	73·04	15·20	...	...	1·60	0·07	2·88	7·32	...	...	100·11

TABLE II.—*Mean Composition of the Constituent Minerals of the Granite of Donegal* (Table X. *loc. cit.*).

	Quartz.	Orthoclase.	Oligoclase.	Black Mica.
Silica	100·00	63·20	59·92	36·18
Alumina	....	18·64	23·68	17·68
Iron (peroxide)	....	0·68	1·17	26·75
Iron (protoxide)	....	....	0·05	0·63
Protoxide of Manganese......	....	....	0·16	0·95
Lime..............................	....	2·75	5·30	0·54
Magnesia........................	....	0·11	0·13	4·65
Soda..............................	....	0·78	6·47	0·32
Potash	....	14·92	2·07	8·83
Water	....	....	....	3·15
Totals	100·00	101·08	98·95	99·68

TABLE III.—*Oxygen-proportions of the Constituent Minerals of the Granite of Donegal* (Table XI. *loc. cit.*).

	Quartz.	Orthoclase.	Oligoclase.	Black Mica.
Silica	51·92	32·81	31·11	18·78
Peroxides	....	8·91	11·41	16·28
Protoxides	....	3·55	3·61	3·94
Totals	51·92	45·27	46·13	39·00

The problem to be solved with respect to the foregoing fifteen granites may be thus stated:—"Given the chemical analysis of a compound rock, and the chemical analyses of its supposed constituent minerals, it is required to find its mineralogical composition expressed in terms of those minerals." At first sight nothing is easier than the mathematical statement of this problem; for each component of the rock-analysis gives us an equation of condition, which is linear, and the whole problem is reduced to the solution of a number of simultaneous linear equations.

In practice, however, the number of equations thus furnished is generally greater than the number of minerals, and the supernumerary equations may be regarded as test-equations, and used to ascertain whether our hypothesis as to the constituent minerals be physically correct or not.

Let us consider this question somewhat in detail as to the Donegal granites.

The hypothesis I make respecting them is, that they are composed of *four* minerals, whose chemical composition is contained in Table II. The equations at my disposal are *seven* in number, derived from the following components:—Silica, Alumina, Iron and Manganese, Lime, Magnesia, Soda, Potash.

It is therefore evident that I have *three* supernumerary equations, which may be used as tests of the accuracy of the fundamental hypothesis, when the mineral composition of the granite has been deduced from any *four* of the seven equations at my disposal. Of the seven equations, those deduced from silica and alumina are the most trustworthy, because they deal with the largest quantities, and because these elements enter into the composition of the constituent minerals in a more precise and definite manner than the protoxide bases.

In addition to the seven equations derived from the components of the rock, there is an *eighth*, which expresses the self-evident fact that the whole rock is equal in weight to the weights of all its constituent minerals; so that we have in reality *eight* equations to determine *four* supposed unknown quantities.

Instead, however, of employing these equations, I prefer, in the first instance, to use three equations derived from the oxygen-ratios of the silica, the peroxides, and the protoxides, together with the equation depending on weights—a method which will give me four reliable equations to find four unknown quantities; and when these are found, the remaining equations may be used to check and test the original hypothesis in a manner which shall be fully explained in the course of the discussion.

Let u, x, y, z denote the per-centage composition of the rock in terms of the four given minerals, of which one (u) is supposed to be quartz. Let the rock be analyzed, and let A_1, B, C denote the per-centage of oxygen present in the rock as silica, as peroxide, and as protoxide; and let a_1, b, c denote the per-centage of oxygen present, as silica, peroxide, and protoxide, in the mineral x; a_1', b', c', that in the mineral y; and a_1'', b'', c'', that in the mineral z; and let q denote the per-centage of oxygen in quartz. We find immediately the following equations:—

$$\left.\begin{aligned} 100\,A_1 &= qu + a_1 x + a_1' y + a_1'' z \\ 100\,B &= \qquad bx + b'y + b''z \\ 100\,C &= \qquad cx + c'y + c''z \end{aligned}\right\} \quad \ldots\ldots \quad (1)$$

$$100 = u + x + y + z.$$

Eliminating u from these equations, and replacing $A_1 - q$ by A, $a_1 - q$ by a, $a_1' - q$ by a', and $a_1'' - q$ by a'', we obtain

$$\left.\begin{aligned} 100\,A &= ax + a'y + a''z \\ 100\,B &= bx + b'y + b''z \\ 100\,C &= cx + c'y + c''z \end{aligned}\right\} \quad \ldots\ldots \quad (2)$$

The granite of Donegal is composed, as I have already shown, of four minerals, namely, Quartz, Orthoclase, Oligoclase, and Black Mica. In order to make use of the preceding equations, we must fix precisely the values of a, b, c; a', b', c'; a'', b'', c'', by means of the chemical composition of the constituent minerals, while the values of A, B, C depend on the analysis of each individual granite-specimen. This is done by means of Table III., from which we find the following:—

$q = 51·92$	$a_1 = 32·81$	$b = 8·91$	$c = 3·55$
	$a_1' = 31·11$	$b' = 11·41$	$c' = 3·61$
	$a_1'' = 18·78$	$c'' = 16·28$	$c'' = 3·94$

from which we obtain also

$$a = -19·11$$
$$a' = -20·81$$
$$a'' = -33·14$$

and, finally, equations (2) become, on banishing the decimals,

$$\left.\begin{aligned} 519200 - 10000A_1 &= 1911x + 2081y + 3314z \\ 10000B &= 891x + 1141y + 1628z \\ 10000C &= 355x + 361y + 394z \end{aligned}\right\} \quad \ldots \quad (3)$$

The solution of equations (2) or (3) is effected by finding nine multipliers, thus defined:—

$$\begin{array}{lll} \alpha = b'c'' - b''c' & \beta = c'a'' - c''a' & \gamma = a'b'' - a''b' \\ \alpha' = b''c - bc'' & \beta' = c''a - ca'' & \gamma' = a''b - ab'' \\ \alpha'' = bc' - b'c & \beta'' = ca' - c'a & \gamma'' = ab' - a'b \end{array}$$

If κ denote the quantity,

$$a\alpha+b\beta+c\gamma=a'\alpha'+b'\beta'+c'\gamma'=a''\alpha''+b''\beta''+c''\gamma'',$$

then x, y, z are given by the following equations :—

$$\left.\begin{aligned} x&=\frac{10000(A\alpha+B\beta+C\gamma)}{\kappa} \\ y&=\frac{10000(A\alpha'+B\beta'+C\gamma')}{\kappa} \\ z&=\frac{10000(A\alpha''+B\beta''+C\gamma'')}{\kappa} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (4)$$

The constants of the system of equations (3) are found, by actual multiplication, to be,

$$\begin{array}{lll} \alpha = 69077 & \beta = -188220 & \gamma = 196703 \\ \alpha' = -113443 & \beta' = 211768 & \gamma' = 79167 \\ \alpha'' = 41702 & \beta'' = -24442 & \gamma'' = -163140 \end{array}$$

$$\kappa=34131692.$$

In the calculation of the values of x, y, z, it will be found more useful to use logarithms, for which reason I here give the logarithmic values of the ten constants of the Donegal granites :—

$$\begin{array}{lll} \log(\alpha) = 4{\cdot}8393335 & \log(\beta) = 5{\cdot}2746658 & \log(\gamma) = 5{\cdot}2938110 \\ \log(\alpha') = 5{\cdot}0547777 & \log(\beta') = 5{\cdot}3258604 & \log(\gamma') = 4{\cdot}8985442 \\ \log(\alpha'') = 4{\cdot}6201569 & \log(\beta'') = 4{\cdot}3881367 & \log(\gamma'') = 5{\cdot}2125605 \end{array}$$

$$\log(\kappa) = 7{\cdot}5331578576.$$

In order to apply these multipliers to the analyses recorded in Table I., we must first calculate the quantities of oxygen present in each constituent of the analyses. This has been done, and the results are recorded in the following Table :—

Table IV.—*Oxygen in Constituents of Donegal Granites.*

No.	Silica.	Alumina.	Iron, peroxide.	Iron, protoxide; and Manganese.	Lime.	Magnesia.	Soda.	Potash.	Total Oxygen.
I.	36·346	7·646	0·838	0·017	0·317	0·282	1·289	0·789	47·524
II.	34·164	5·981	1·988	0·039	0·828	0·609	1·297	0·745	45·651
III.	35·804	8·132	0·753	......	0·795	0·162	0·776	0·889	47·311
IV.	30·341	9·348	1·928	0·454	1·341	0·625	0·976	0·477	45·490
V.	36·032	7·478	0·907	0·066	0·649	0·214	1·068	0·756	47·170
VI.	35·306	7·851	1·101	0·144	1·151	0·378	1·107	0·345	47·383
VII.	35·409	7·459	1·104	0·221	0·828	0·310	0·960	0·700	46·991
VIII.	36·677	7·309	0·789	......	0·700	0·058	0·976	0·767	47·276
IX.	37·507	6·967	0·486	0·121	0·484	0·142	0·899	0·864	47·470
X.	38·214	6·449	0·778	......	0·224	0·199	1·079	0·884	47·827
XI.	35·721	7·664	0·599	0·202	0·497	0·338	0·788	0·894	46·703
XII.	35·929	7·664	0·625	0·221	0·292	0·338	1·077	0·884	47·030
XIII.	28·660	9·010	1·821	0·313	1·443	1·461	1·186	0·536	44·430
XIV.	39·065	7·244	0·179	......	0·638	0·054	1·246	0·553	48·979
XV.	37·923	7·104	......	......	0·454	0·027	0·738	1·240	47·486

From the preceding Table the following is deduced :—

TABLE V.—*Oxygen contained in Silica, Peroxides, and Protoxides in the Donegal Granites.*

No.	Oxygen contained in Silica.	Oxygen contained in Peroxides.	Oxygen contained in Protoxides.	$51 \cdot 92 - A_1$
	A_1	B	C	A
I.	36·35	8·48	2·69	15·57
II.	34·16	7·97	3·52	17·76
III.	35·80	8·88	2·62	16·12
IV.	30·34	11·27	3·87	21·58
V.	36·03	8·38	2·75	15·89
VI.	35·31	8·95	3·12	16·61
VII.	35·41	8·56	3·02	16·51
VIII.	36·68	8·10	2·50	15·24
IX.	37·51	7·45	2·51	14·41
X.	38·21	7·22	2·38	13·71
XI.	35·72	8·26	2·72	16·20
XII.	35·93	8·29	2·81	15·99
XIII.	28·66	10·83	4·94	23·26
XIV.	39·06	7·42	2·49	12·86
XV.	37·92	7·10	2·46	14·00

If we now introduce the values of A, B, C, contained in Table V., into equations (4), we obtain, finally,

TABLE VI.—*Calculated Mineralogical Composition of the Granites of Donegal.*

No.	Orthoclase, $=x$.	Oligoclase, $=y$.	Mica, $=z$.	Quartz, $=u$.
I.*	2·51	71·03	0·93	25·39
II.	122·87	−14·15	− 8·33	− 0·51
III.	− 12·45	75·95	8·13	28·74
IV.	38·28	71·75	− 2·01	− 8·17
V.*	17·98	55·58	2·69	23·91
VI.	22·41	75·60	−10·28	12·76
VII.	36·13	52·38	− 3·92	15·85
VIII.*	5·83	54·02	8·70	31·33
IX.*	25·45	41·50	2·74	30·30
X.*	16·48	46·31	2·05	35·36
XI.*	29·12	37·02	8·77	25·08
XII.*	29·45	48·07	1·69	20·78
XIII.	158·22	12·83	−29·48	−42·41
XIV.	− 5·41	90·69	−15·02	29·46
XV.*	33·58	32·25	2·63	31·65

Of the fifteen granites examined, eight, which are thus marked (*), give positive values for u, x, y, z; and seven have some one or more of these quantities negative; hence it follows that seven-fifteenths of the granites, or $46\frac{2}{3}$ per cent., are certainly not composed of quartz, orthoclase, oligoclase, and black mica.

An important question, however, remains to be determined; namely, whether the remaining eight granites, amounting to $53\frac{1}{3}$ per cent. of the whole, are really composed of these four minerals or not.

It has been demonstrated, mathematically, that they might be formed of four such minerals, having the oxygen-ratios of these minerals as they are found crystallizing out from the mass of the Donegal granites. But is the rock really made up of only four minerals or not? It is the opinion of many skilful mineralogists, that the composition of the crystals which may be picked out of a granite or other crystalline rock may differ essentially from the composition of the same mineral when it enters into the constitution of the general rock-mass; and it is certainly not to be assumed as self-evident that a rock is composed of those minerals, and of those only, which may be seen in separate crystals, and analyzed as such.

To solve this interesting problem in the case of the Donegal granites, we must call to our aid the auxiliary equations not yet used, depending on iron, lime, soda, potash, &c., which have been grouped together hitherto, by us, in the equation containing the oxygen of the protoxides.

In fact, before we can say that the granites are really made of the four minerals whose composition is given in Table II., we must be certain that the equations of condition furnished by each constituent are all fulfilled, as well as those furnished by the oxygen-ratios. These equations of condition are the necessary supplement of the preceding analysis, which has only proved that certain granites might be made of certain minerals with given mineralogical formulæ; but which has not proved that they might be made of certain minerals of given chemical compositions.

The method of using these test-equations will be readily understood from the following discussion:—

Granite No. I.

This granite might be formed of four minerals having the same oxygen-ratios as the minerals of Table II., but it cannot be formed of minerals having the chemical composition of those in Table II., because it fails to satisfy, *inter alia*, the potash test.

The quantity of potash in this granite, as appears from Tables II. and VI., should be

$$\frac{2{\cdot}51\times14{\cdot}92}{100}+\frac{71{\cdot}03\times2{\cdot}07}{100}+\frac{0{\cdot}93\times8{\cdot}83}{100}=1{\cdot}926\,;$$

but the quantity actually found by analysis was 4·66 (Table I.); from which it is evident that the calculated and observed amounts of potash cannot be made to agree, and therefore that this granite cannot be composed of the four minerals of Table II.

This granite also fails to satisfy the test-equations derived from iron and lime. It will be found on trial that the calculated quantity of iron, like that of potash, is too small; while that of lime will be found too great.

Granite No. V.

This granite fails to satisfy the test-equation derived from iron.

From Tables II. and VI., it appears that the calculated quantity of iron-oxides is—

$$\frac{17{\cdot}98 \times 0{\cdot}68}{100} + \frac{55{\cdot}58 \times 1{\cdot}22}{100} + \frac{2{\cdot}69 \times 27{\cdot}38}{100} = 1{\cdot}533\,;$$

while the quantity actually found by analysis (Table I.) was 3·33.

Granite No. V. fails also to satisfy the lime test-equation.

Granite No. VIII.

fails to satisfy the potash test-equation. The calculated quantity of potash is much less than the amount found by analysis.

Granite No. IX.

fails with respect to lime and iron. The calculated quantity of lime is

$$\frac{25{\cdot}45 \times 2{\cdot}75}{100} + \frac{41{\cdot}5 \times 5{\cdot}3}{100} + \frac{2{\cdot}74 \times 0{\cdot}54}{100} = 2{\cdot}913\,;$$

but the quantity of lime found on analysis was only 1·68.

It also fails with respect to iron-oxides.

Granite No. X.

fails with respect to potash, soda, lime, and iron.

Granites Nos. XI. *and* XII.

fail to satisfy the soda, iron, and lime test-equations.

Granite No. XV.

fails with respect to potash and lime.

From the preceding discussion it is plain that not a single granite of those analyzed can be composed of quartz, orthoclase, oligoclase, and black mica, having the precise composition of those minerals given in Table II.

Of the fifteen granites, that which comes nearest to being composed of these minerals is No. IX., from Doocharry Bridge.

I here give its observed and calculated composition.

Doocharry Bridge Granite.

	Observed.		Calculated.
Silica	72·24	....	72·24
Alumina	14·92	....	15·05
Iron and Manganese oxides	2·18	....	1·52
Lime	1·68	....	2·91
Magnesia	0·36	....	0·48 (diff.)
Soda	3·51	....	2·89
Potash	5·10	....	4·90
	99·99	....	99·99

From the entire of the preceding, it may be safe to draw the following conclusions respecting the granites of Donegal:—

1. That nearly half of them are certainly not composed altogether of the four minerals, quartz, oligoclase, orthoclase, and black mica, that are found in them in distinct crystals.

2. That the remaining half, even if they be composed of these minerals, must have a paste made of quartz, orthoclase, oligoclase, and black mica, not having precisely the chemical composition of the separate crystals.

§ II. *On the Syenites of Donegal.*

In many parts of the co. Donegal syenites are found, which appear to form great bedded masses, rudely stratified like the granites; and, like them, also occasionally penetrating the neighbouring rocks in dykes, making various angles with the beds of stratification. The following Table contains the analyses of such as I have examined.

TABLE VII.—*Analyses of Donegal Syenites.*

No.	Locality.	Silica.	Alumina.	Iron, peroxide.	Iron, protoxide.	Lime.	Magnesia.	Soda.	Potash.	Manganese, protoxide.	Water.	Total.
1.	Lough Anure ...	49·20	18·32	7·12	1·95	9·72	7·11	1·92	1·72	1·00	1·20	99·26
2.	Kilrean	44·40	25·00	6·45	2·11	10·17	3·51	2·58	2·66	0·84	1·08	98·80
3.	Doonane	50·08	18·84	7·05	1·03	12·37	6·57	2·39	0·57	0·88	0·80	100·58
4.	Precise locality unknown......	58·05	16·08	8·27	0·45	6·52	2·94	4·65	2·21	1·12	......	100·28

1. *Lough Anure.*—A medium-grained syenite, or crystalline greenstone, composed of small plates of black mica, with some hornblende, aggregated together; and of a felspar, which seems to be oligoclase.

2. *Kilrean.*—A coarse-grained syenite, containing—
   (*a.*) Long crystals of green hornblende.
   (*b.*) White felspar (? oligoclase).
   (*c.*) Specks of iron pyrites.

   In addition to the constituents given in the analysis, this rock contained 1·078 per cent. of sulphur, which, no doubt, was present in the form of the bisulphuret of iron. It is one of the toughest rocks I have ever met with.

3. *Doonane Hill, near Donegal.*—A crystalline, greasy trap-rock, forming a dyke penetrating the lower arenaceous Carboniferous Limestone, and then expanding into a mass on the summit of the hill. It contains—
   (*a.*) Black hornblende.
   (*b.*) Green felspar.

4. This specimen closely resembles those found in the Black Gap, near Pettigo; it forms a connecting link between the true granites and the greenstone-syenites, as it contains—
   (*a.*) Quartz.
   (*b.*) Oligoclase, pinkish yellow, in large crystals with brilliant cleavage.
   (*c.*) Hornblende, dark glossy black-green.
   (*d.*) Occasional facets of sphene in minute crystals.

§ III. *Comparison of the Granites of Donegal with those of Scotland and Sweden.*

The granites of Scotland and Sweden resemble the granites of Donegal in being stratified and in containing the same constituent minerals.

I here give the analyses of two Scotch granites, for the opportunity of examining which I am indebted to the courtesy of Sir R. I. Murchison, K.C.B.

TABLE VIII.—*Analyses of Scotch Granites.*

No.	Locality.	Silica.	Alumina.	Iron, peroxide.	Iron, protoxide.	Lime.	Magnesia.	Soda.	Potash.	Manganese, protoxide.	Water.	Total.
1.	Strontian.........	62·00	17·60	4·78	0·74	4·95	3·17	4·08	3·25	0·40	...	100·97
2.	Tobermurry, Mull ...	70·60	16·40	1·52	0·36	2·47	1·00	4·14	4·29	0·48	...	100·26

1. *Strontian.*—This granite is somewhat like the Ardara granite in appearance, and also like the black gneissose granite, which is found as a variety at Glen, in the co. Donegal. It is medium grained. It contains—
   (*a.*) Quartz.
   (*b.*) Felspar, white (oligoclase), having the characteristic striæ.
   (*c.*) Black mica, abundant.

2. *Tobermurry, Mull.*—A coarse-grained granite, resembling the coarser varieties of the typical granite of Donegal. It contains—
   (*a.*) Quartz, abundant.
   (*b.*) Pink orthoclase, large crystals ($\frac{1}{2}$ in. to $\frac{1}{4}$ in.).
   (*c.*) White oligoclase, striated.
   (*d.*) Black mica, not abundant.
   (*e.*) Sphene-facets, occasional.

It remains to be considered how far the analyses of the Scotch granites admit of being represented by a mixture of quartz, orthoclase, oligoclase, and black mica. In order to solve this question, it is necessary to calculate their oxygen-ratios, and apply equations (4) to them.

TABLE IX.—*Oxygen in Scotch Granites.*

Locality.	Silica.	Alumina.	Iron, peroxide.	Iron and Manganese, protoxide.	Lime.	Magnesia.	Soda.	Potash.
Strontian	32·192	8·227	1·432	0·253	1·407	1·239	1·047	0·551
Tobermurry ...	36·657	7·666	0·455	0·186	0·702	0·427	1·062	0·728

From this Table the following is deduced :—

TABLE X.—*Oxygen contained in the Silica, Peroxides, and Protoxides of Scotch Granites.*

Locality.	Oxygen of Silica.	Oxygen of peroxides.	Oxygen of protoxides.	$51{\cdot}92-A_1$.
	A_1.	B.	C.	A.
Strontian	32·19	9·66	4·50	19·73
Tobermurry	36·66	8·12	3·10	15·26

Introducing the preceding values of A, B, C into equations (4), we find the following per-centages of quartz, orthoclase, oligoclase, and black mica:—

TABLE XI.—*Calculated Mineralogical Composition of Scotch Granites.*

Locality.	Orthoclase, $=x$.	Oligoclase, $=y$.	Black mica, $=z$.	Quartz, $=u$.
Strontian	125·94	47·96	−43·79	−29·14
Tobermurry......	39·71	86·50	−19·87	− 5·08

The negative values of z and u, in the foregoing Table, demonstrate that the Scotch granites, like many of those of Donegal, cannot be represented by any combination of quartz, orthoclase, oligoclase, and black mica; and yet they contain all those minerals.

The granites of Norway, Sweden, and Finland, so far as I have had an opportunity of examining them in the field, have the same stratified geological structure as the granites of Donegal, and they are composed of the same constituent materials, namely, 1, Quartz; 2, Orthoclase; 3, Oligoclase; 4, Black mica; 5, White mica (in veins).

I do not remember to have seen hornblende or tourmaline in the Swedish granite and gneiss.

The orthoclase is generally pink, and the oligoclase either white or waxy greenish, very like the oligoclase of the Garvary Wood veins, near Castle Caldwell.

The black mica is much more abundant than the white, which is generally found in veins, as in the quarry of Ytterby and other celebrated mineral localities.

I have made the following analyses of the constituent minerals of the Swedish granite and gneiss.

(a) *Oligoclase * from Ytterby †, Sweden.*

	Per-centage.		Atoms.
Silica	63·66		1415
Alumina	23·45		451
Lime	3·53	126	417
Magnesia	0·05	2	
Soda	7·91	255	
Potash	1·59	34	
	100·19		

(b) *Black Mica of Swedish Granite and Gneiss.*

	No. 1.	No. 2.
Silica	39·70	32·60
Alumina	12·25	15·56
Iron, peroxide	23·55	27·94
Iron, protoxide	0·96	7·45
Manganese, protoxide	1·00	0·80
Lime	4·48	1·15
Magnesia	7·25	4·79
Soda	0·47	0·82
Potash	7·30	4·30
Loss by ignition	1·00	6·80
Totals	97·96	102·21

No. 1. *Jonesed.*—From the black micaceous gneiss of Jonesed, near the Trollhätta Falls: this gneiss is composed of red felspar and black mica, and is much contorted even in hand-specimens; the direction of its bedding coincides at the Falls with that of the river, W. 30° S. (mag.).

No. 2. *Ytterby.*—Occurs in the black micaceous partings already described; in large flat crystalline sheets.

(c) *White Mica of Swedish Granites.*

The specimen of white mica that I analyzed was taken from a large mass found by me in the quarry at Ytterby, within a foot of the black sheets of mica. It had the following composition:—

* Throughout the entire mass of the large crystals of oligoclase examined, minute specks of quartz were occasionally visible—a circumstance which seems to me irreconcileable with the supposition of the formation of this oligoclase by fusion, in the dry way.

† The celebrated quarry on the Island of Ytterby, near Waxholm, has been worked for upwards of half a century for china-felspar. It consists of a dyke 12 feet wide, vertical, and bearing 20° east of north (mag.). This dyke is filled with the constituent minerals of the granite developed on a grand scale, the milky quartz and white oligoclase preponderating, sometimes in masses upwards of a foot in length; and pink orthoclase, in large tabular crystals, is intimately mixed up with them. The black and white micas are developed in parallel sheets traversing the dyke obliquely; the sheets of black mica are from ½ inch to 2 inches asunder, the intervals being filled with orthoclase and oligoclase. So far as I could judge, the rare minerals of the quarry, yttrite, yttrotantalite, phosphate of yttria, and others, were only developed in the felspar between the sheets of black mica.

		Oxygen.	
Silica	44·64	23·176	23·176
Alumina	35·36	16·528	17·584
Iron, peroxide	3·52	1·056	
Iron, protoxide	0·30	0·066	2·685
Manganese, protoxide	0·20	0·044	
Lime	0·90	0·255	
Magnesia	0·36	0·142	
Soda	1·44	0·368	
Potash	10·68	1·810	
Loss by ignition	2·80		
	100·20		

This corresponds to $(SiO_3 : R_2O_3 : RO) = (7{\cdot}908 : 6 : 0{\cdot}916)$.

Extracts *from* Letters *relating to the further* Discovery *of* Fossil Teeth *and* Bones *of* Reptiles *in* Central India. By the late Rev. S. Hislop.

[Communicated by Prof. T. Rupert Jones, F.G.S.]

(Read December 16, 1863*.)

The following extracts from letters, relating to late discoveries, by the Rev. S. Hislop and Major Gowan, of fossil Bones in Central India, are offered to the Society, not only as being of interest in themselves, but as being the last remarks on the subject by Mr. Hislop, whose sudden removal, in the prime of life, we most deeply feel.—T. R. Jones.

From Letter, April 7th, 1862.—" The country all around Kotá is the most interesting geological locality in the Central Province. Often would I wish to visit it; but it is far, and my duty does not carry me there. I can only learn about it by messengers.

" A friend of mine, at my request, lately visited Mále*di*, and, I understand, has found something new, but what it is I have not yet heard. All my acquisitions from that spot I have lately entrusted to a lady, who leaves Calcutta by steamer tomorrow, and who, I trust, will reach London before the end of May. She carries with her all the bones mentioned in p. 202, ' Bombay Asiatic Soc. Journal,' xxi., some of which are very interesting, particularly the jaws, thickly set with teeth, and grooved, as I believe, by an upper jaw, narrow and sharp, like a knife-edge. This must be something new. Oldham does not think the vertebræ Dicynodont. All the bones sent were found on the surface of the red clay, near each other; but I have no proof that they all belonged to the same animal . . . . . You remember, Mále*di* is the place where were discovered the Ceratodus-teeth described by Oldham in Mem. Ind. Geol. Surv. vol. i. p. 295."

Letter, August 17th, 1863.— . . . . . " When Prof. Huxley is describing Reptilian Remains from India, will you kindly see that he gets the specimens from Mále*di* to examine? He seems to be interested in them, and will do them every justice. I have got more

* For the other communications read at this Evening-meeting, see p. 116.

from the same place, which I have no doubt Prof. Huxley will think worthy of study. I shall endeavour to send them to him, if I can find an opportunity; if not, I shall forward to him drawings. In the meantime I shall give you a brief account of them.

"The specimens are all found in connexion with red clay strata, and generally on the surface. The localities are three. On W.S.W. Ceratodus-teeth are met with, along with pitted and grooved scales. On S. are found the jaws with numerous conical teeth, such as have already been sent to London. Near those jaws, also, have been discovered scutes, much the same as above, and vertebræ. Of the vertebræ some appear to be dorsal and others caudal. Besides these are two phalanges, which seem to fit into each other; and other bones, the position of which it is difficult for me to indicate. I think, among the specimens that Dr. Oldham left at the Geol. Museum was a sharp bone, which may have belonged to the upper jaw, and formed the channel in the lower. Another such sharp bone has been found with something like rudimentary teeth along the edge. On the same (south) side of the village, and quite near the bones, but at a little higher level, where the clay, somewhat sandy, is whitish, were collected fragments of one large species of *Unio*, and more complete specimens of a smaller species.

"These two sites (W.S.W. and S.) were known before. This year I sent my collector, Vira, again to Mále*d*i, where he discovered fossils on the north side. Among these were vertebræ much shorter than those from the south side; one with both ends pretty equally concave; another with one end more concave than the other; and a third (the smallest) with both ends somewhat plane. Here also were scutes, much as before, but only one bone with teeth (jaw or palate?). The summit is furnished with rudimentary sort of teeth; from that there is a slope down, at the base of which there is a row of thinly set conical teeth, resembling those in the jaws from the south. In the immediate neighbourhood were picked up 16 or 17 teeth, like those of *Megalosaurus.* They are of all forms, from the long-conical to the stout lance-shaped. You may remember a beautifully serrated tooth found by Dr. Rawes at Takli, and deposited in the Geol. Society's Museum. One of those recently found bears a great similarity to it, only the Mále*d*i specimen is considerably thicker. It is strange that we should meet with at Mále*d*i, along with the remains of *Ceratodus,* a tooth so like one from the 'Inter-trappean': but the strangeness ends not here: one of the conical varieties from Mále*d*i is, I should say, almost exactly like a tooth found along with *Physa Prinsepii* and other 'Inter-trappean' shells in the 'Sub-trappean' of Phísdura. I do not know whether it may increase the wonder to add that in a nulla at Mále*d*i, which cuts through strata immediately underlying the bed with Megalosaurus-like teeth, there was presented in position an abundance of the smaller species of *Unio* mentioned before. I cannot assert that this species resembles any of the species of Unios that occur in the 'Inter-trappean.' I rather think it is a new species. Still it is as modern-looking as any I have described in my paper on the Eocene Mollusks of Central India.

"By the by, in your Tabular View of Indian Rocks*, positions are assigned to some of our strata, in which, with my present light, I find it difficult to concur. I feel that I am to blame for any mistake there may be, except, perhaps, in regard to the Mángali sandstone. It seems to me that both it and the shales of Korhádi and the red clay of Má*led*i should be above the Umret Coal and the Plant-sandstones. In the course of my tour last January, I met with shales very like those of Korhádi, and they appeared to lie at the base of our Eocene shelly beds, and would therefore require to be included with the strata I have comprehended under the name of the 'Takli series' (Bombay Asiat. Journal, No. 21). The state of my mind in regard to the Má*led*i clay, as you may have gathered above, is very unsettled. The Mángali beds, I decidedly think, lie above the coal-strata. This month, palæontological evidence has been obtained bearing on this point.

"An officer (Major Gowan) of the Bengal Army, in wandering about the base of the Mahadewa Hills, stumbled upon a slab of sandstone bearing the impression of a vertebral column and ribs. He reported his discovery to the Governor at Calcutta, and the officials there, moved by the Bengal Asiatic Society, addressed the officials here, requesting the specimen to be forwarded to them. It has been brought down to this place on its way to Calcutta, and it has been submitted to my care in the meantime. It turns out to be a Labyrinthodont of a size considerably larger than the *Brachyops*, and is pretty complete (as an impression), wanting only the lower part of the abdomen and the tail, and three of the legs. The head, when found, was perfect; but, when laid bare, the long scutes crumbled into small fragments. It shows a long row of teeth on each side, like the *Brachyops*; but the position of the orbits of the eyes indicates little affinity with that genus. The Mángali Reptile, in fact, belonged to v. Meyer's Prosthophthalmian subdivision of Labyrinthodontidæ, whereas that from the south base of the Mahadewa Hills is an Opisthophthalmian. The former are found, according to the German geologist, in the Upper Triassic, while the latter occur lower down. Now, the strata in which this more ancient Reptile was imbedded must have been our Indian Coal-beds; for, although the sandstone slab was not in position, yet I have every reason to know that it could have belonged only to them.

"During my last Missionary-tour I met with some more bones at Phísdura. Some of them are very large and massive. One femur is upwards of a foot broad at the condyles. One vertebra is about 7 inches across. The vertebræ have all lost their processes; but the number I have in my possession now is very great. They are so heavy that I fear I shall not be able to send them home; but if Dr. Falconer would undertake to say something about them, I should be glad to make careful drawings of them. You may recollect these remains occur with coprolites, some of them huge enough, and an abundance of *Physa Prinsepii*, *Paludina Deccanensis*, and other shells of the 'Inter-trappean.'"

* Quart. Journ. Geol. Soc. vol. xix. p. 150.

On the Pebble-bed *of* Budleigh Salterton. By W. Vicary, Esq., Esq., F.G.S. *With a* Note *on the* Fossils; by J. W. Salter, F.G.S., A.L.S.

(Read December 16, 1863 *).

[Plates XV.–XVII.]

In bringing the fossils figured in Plates XV.–XVII. under the notice of the Geological Society, I beg to offer a few remarks on the locality in which they were found, and on one or two other circumstances connected with them.

If we look at a geological map of Devon, it will be seen that from Petit Tor, near Babbacombe Bay, to a little way beyond Sidmouth, the coast exhibits cliffs of the New Red Sandstone formation. These rocks present us with variously modified features. At about a quarter of a mile west of Budleigh Salterton, and for about a mile and a half further on in the same direction, is a bed containing pebbles in large quantities, varying from a small size to that of a man's head. These are generally of a flattened-oval form, are completely free from angularity, and are known in the neighbourhood as Budleigh pebbles or "popples."

The figures illustrating this paper represent the part of the cliff where this pebble-bed is found, and which furnishes the pebbles in which the fossils are imbedded.

The coast here runs in a direction nearly east and west, and it will be observed that the dip of the bed is to the east. The diagram

Fig. 1.—*View of the Cliff, looking Eastward.*

also shows that as the pebble-bed rises up from its first appearance at the beach to its highest level, the regularity of the rise is disturbed by the interference of several small faults. The greatest thickness of the bed is probably a little over a hundred feet. The pebbles and sand of which it is composed cohere so slightly that any portion

* For the other communications read at this Evening-meeting, see p. 116.

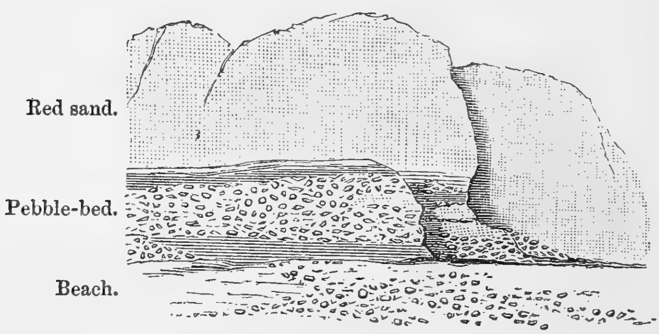
removed from the rock readily falls apart, so that even the beds of fine sand and soft marl yield less to the denuding agents than does this bed.

When first the bed appears at the beach it is overlain by one of fine red sand, which is about seventy feet thick and contains no

Fig. 2.—*View of the Cliff, looking Westward.*

pebbles; but a bed immediately above this has here and there a pebble. The exposure of the pebble-bed itself, from where it is first

Fig. 3.—*Front View of the Cliff, showing the Pebble-bed as it first rises from the beach.*



seen to begin eastward, to the point westward where it rises above the beach, is near half a mile; and here the underlying bed in contiguity with it is shown to be red marl.

Going westward, again, we find about a quarter of a mile further on that the red sand-bed lying above the pebble-bed thins out, and about half a mile further westward still the pebble-bed itself disappears, and the whole of the cliff becomes red marl.

This bed of red marl extends as far west as Littleham Bay, about a mile beyond the point where the pebble-bed thins out; and here it abuts against a conglomerate containing pebbles of Carboniferous Grit, of small size and very angular. This abrupt junction of the red marl and conglomerate would appear to indicate a fault of some considerable extent. I have not carried on the diagram so far as this termination of the red marl.

Another feature represented in the diagram (fig. 3), in connexion with the pebble-bed, which I would mention, is that in several places there are small interstratified patches of fine red sand, generally of about four feet thick, and extending to about forty or fifty feet in length, and then thinning out at both ends. In these patches oblique lines of deposition are visible, running at a considerable angle to the general dip of the beds. These lines extend some distance beyond the patches of sand into the pebble-bed, at which places the pebbles lie with their longer axis in the direction of this minor stratification. Passing through different parts of the bed are also strings of oxide of iron, which are locally called "pans," uniting and cementing the sand and pebbles together.

The beach from the River Exe on the west to the River Otter on the east is mainly composed of the pebbles from this bed, and they may be found sparingly for three or four miles beyond Sidmouth.

It will be seen from this that the pebbles on the beach extend much further than the pebble-bed in the cliff, from which it might be supposed they have directly come. But this is by no means certain, since there are other sources from which they might have been brought.

On again looking at the map it will be seen that the coast we have been describing lies between the Rivers Exe and Otter before alluded to, which are distant from each other about six or seven miles. The top of the cliffs for nearly the whole of this distance is capped by a bed of gravel composed of Budleigh pebbles with a considerable admixture of flint, probably one-third.

This same kind of gravel extends up the eastern banks of the Exe to Topsham, where it becomes mixed with a considerable amount of Carboniferous Grit pebbles; and also up the banks of the Otter as far as Fairmile, or a distance of seven or eight miles. These sources might have contributed to the mass of pebbles found on the beach; and this is the more likely as at the mouth of the Otter the pebbles are more numerous and in such quantities as to form quite a bar across the mouth of that river.

We have said that the dip of the pebble-bed is towards the east, consequently the strike would be north and south; and in this direction we have a ridge of hills, extending for about ten or twelve miles inland, almost wholly composed of Budleigh pebbles.

Near the termination of this ridge of hills to the north are the Straightwayhead gravel-pits, which Sir H. De la Beche, in his 'Report of the Geology of Devon,' page 396, considers to belong to the Plastic-clay series. I have not been able to discover any difference in character of the bed at Straightwayhead and the bed at Budleigh Salterton.

The pebbles are generally sandstone, but sometimes are so compact as to assume a quartzite character; they frequently contain flakes of mica, and in some instances small crystals of felspar. Small rounded pebbles of quartz and agate are also sometimes found imbedded in them; occasionally also small nodules of iron-pyrites.

Here and there amongst these sandstone-pebbles are found some of pure quartz, of lydian-stone, and others of a schorlaceous character.

The New Red Sandstone of this district is proverbially barren of organic remains of its own time, and I have never seen any trace of such a fossil, save now and then a worm-track or a ripple-mark. But of the fossils of the older rocks, furnished by the fragments of those rocks imbedded in the conglomerates, they are very rich. The red rocks at Dawlish and Teignmouth afford us some of the best specimens we have of the Corals and Sponges of the Devonian age. At North Tawton, twenty miles at least from any spot where these rocks are seen *in situ*, similar fossils are also found.

From the conglomerates at the Ness, near Shaldon, I have obtained several fossils of a Nautiloid form, which Mr. Salter thinks must certainly belong to the age of the Petherwin beds as *Clymenia linearis* is common among them. Regarding the fossils now submitted for your inspection, Mr. Salter has kindly furnished me with a report, which I now subjoin.

Note on the Fossils *from the* Budleigh Salterton Pebble-bed. By J. W. Salter, F.G.S., A.L.S.

When I first examined the pebbles from the Budleigh Salterton beds in the choice cabinet of Mr. Vicary, of Exeter, the impression made upon me was that anything and everything might be expected on British soil. Familiar as we had long been with the great variety of forms displayed by our own Silurian series, there had, nevertheless, been so far among them a great uniformity of type, and that a type shared by the fossils of the whole of the northern or Scandinavian area, as Sir R. I. Murchison and others have long ago indicated. We knew that the principal forms found in Russia and Sweden were represented more or less perfectly in the sandstones and shales of the Border-counties, and the slates of our Welsh and Cumbrian series. Nor would it have surprised any student of the palæozoic rocks to find a large development of North American forms in our western limits, as, for instance, the Canadian fossils found by Sir R. I. Murchison in the West Highlands, or the New England types discovered and described by General Portlock in the county of Tyrone.

But the central European type—that exhibited in France and Spain, and which has been shown by Barrande and De Verneuil to be identical with the groupings of the Bohemian basin—had not yet given to Britain a single fossil. No sooner do we cross the Channel than we are introduced to an entirely new set of Lower Silurian fossils, and it would puzzle any geologist to identify accurately the subdivisions of the Llandeilo and Caradoc rocks in Wales and Normandy, while he would find no such difficulty in drawing his lines along the whole northern zone from Siberia to Canada. The apparition, therefore, of the true French type in Devonshire was as unexpected as welcome; and the inference to be drawn from this extension of it into our southern provinces is an obvious one. It implies that the barrier indicated by Barrande, and adopted by Mr. Godwin-Austen, divided the Scandinavian and mid-European areas all but completely along a line which ranged to the north of the Cornish and Devonian areas. This view has long been held by myself and, I believe, by others; and it is lately illustrated in the Geological Magazine for July of the present year, No. 1.

For some unexplained reason, while the northern zone has been well explored and its contents duly published, the Mid-European group of slate rocks, though rich in fossils, has had but very few illustrators. There are scarcely any reliable figures extant, if we except those of the great Trilobites of Angers, by Marie Rouault, the Spanish fossils published by De Verneuil and M. Prado from the Sierra Morena and Almaden*, and the species from Busaco illustrated by the late Daniel Sharpe†. The splendid work of Barrande is, of course, excepted; but though his plates, now in preparation, will doubtless give us as good an insight into the Mollusca as we have already of the Crustacea, so far we are without any precise indications what the Lower Silurian fauna of Central Europe has in store for us; and we want figures very much.

The Normandy fossils, however, have been by no means neglected, though illustrations of them are rare. No one can have read the results of Rouault's labours in the district of Rennes‡ without seeing that there is abundance of material for the engraver, while Rouault's description will enable us to recognize many of the more prominent species. That enthusiastic worker has described the giant *Lingulæ* and Fucoids of the Armorican sandstone, and his labours and those of MM. Triger and De Verneuil have ascertained the exact horizon of those Trilobites long ago roughly catalogued and figured by Deslongchamps. The quartzites of May and Gahard have many species identical§ with those here described, and some of those which I could not otherwise recognize have been kindly identified from our figures by M. de Verneuil. There is a small collection of Norman fossils in the cabinets of the Geological Society, and it was the perfect identity of these, even as to accidents of mineral composition, which first attracted attention. In brief, then, the mass of the Budleigh Salterton fossils are Norman types of the May Sandstone, and some belong to the "Grès Armoricain;" several of the species have been already named in France, and some of the more conspicuous shells, though apparently undescribed, are characteristic of the rocks on both sides the Channel.

* Bull. Soc. Géol. France, 2ᵉ sér. vol. xii.

† Quart. Journ. Geol. Soc. 1853, vol. ix.

‡ Bull. Soc. Géol. France, 2ᵉ sér. vol. vii. p. 725, vol. viii. p. 358.

§ According to M. Rouault's latest opinion, and the sections given by M. Triger (*loc. cit.* vol. vii. p. 794), the May sandstone lies quite above the Armorican sandstone with the *Lingulæ*, a formation which seems to be part of the great slaty series of Angers, and which therefore far underlies the May sandstone.

As the fossils are both numerous and attractive as to size, colour of stone, and degree of preservation, no doubt the spot will be well visited, and we shall eventually obtain a host of French Silurian species from a mile or two of New Red Sandstone cliff in Devonshire. Meanwhile it will be advisable to give a general list, with references to French authors, and localities of the species collected, and then describe such as need it.

PLANTS.

I know not how we can definitely describe these rough and shapeless casts, which nevertheless are, I believe, rightly referred to the *Algæ*; M. Rouault finds such remains abundant in the rocks of Normandy, and he has carefully described and distinguished the irregular crisped fronds by the name *Dœdalus*, while the palmate forms with a stem and lateral rib he calls *Vexillum*. Both are probably Calciphytes, and probably of the same kind as the well-known *Cauda-Galli* of America and Scotland. All M. Rouault's species appear to be transversely ridged or waved, and cannot therefore be identical with ours, which unfortunately we have no means of figuring in the present memoir. They are figured in the First Number of the Geological Magazine, July 1864.

1. Vexillum? Geol. Mag. vol. i. p. 10. fig. 2.

We have two species, neither of which is very regular. The most complete is an undulated palmate plate, thickened on one margin (?), and irregularly undulated in the longitudinal direction. Such a form may well be due to the remains of some expanded *Alga*; but it may also have been caused by the movements of an animal in the arenaceous matrix.

2. Dædalus? Geol. Mag. *l. c.* p. 11. fig. 3.

An irregular expanded plate, bent three-fourths round upon itself into a compressed funnel-shaped form, and which must have been 3 or 4 inches long, at least, when the cone was perfect; the whole surface is occupied by curved ridges nearly parallel to one another, but oblique to the general direction of the plate. The actual margin of the plates, against which these ridges abut, is not clearly seen. No trace of a midrib.

ANNELIDA.

Common as are the tubes of Annelides in all Palæozoic rocks, it is only now and then that they present sufficient characters to enable us to refer them to definite genera. Of these, *Trachyderma*, described by Prof. Phillips, is distinguished by the close corrugation of its corneous tube, which I have seen (in a Silurian locality in the West of Ireland) holding an upright position in the bed. I think we may refer the following, without much doubt, to that genus.

List of the Budleigh Salterton Fossils.

Species.	Plates and figures.	Where described.	Foreign localities.
Vexillum?, sp. .... Dædalus?, sp. Plant or Sponge, tubular	Not figured here ...	*Vexillum* and *Dædalus*, Rouault, Bull. Soc. Géol. Fr. 2 sér. vol. vii. p. 734; Salter, Geol. Mag. vol. i. July 1864, pp. 10 & 11. figs. 2, 3.	Various localities near Rennes, in the Armorican grit.
Trachyderma serrata	Pl. XV. fig. 9.		
Homalonotus Brongniarti ...	Pl. XV. figs. 1, 2......	*Asaphus*, Deslongchamps, Trans. Linn. Soc. Calvados, vol. ii. pls. 19, 20.	May, Normandy; Vitré (Rouault); not in Spain. *H. Brongniarti* of De Verneuil is distinct.
——, sp.	Pl. XV. fig. 3..........	Salter, Monog. Palæont. 1864.	
Phacops incertus	Pl. XV. fig. 4..........	*Asaphus*, Deslongchamps, *l. c.* pl. 20. fig. 5; Salter, Monog. Pal. Soc. 1864, pl. 1. figs. 27, 28.	May, Caen, Normandy; Gahard, Rennes.
Calymene Tristani	Pl. XV. fig. 5..........	Brongn. Crust. pl. 1. fig. 2; De Verneuil, Bull. S. G. Fr. 2 sér. vol. xii. pl. 25. fig. 3.	Sierra Morena, Spain, abundant; Couyère, Angers, Vitré, Caro, Morbihan, Parennes.
Myocaris Lutraria, n. sp.......	....	Geological Magazine, vol. i. 1864, p. 11. fig. 4.	
Lingula Lesueuri	Pl. XVII. fig. 1	Rouault, Bull. Soc. Géol. Fr. 2 sér. vol. viii. [p. 727.	
—— Hawkei....................	Pl. XVII. figs. 2, 3...	*Ibid.* p. 728.	
—— Rouaulti	Pl. XVII. figs. 4, 5.		
—— Brimonti	Pl. XVII. fig. 6.	*Ibid.* p. 728.	
Leptæna Vicaryi	Pl. XVII. figs. 16, 17.		
Porambonites, sp.	Pl. XVII. fig. 9.		
Orthis pulvinata	Pl. XVII. fig. 8.		
—— redux, *Barr*...............	Pl. XVII. fig. 7.	*O. testudinaria*, De Vern., Bull. Soc. Géol. [Fr. 2 sér. vol. xii. pl. 27. fig. 9.	Like *O. Filicieri*, Rouault. May, Caen; Bohemia; Spain.
Spirifer antiquissimus	Pl. XVII. figs. 10–12.		
—— Davidis, *Rou.*?............	Pl. XVII. fig. 13 ...	Bull. Soc. Géol. Fr. 2 sér. vol. viii. p. 368 ...	Hunaudière, Angers, &c., Gahard.
Rhynchonella, sp.	Pl. XVII. fig. 15......	Very like a Devonian fossil, *R. Pareti*, De [Vern.	
——, sp.........................	Pl. XVII. fig. 14.		
Modiolopsis obliquus..........	Pl. XVI. fig. 3 (3*c*, young).		
—— Armorici..................	Pl. XVI. fig. 1	....	May, Caen.
—— liratus	Pl. XVI. fig. 4	....	May, Caen (De Vern.).
——, sp.........................	Pl. XVI. fig. 2.		
—— lingualis	Pl. XVI. fig. 5.		
Hippomya (n. g.) ringens......	Pl. XV. fig. 7.		
Lyrodesma cælata	Pl. XVI. fig. 7.		
Orthonota Grammysioides ...	Pl. XVI. fig. 10	Compare *Cypricardia Ludoviciana*, Rouault, [*l. c.* vol. viii. p. 374.	*C. Ludoviciana* is from Devonian, Gahard.
Clidophorus? amygdalus......	Pl. XVI. fig. 6..........	....	May, Caen (De Vern.).
Ctenodonta Bertrandi..........	Pl. XV. fig. 8..........	Rouault, Bull. S. G. Fr. 2 sér. vol. iv. p. 322	Poligné.
Arca? Naranjoana?, *De Vern.*	Pl. XVI. fig. 8..........	Bull. Soc. Géol. Fr. 2 sér. vol. xii. 1855, pl. 26. fig. 12.	Sierra Morena.
Palæarca secunda	Pl. XVI. fig. 9.		
Solen?	Pl. XVI. fig. 11.		
Bellerophon, 2 sp.			
Orthoceras, sp. (lateral siphon)			
——, two smooth species.			

1. Trachyderma serrata. Pl. XV. fig. 9.

Tube cylindrical, strongly corrugated by irregular transverse ridges, which are closely set in some portions and irregularly remote at others (see fig. 9*a*). As the tube grows larger, it appears (fig. 9*b*) to lose the regular transverse ridges, and to be furnished only with irregular rugæ or varices of growth, but rather closely set. These varices are roughly trumpet-shaped upwards, and where the tube is perfect (fig. 9*a*) expand into wide-spreading lamellæ, which stand out at right angles for a distance equal to about half the diameter of the tube itself; they are of various sizes, and occur at intervals corresponding to the irregular rings or varices from which they take their rise. Only the two specimens here figured have yet been observed; but it is probably a very common fossil. It is nearly half an inch in diameter.

I do not attempt to identify this with either of M. Rouault's species of *Tigillites* (Bull. Soc. Géol. Fr. 2nd ser. vol. vii. p. 741, &c.), though it is quite possible the *T. Dufrenoyi* is a tube formed by a larger but closely allied species. *T. Danielii* would be about the same diameter ($\frac{3}{10}$ inch), but its surface is not described. Nor do I think the genus *Tigillites* necessary, as, if not referable to *Trachyderma*, the genus *Scolithus*, Hall, would receive them.

I think M. Rouault's genus *Humilis* can only be the filled-up crossing and anastomosing burrows of marine worms. His genus *Tigillites* is the vertical burrow; *Foralites* comprises the less regular perforations among the vegetable masses; and *Vermiculites*, as its name implies, are the irregular surface-markings produced by other animals of the same order.

CRUSTACEA.

Of Trilobites we have only four species, but three are characteristic of the May Sandstone group of Normandy. The well-known *Homalonotus Brongniarti* and *Calymene Tristani* occur here, with the *Phacops incertus*. I need hardly describe these, but offer a few explanatory notes on each.

1. Homalonotus Brongniarti, Deslongchamps. Pl. XV. fig. 1 (and fig. 2?).

Asaphus Brongniartii, Deslongch. Trans. Linn. Soc. de Calvados, 1825, vol. ii. pls. 19, 20.

Homalonotus Brongniartii, Rouault, Bull. Soc. Géol. Fr. 2nd ser. vol. vi., 1849; vol. viii. p. 370, 1850.

Although Deslongchamps's figures are not quite so perfect as they would be in these critical days, there is no difficulty in recognizing the species so carefully illustrated by him. He gives us a large Trilobite, fully 9 inches long, and has figured every portion but the labrum. The parabolic glabella, convex front border ("chaperon") separated by furrows from the equally convex cheeks, the small eye placed far back, the body strongly trilobed for the genus, and the smooth contour of the rhomboidal tail are all well shown. In one particular only does his description need an appendix: he has not noticed that the sharp furrows on the sloping sides of the tail decussate the incurved margin so much as to produce decided serratures all along; and this character is so rare for *Homalonotus* as to deserve special attention.

As M. Rouault thinks there is no doubt he has the same species from the lower or Armorican Sandstone, I can only repeat his observation; but it is not usual for Trilobites of this genus to have a great range. The species so quoted by De Verneuil, from the Sierra Morena in Spain, is clearly distinct, both as to the head, which has much wider cheeks, and the tail, which is triangular and has interlined ribs.

I doubt if the fossil represented in our fig. 2 is distinct; but the outline is squarer, and the front is not so much raised.

2. Homalonotus, sp. Pl. XV. fig. 3.

This, of which we have but one specimen, is a truly distinct fossil. It has a short, broad, convex tail, not a rhomboidal one with steep sides as in *H. Brongniarti*, and the lateral lobes, strongly curved down, have also bent ribs, with intermediate furrows near their tips. The ribs do not reach the actual margin, which is granular and rounded off, not abruptly angular and serrated as in the common species. It is hardly complete enough to name, and will probably be found in a more perfect state in France; though M. de Verneuil has not recognized it yet. We have a single specimen of the tail of a third species of *Homalonotus*.

3. Calymene Tristani, Brongniart. Pl. XV. fig. 5.

C. Tristani, Brongn. Crust. Fossiles, pl. 1. fig. 2, 1822; De Verneuil, Bull. Soc. Géol. Fr. 2nd ser. vol. xii. pl. 25. fig. 3.

Of this we have only the caudal portion, but that is sufficiently characteristic. It differs from the *C. Arago*, a kindred species, by having both the axis and sides ribbed throughout. *Calymene Arago* and *C. Salteri*, Rouault, have the sides of the tail smooth.

4. Phacops incertus, Deslongchamps. Pl. XV. fig. 4.

Asaphus incertus, Deslongch. Trans. Soc. Linn. de Calvados, vol. ii. p. 298. pl. 20. fig. 5, 1825.

Dalmania incerta, Rouault, Bull. S. G. Fr. 2nd ser. vol. viii. p. 371.

Phacops incertus, Salter, Monograph of British Trilobites, Part 1. Palæont. Soc. Trans. pl. 1. figs. 27, 28, 1864.

We have only the head and tail of this species, but they are so much more perfect than the specimen figured by the French author, that we are now enabled to see its close relationship to the *P. socialis*, Barr., a species which occurs commonly in the quartz-rocks of Bohemia.

P. incertus must have been about 2 inches long; and while in the inversely pyramidal form of the glabella it resembles *P. socialis*, it differs from it in the more triangular form of that part, and in the much more prominent basal lobes. It must have had very short spines to the head-angles, if any. There is no margin in front of the glabella. The eyes are small, placed centrally on the cheek, not in advance of this position. The tail has a broad stout mucro. Side-ribs about six; these are flat, slightly arched, and directed obliquely backward; they nearly reach the narrow flat margin, and are duplicate throughout. The sides are rather flat, but become tumid where they run into the broad base of the thick recurved mucro, which was probably, when perfect, as long as the tail itself. *P. socialis* has a more slender and less recurved spine; but the species are closely allied.

5. Myocaris Lutraria, gen. et spec. nov., Salter, Geol. Mag. vol. i. p. 11. fig. 4.

We have only the interior cast of this curious fossil; and as there is no room to figure it here, I must refer to the first number of the 'Geological Magazine' for details.

It is closely allied to the *Ceratiocaris*, an Upper Silurian genus of bivalve Crustacea, from which its deep cervical furrow, indicated on the cast, and reaching from a point in advance of the umbo to some distance backwards, separates it. There are so many other characters of habit—the deeply emarginate anterior border, the strongly ridged and ornamented posterior slope, &c.—that I cannot doubt it is a distinct genus.

The strong internal subcardinal ridge, marking the position of the cervical furrow, leads me to suspect that *Ribieria**, a Lower Silurian genus which has not yet found its place, may be a cognate form. A univalve carapace would be nothing remarkable among the allies of *Nebalia*, but is very puzzling if referred to Lamellibranchs, while the whole aspect is unlike that of any of the Calyptræiform shells. I think we may have here the true affinity, but the suggestion is only given to induce research. The strong muscular scar behind the beak is against it.

BRACHIOPODA.

One of the most interesting discoveries of Marie Rouault in the rocks of Normandy was without doubt that of the group of large *Lingulæ* which he describes from the Armorican Grit of Montfort, Guichen, Soulevache, &c., which grit also contains the fucoids above cited. M. Rouault describes three species of *Lingulæ*, all of which I think are identical with ours.

1. Lingula Lesueuri, Rouault. Pl. XVII. fig. 1. Marie Rouault, Bull. Soc. Géol. Fr. 2nd ser. vol. viii. p. 727.

There cannot be much doubt of this elongate species. It is fur-

* *R. pholadiformis*, Sharpe, Quart. Journ. Geol. Soc. vol. ix. pl. 9. fig. 17, and *R. complanata*, Salter, 'Siluria,' 2nd edit. p. 50, woodcuts of Foss. 8. fig. 3. (This last was erroneously called *Redonia* in the text; see Errata.)

nished, within the beak of one valve at least, with a pair of parallel short ridges which border the byssal area. The sides are strictly parallel for more than half the length of the shell, and then taper gradually and with a very slight curve to the beak, as described by Rouault, who however had larger specimens, over 2 inches long; ours do not reach a length of more than 1½ inch.

2. Lingula Hawkei, Rouault. Pl. XVII. figs. 2, 3. Marie Rouault, *loc. cit.* p. 728.

I think these are small specimens of Rouault's species. Our shell is 1¼ inch in length, and barely so wide as long, even in front, where it is widest. It is truncate in front and a very little emarginate; tapers slowly, with much-curved sides, from the front towards the hinge, and is there broadly rounded into the very blunt and inflated beak. Probably older specimens would become still rounder in outline. The surface shows at intervals strong ridges of growth, most distinct in the outer half and near the margin; and these are crossed by fine radiating lines, with here and there a longitudinal ridge among them. Fig. 3 shows the larger and flatter valve; it has a more produced beak. The other valve is shorter and rounder, and has the central area very distinct and prominent.

3. Lingula Rouaulti, spec. nov. Pl. XVII. figs. 4, 5.

[Compare with *L. Brimonti*, M. Rouault, *loc. cit.* p. 728.]

A most remarkable fossil, and common in the Budleigh Salterton pebble-bed. It very much recals the description of *L. Brimonti*, being short, robust, much inflated, wider than long. But the margin cannot be called circular in any sense; and, moreover, I believe fig. 6 is the true *L. Brimonti*, as does also M. de Verneuil.

L. Rouaulti is truly triangular, but with a produced beak, the front truncate, the sides very little arched in the smaller, and nearly straight in the larger, valve. It is an inch and $\frac{6}{10}$ths long, and only $\frac{4}{10}$ths broad. Both valves are highly convex for the genus, but the smaller one by far the most so, and regularly inflated from the small pointed beak (without ridges to mark out the central area as in the next species). A slight depression occurs down the centre. In the opposite valve the convexity is less, but the central area is still very much raised, and bordered on each side by an angular convexity, which is not a ridge, because there is no central depression, only a flattening along the middle of the valve. Its sides slope steeply to the edge, and form true lateral areas. The edges are very sinuous, the side-view showing a strong projection forwards from about the middle of the larger or ventral valve. The lines of growth are remarkably strong at intervals, and form strong squamous ridges on the outer portions of the shell. Between these the surface is rather smooth and even, and the numerous and strong radiating striæ that show themselves on the inner surface of the shell, and permeate its substance (see fig. 4, 4*a*), are not at all seen on the outer surface.

The muscular scars are strong, and approximate in the dorsal valve. It is very possible this triangular species may belong to *Obolella*, but we have not sufficient evidence of this.

4. Lingula Brimonti, Rouault. Pl. XVII. fig. 6. Rouault, *loc. cit.* p. 728.

I think this broad and inflated shell, with its abruptly truncate and even emarginate front, greatly arched sides, obtuse beak, and close conspicuous lines of growth, can hardly be other than the *L. Brimonti*. Rouault describes his species as having the convexity in the form of obtuse ridges running from the beak to each of the basal angles. Our shell has this character, and so differs from the *L. Hawkei* described above.

The remaining species must be compared rather with those found by Rouault in the Upper or May Sandstone, of Gahard and other places near Rennes; but there is no difference appreciable in the character of the matrix, and I suppose they have been derived in the British locality from the same beds as the *Lingulæ* and Fucoids above described.

5. Orthis redux, Barrande. Pl. XVII. fig. 7.

[*O. testudinaria*, Barr. and De Vern. Bull. Soc. Géol. Fr. 2nd ser. vol. xii. pl. 27. fig. 9. ?]

Circular, not half an inch in diameter, with only a slightly prominent beak to the larger valve, which is convex, but not ridged, and closely covered by straight radiating fine striæ repeatedly interlined till they become very close and fine near the border. The dorsal valve is flat (fig. 7*a*) or slightly convex (fig. 7*b*). The ventral valve has widely divergent lamellæ and rather large inconspicuous muscular scars (fig. 7*c*). The dorsal valve with short divergent teeth, and the cardinal process prominent and rounded, but very short. The central ridge is broad and low, and the muscles ill defined.

I should have thought this abundant fossil (equally common in the May Sandstone) to be the *O. Filicieri* of Rouault; but he describes that species as having a large area, and a very convex (dorsal) ventral valve covered by large striæ. Ours are closely striate, but with prominent striæ interlined with smaller ones. It is the well-known *O. redux* of Bohemia.

Orthis redux, var. Pl. XVII. fig. 7*d*.

This has the dorsal valve with a much wider hinge than the last, and a channel all down it, like *O. parva* of the English Silurian rocks. It may be only a variety of the preceding, and I think it is so, but note the differences. It is very like the figure of *O. testudinaria* above quoted.

6. Orthis pulvinata, spec. nov. Pl. XVII. fig. 8.

Dorsal valve truly transverse oval, $\frac{7}{8}$ inch wide, regularly and rather strongly convex, the area not so wide as the shell, the upper angles rounded, the centre not at all depressed. The surface is not known, but the striæ seem to have been very fine. A few concentric ridges of growth show on this valve, which do not interfere with the regular convexity of the valve. The hinge-area is not so wide as the shell.

The interior is characteristic, and unlike any British species I am acquainted with, except *O. lata*, Sowerby. The hinge-teeth are strictly parallel, and rather converge instead of diverge; and the cardinal process is exactly as long as the teeth. The three extend the same distance, and, being very prominent, form in the cast a deep circumscribed depression, beneath which the quadripartite muscular scars are very distinct. The muscles include a circular space, divided by a thick prominent median ridge, which extends the whole length of the muscles. The upper pair are only half the size of the lower. The shoulders, formed in the cast by the hollow spaces outside the teeth, are very square, and rise close to the narrow hinge-area, thereby indicating that the teeth and the shell itself about the hinge are very thin. These internal characters are found to be very distinctive in species of *Orthis*.

Porambonites, sp. Pl. XVII. fig. 9.

This is certainly a *Porambonites* (see Quart. Journ. Geol. Soc. vol. ix. p. 8), but I do not wish to name the species from a single specimen.

7. Spirifer antiquissimus, spec. nov. Pl. XVII. figs. 10–12.

To all appearance this is a *Spirifer*, and I am compelled from the structure of the teeth to describe it as such. But we have a British species of *Orthis* (*O. spiriferoides*), in the Caradoc Sandstone, which exactly resembles it in outline and convexity. Otherwise I might believe, with my friend M. de Verneuil, that it was a Devonian fossil introduced into these beds. It would seem that there is at least one allied species of *Spirifer* in the French Silurian deposits—*S. Davidis*, Rouault.

We have three specimens of the dorsal (smaller) valve, which is 1 inch and $\frac{3}{10}$ths wide, and not so long as broad, being only 1 inch and $\frac{1}{10}$th in length, with a straight hinge-line as wide as the shell. The form is semioval and regularly convex, except a rather broad dorsal fold, which projects a good deal beyond the front margin and interrupts the otherwise regular semioval contour.

The sinus is about one-third the whole width at the front, and thence tapers regularly to the hinge; it is abruptly raised and then flattened above, and both it and the rest of the shell are regularly covered by radiating ribs, about four in the space of a line, which are uniform from the beak to the front, not interrupted by ridges of growth, nor interlined by other ribs.

The internal cast shows the teeth widely divaricating at an angle of 130°, and without the strong central cardinal process which would be present if it were an *Orthis*. The muscular impressions are elongate, instead of quadrate. The median septum extends two-thirds down the shell. The opposite valve has the strong, thickened, and slightly divergent lamellæ characteristic of *Spirifer*, a high but narrow cardinal area (fig. 12), above which the thick convex beak is slightly incurved.

We have a variety in which the sinus is not only depressed more than usual, but has a furrow down its middle.

8. Spirifer Davidis, Rouault? Pl. XVII. fig. 13. Rouault, Bull. Soc. Géol. Fr. 2nd ser. vol. viii. p. 368.

The shape agrees with that of M. Rouault's shell, which however has fewer ribs—only thirty-six in all.

These are the oldest-known species of the genus; if indeed it be not the case that they are, as above suggested, pebbles from some Devonian rock, mixed with the others.

9. Leptæna Vicaryi, spec. nov. Pl. XVII. figs. 16, 17.

Nearly nine lines long by eleven wide, and with a depth of five lines. The larger valve of this species presents a highly inflated form, gibbous in fact, for the convexity is greatest above the middle of the shell. The beak is very prominent and projecting in front, and rather compressed than broad. There is a very slight central sinus, but no fold in front, the shell being quite regularly convex throughout. The hinge-line is just equal to the width, the ears square, and the front angles rounded off.

We have only one (internal) cast of the larger valve. It shows deep radiate muscular scars near the beak, on each side, and is somewhat rugose within. Of the other valve there are two external casts (fig. 17), which show it to have been regularly but not so deeply concave as the other, with a few concentric wavy lines of growth, becoming rather strong rugæ along the hinge-line. These ridges decussate the margin roughly, and become grouped in pairs or threes, mixed too with frequent short longitudinal depressions, which give the idea of bases of spines, and which are scattered all over the surface (probably of both valves). The central line is concave in a narrowed area (as the other valve is convex along the median space), and there is a depressed line answering to the median plate within. Faint radii occur on the surface of both valves.

I know no Silurian species, except the small *L. quadrata* of Russia and *L. tenuicincta* of Britain, which resembles this in form. Both are much smaller and less gibbous.

10. Rhynchonella, sp. Pl. XVII. fig. 15.

This is certainly not the *Terebratula Thebeaultii*, Rouault, from Gahard, Rennes; and I know no other French form to compare with it. It is not unlike several of our British Caradoc forms, and is not worth a separate description. It, too, may possibly be a Devonian fossil introduced into these beds: M. de Verneuil thinks it very like *R. Pareti*, a common Devonian fossil in W. Europe. It has thin, subparallel, short cardinal lamellæ.

11. Rhynchonella, sp. Pl. XVII. fig. 14.

A remarkable fossil, which, if it were more perfect, should receive a name. It is singularly inflated, both on the sides and in the great dorsal fold, which occupies one-half of the width, and is $\frac{7}{10}$ths of an inch long, and scarcely so wide, while the depth of the single dorsal valve we possess is $\frac{4}{10}$ths. The shape is broad-ovate, the beak much pointed and rather produced, the sides arched, inflated, and separated by a rather broad depressed space from the raised sinus, which has four strong plaits. The sides are only faintly ribbed. The front is strongly incurved.

The hinge-teeth diverge widely at 120°, and are broad and thick for the genus.

LAMELLIBRANCHIATA.

1. Modiolopsis Armorici, sp. nov. Pl. XVI. figs. 1, 1 *a*.

This large and fine shell is particularly abundant in the pebble-bed; it is an excellent example of the Silurian *Modiolopsis*, a genus conveniently enough separated from the living *Modiola*, while it is not easy to find absolute characters for it. The stronger anterior muscle is a good general mark, and the form of the shell is usually much rounder than in the modern genus. It is identical with a species common in the May Sandstone of Caen.

About 2 inches wide, $1\frac{1}{2}$ inch in height, and with the united valves $\frac{3}{4}$ths of an inch thick. The shape is transverse-oval, a good deal broader behind than at the beaks, which are very slightly prominent, and lie at the anterior fifth. From thence to the posterior angle runs a regular convexity, not separated by any defined sinus from the flatter anterior slope. The beak is not very convex. Anterior margin strictly rounded. Posterior margin also rounded, the posterior slope not much flattened, and its cardinal angle obtuse. The whole shell covered by concentric lines of growth, interrupted in the outer half of the full-grown shell by several distinct sharp rugæ, placed equally apart from one another. These ridges or varices do not imbricate, but lie at the same level of the shell.

A transverse variety, with less conspicuous ridges and closer lines of growth, may be a distinct species. We have not room to figure it.

2. Modiolopsis liratus, sp. nov. Pl. XVI. fig. 4.

Transverse-ovate; length $1\frac{3}{4}$ inch; height 13 lines; depth of united valves 8 lines. Anterior side produced, rather narrow, rounded. Beak at the anterior fourth. Posterior margin somewhat obliquely truncated above, the angle rounded off; no sinus.

Whole surface concentrically striate, but not closely so, passing on the anterior side into close-set wrinkles tolerably equal in size over the anterior portion from beneath the beak forwards.

We have only one valve. It is a narrower species than the last, and the close wrinkling of the front is a good character. This also occurs in the May Sandstone of France (De Verneuil, *in literis*).

3. MODIOLOPSIS, sp. Pl. XVI. fig. 2.

Clearly distinct by its subquadrate form, but not perfect enough to require a name. It is nearest to *M. Armorici.*

4. MODIOLOPSIS OBLIQUUS, spec. nov. Pl. XVI. fig. 3 (and 3*c*, young).

Trapezoidal, the anterior side a little produced and narrow, the posterior broad and expanded, the posterior angle rounded. Beaks compressed, close, placed at the anterior third; the umbonal ridge distinct, prominent, rounded; the posterior slope somewhat flattened, the anterior much so, and with a slight marginal sinus, not forming a lobe. Lines of growth conspicuous, becoming irregular wrinkles over the anterior slope. Anterior muscular scar large, not deep, placed high up towards the beak; ligamental ridge well defined, but not prominent.

The young shell (fig. 3 *c*) shows the marginal sinus even more distinctly than the old, and was at first taken for a distinct species. I do not know that this form occurs in France.

5. MODIOLOPSIS LINGUALIS, sp. nov. Pl. XVI. fig. 5.

A small species, easily distinguished from the above by the following characters.

The length is three-quarters of an inch; the breadth posteriorly half an inch, beneath the beak hardly more than quarter of an inch; the depth of the valve slight. The beak is placed far forwards, the posterior slope convex; a distinct sinus separates this, behind the anterior third, from the rather flattened anterior slope. The posterior margin is much rounded. The surface smooth, except a few ridges of growth, most visible on the anterior portion.

It may be compared with such species as the *M. expansa*, Portlock, or the *M. modiolaris*, M'Coy (Siluria, 2nd edit. p. 213), but is quite distinct.

6. CLIDOPHORUS? AMYGDALUS, spec. nov. Pl. XVI. fig. 6.

Sixteen lines long by 8½ high, the depth of the united valves being fully half an inch. Transverse oval-oblong, gibbous; the beaks depressed, closely approximate, and very near the small rounded anterior end, which has a strong circular muscular scar. A strong diagonal rounded ridge runs from the low beak to the rounded posterior margin. The disk convex, the posterior slope only slightly flattened. Surface concentrically striate.

The hinge has the subcardinal ligamental posterior ridge short and slight, and anteriorly shows a pair of divergent teeth. The genus is doubtful. The affinity of *Clidophorus* with the *Arcadæ* is not yet settled, but there is a good deal of resemblance, in the species here described, to such forms as *Redonia*. This form occurs in the Caen Sandstone (De Verneuil).

PSEUDAXINUS, gen. nov.

We have for some time wanted a name under which to include a series of thin edentulous Silurian shells, which Professor M'Coy has arranged provisionally in his genus *Anodontopsis*. There is no certainty that *Pseudaxinus* is related to *Modiola*, although *Anodontopsis* belongs to that group; and the presumption is against it. It may quite as likely be an edentulous form of *Arcadæ*.

Thin, edentulous, convex, with prominent umbones and a strong posterior carinated ridge; beaks anterior; no lunette. Surface smooth or only concentrically striate.

Types, *P.* (*Anodontopsis*) *securiformis*, M'Coy, and *P. trigonus*, here described.

7. Pseudaxinus trigonus, spec. nov. Pl. XV. fig. 6.

Eleven lines long, and ten high; the depth of the united convex valves being $7\frac{1}{2}$ lines. Beaks very prominent, almost gibbous, from which a strong carina runs to the posterior angle. Anterior side very convex, rounded, somewhat oblique, with no lunette or depression beneath the beak; posterior side obliquely truncate, pointed, concave. Surface with fine concentric striæ.

Hippomya, gen. nov. (Fam. Mytilidæ.)

A curious shell, whose affinities with the *Mytilidæ* I do not think doubtful, but which may probably indicate still more closely the relation between this group and the *Arcadæ*. In no living genera allied to *Modiola* is there so extensive a development of the foot and byssus as must have been here present, to give rise to the great horseshoe-shaped sinus on the anterior part of the ventral aspect. The typical *Arcadæ* (*Byssoarca*) have a somewhat similar character. Yet this is a thin shell, with close umbones and no trace of cardinal area, while the obscurity in our specimen of any muscular scars prevents a close comparison with the genera of either group. I cannot help suspecting that *Modiolarca* is its nearest ally *. The name may be understood to have only a general signification, and not to indicate any close relations with *Mya*. The shell does not gape at either end, except for the foot and byssus.

A gibbous shell, with anterior inflated close beaks, a long cardinal edge, but no area, not gaping at either end, the anterior side short, rounded, and separated by a strong sinus from the inflated posterior ridge and slope; surface with lines of growth only, no radii. Anterior margin, for nearly half the length of the shell, strongly incurved, and widely open for the passage of a large ovate byssus, which was probably very short, horny, and disk-like.

8. Hippomya ringens, sp. nov. Pl. XV. fig. 7.

An inch and a quarter long by ten lines high, and depth of united valves fully one inch. The valves are obliquely trapezoidal-ovate, the posterior margin obliquely truncate above, the anterior equally truncate below and parallel to it. A regular gibbosity marks the posterior slope, greatest in the middle of the shell, which is decidedly

* See Woodward, Ann. Nat. Hist. 1856.

constricted behind the anterior or byssal portion, and is covered by lines of rugæ and lines of growth.

9. ORTHONOTA GRAMMYSIOIDES, sp. nov. Pl. XVI. fig. 10.

(Compare *Cypricardia Ludoviciana*, Rouault, Bull. Soc. Géol. Fr. 2nd ser. vol. viii. p. 374.)

Transverse oblong, rounded at both ends, with prominent curved beaks overhanging the thin edentulous hinge-line. A broad depression runs from the beak to the front margin, making the shell trilobed, and partially obliterating the strong concentric rugæ which ornament the whole shell. These are very strong rounded ridges on the convex anterior portion, and become duplicated and interlined as they pass over the abrupt but not keeled umbonal ridge behind.

The ornaments on this pretty species (which, notwithstanding some discrepancies, closely resembles Rouault's shell from Gahard) recal those of *Grammysia*, to which the genus *Orthonota* is closely allied. The name is intended to express this affinity. M. de Verneuil thinks this, too, may be Devonian. I confess I do not.

Cypricardia Mariana, Rouault, appears to belong to the same group, but has fine concentric ridges.

10. LYRODESMA CÆLATA, spec. nov. Pl. XVI. fig. 7.

Ovate, 11 lines long by half an inch high at the slightly prominent beak, which is placed at the posterior? * fourth, where the shell is widest. In advance of this the shell tapers rapidly, and the anterior? end is obtusely pointed, almost almond-shaped.

The surface is closely covered with fine lines of growth, but appears smooth. The muscular scars are deep, divided from the umbonal cavity by thick subcardinal ridges. The hinge-plate broad, and has beneath the beak six or seven radiating teeth, of which the posterior? one (that nearest the rounded end) is the largest.

11. ARCA? NARANJOANA, De Vern.? Pl. XVI. fig. 8. Bull. Soc. Géol. Fr. 2nd ser. vol. xii. 1855, pl. 26. fig. 12.

This agrees so well with De Verneuil's figure and description (except the hinge-area, which we cannot see) that I do not like to give a new name. It is a little shorter in proportion. I doubt its being an *Arca*.

12. PALÆARCA † SECUNDA, spec. nov. Pl. XVI. fig. 9.

Nearly an inch wide, three-quarters high, and, with valves united, 4 lines thick. Subtrigonal-ovate, the beak placed at the anterior? fourth, pointed, but not incurved. Anterior and ventral margins well rounded, posterior truncate. Umbonal ridge angular, arched, leaving but a narrow vertical anterior slope. Lunette? Hinge-

* I am not sure that the *Lyrodesma* falls into the usual character of the *Nuculæ* in having the beak posterior.

† For the characters of this genus see Billings's Reports (under *Cyrtodonta*), 1857, and the Memoirs of the Geol. Survey Canada, vol. iii. (ined.).

area much arched, furnished with four or five oblique teeth, which are all in the same direction; hence the name. There are three distinct and very oblique nearly transverse teeth in front of the beak, and behind it one long cardinal tooth in each valve, as indicated by the cast. This long tooth reaches to the extremity of the arched hinge-line, and is quite parallel to the margin. The others radiate more or less, not from the beak outwards (as in the *Lyrodesma,* just described) but from the lower edge of the hinge-plate; the muscular scar in front is large and round, the hinder one elongated.

The subtrigonal shape distinguishes this easily from all the Canadian species (Geol. Canada, 1863, p. 147, &c.). None of the British species have so narrow and pointed a posterior end.

13. Ctenodonta Bertrandi, Rouault, sp. Pl. XV. fig. 8.

Nucula Bertrandi, Rouault, Bull. Soc. Géol. Fr. 2nd ser. vol. iv. 1846–47, p. 322.

I do not feel certain of this identification, but M. de Verneuil, in his letter to me, admits it.

14. Solen? (or some allied genus). Pl. XVI. fig. 11.

There are, besides the above, a *Strophomena* somewhat allied to *S. compressa,* 'Sil. Syst.,' and of about the same size, plano-convex in form; two species of *Bellerophon*; an *Orthoceras* with close septa and a nearly lateral siphon, and one or two other smooth species of the same genus; and several undescribed Lamellibranchiata, which must await illustration at some future opportunity.

EXPLANATION OF PLATES XV., XVI., XVII.

Illustrative of Fossils from Budleigh Salterton.

Plate XV.

Fig. 1. *Homalonotus Brongniarti,* Deslongchamps, sp.: *a,* glabella and fixed cheeks; *b,* free cheek; *c,* thorax-joint; *d,* tail, showing serrate margin.
2. *H. Brongniarti,* var. with somewhat squarer outline to head.
3. *Homalonotus,* sp. not yet described in France or England.
4. *Phacops incertus,* Deslongch., sp.: *a,* interior cast of head; *b,* exterior mould, in gutta-percha, of the tail-piece.
5. *Calymene Tristani,* Brongn. Interior cast of tail.
6. *Pseudaxinus trigonus,* Salter. Two views of an interior cast of the right valve of a thin shell.
7. *Hippomya ringens,* Salter: *a,* dorsal view; *b,* ventral view, showing the passage for the huge byssus.
8. *Ctenodonta Bertrandi,* Rouault: *a,* interior of right valve; *b,* magnified surface.
9. *Trachyderma serrata,* Salter: *a* shows the projecting squamose ridges of the tube; *b* is a rough interior cast.

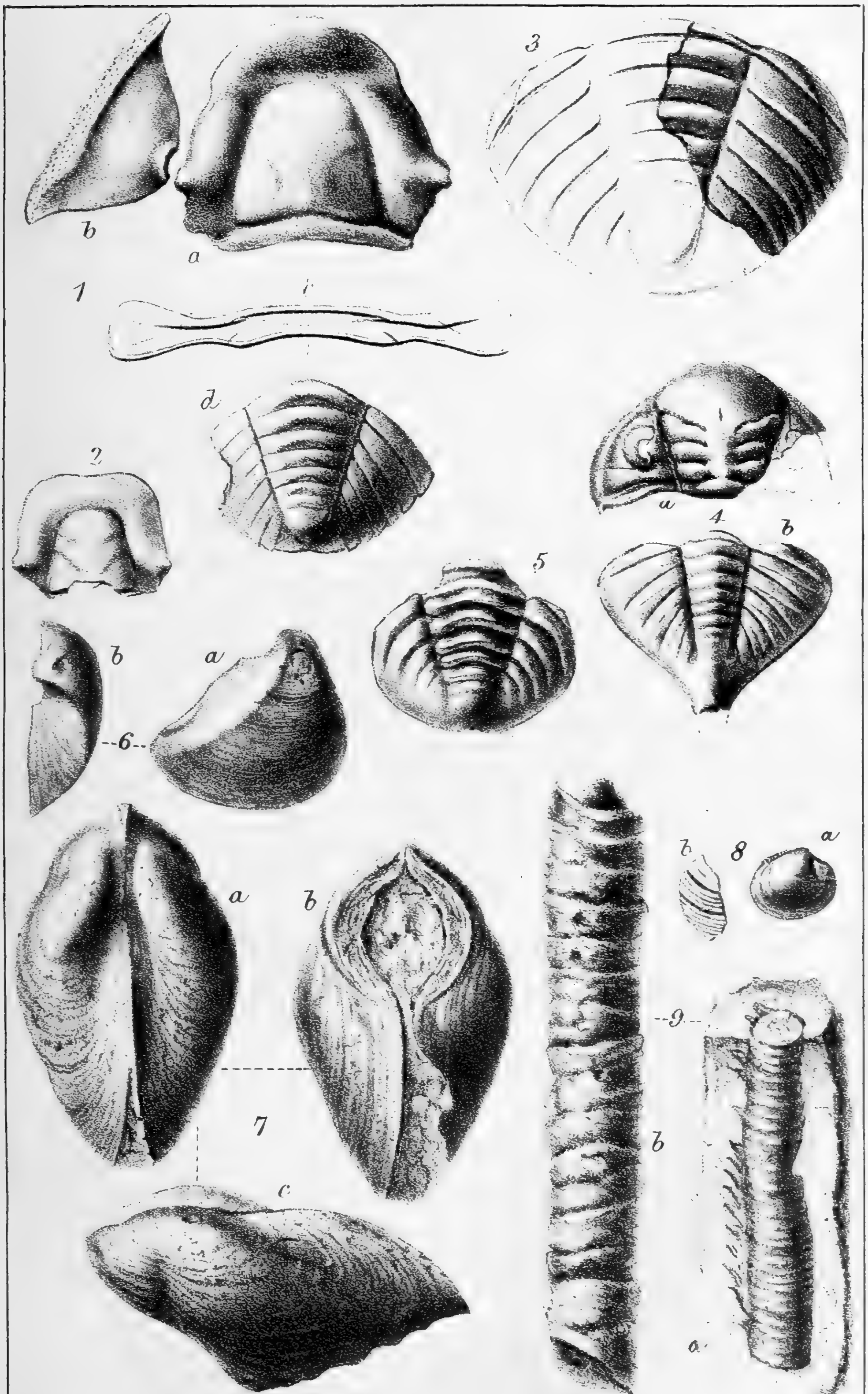
Plate XVI.

Fig. 1. *Modiolopsis Armorici,* spec. nov.: *a,* cast of interior, right valve; *b,* dorsal view of broken pair of valves.
2. *Modiolopsis,* sp.: cast of left valve, and edge-view of ditto.

Fig. 3. *Modiolopsis obliquus*, spec. nov.: *a*, interior cast of left valve; *b*, restored figure; *c*, right valve of young specimen.
4. *Modiolopsis liratus*, spec. nov.: left valve, interior cast, and edge-view of the same.
5. *Modiolopsis lingualis*, spec. nov.: right valve, interior cast.
6. *Clidophorus? amygdalus*, spec. nov.: *a*, interior cast of right valve; *b*, edge-view; *c*, restored hinge from gutta-percha cast.
7. *Lyrodesma cœlata*, spec. nov.: *a*, interior of right valve; *b*, hinge, cast in gutta-percha from *a*.
8. *Arca? Naranjoana?*, De Verneuil. Right and left valves, interior casts.
9. *Palæarca secunda*, spec. nov.: *a*, interior cast of left valve; *b*, edge-view; *c*, hinge, cast in gutta-percha from *a*.
10. *Orthonota Grammysioides*, spec. nov.: *a*, right valve; *b*, edge-view.
11. *Solen?*, sp. Imperfect external impression of right valve.

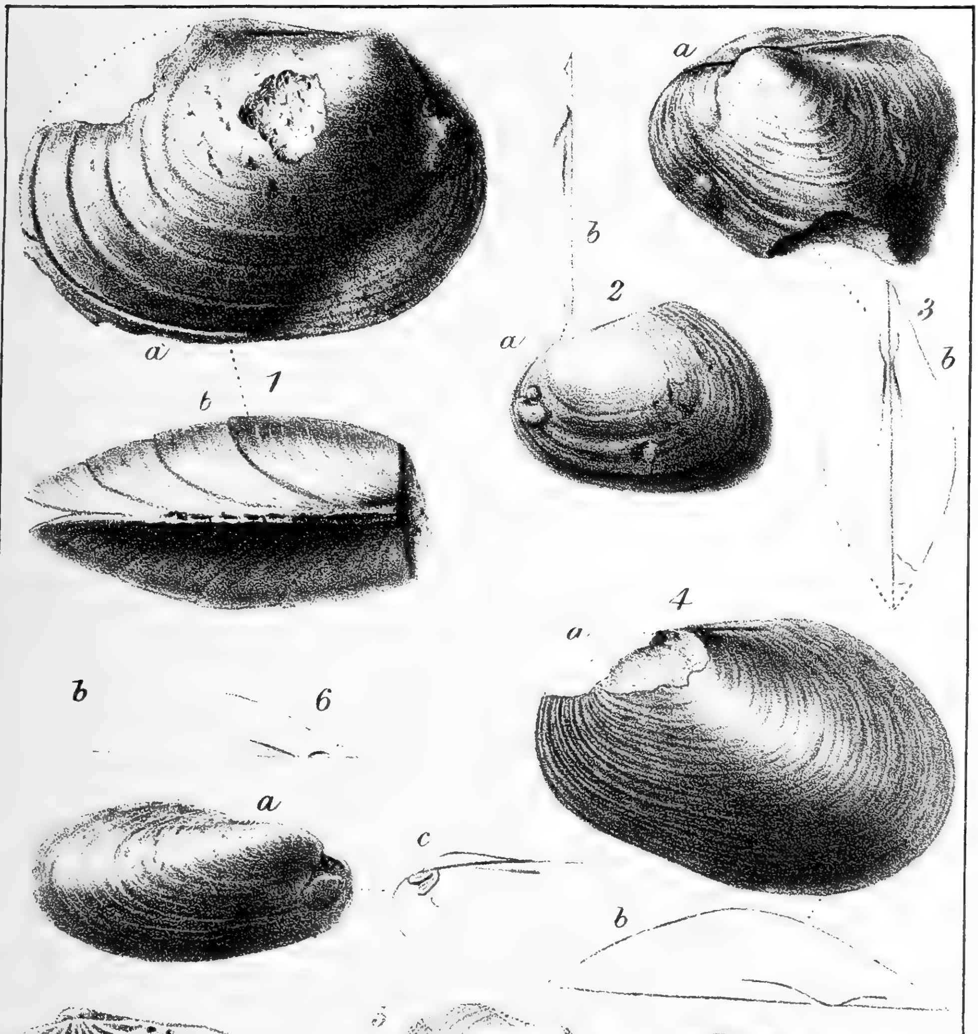
Plate XVII.

Fig. 1. *Lingula Lesueuri*, Rouault.
2, 3. *L. Hawkei*, Rouault. Both valves, and edge-view of the same.
4, 5. *L. Rouaulti*, spec. nov. Upper and lower valves: 4*a*, edge-view of united valves.
6. *L. Brimonti*, Rouault. Smaller valve.
7. *Orthis redux*, Barrande: *a*, *b*, interior casts of dorsal valve; *c*, interior casts of ventral valve.
7*d*. Variety with deeper furrows, dorsal valve.
8. *Orthis pulvinata*, spec. nov. Interior dorsal valve.
9. *Porambonites*, sp.
10, 11. *Spirifer antiquissimus*, spec. nov. Interior casts of dorsal valve: 10 *a*, edge-view of ditto.
12. Interior cast of ventral valve of ditto.
13. *S. Davidis*, Rouault? Interior of dorsal valve.
14. *Rhynchonella*, sp. } Possibly Devonian forms.
15. ——, sp. }
16, 17. *Leptæna Vicaryi*, spec. nov.: 16 *a*, *b*, two views, internal cast of the deep ventral valve; 17, cast of external surface of the concave smaller or dorsal valve.



J.W. Salter, A. Gawan, lith ad nat. W. West imp.

FOSSILS FROM BUDLEIGH SALTERTON.



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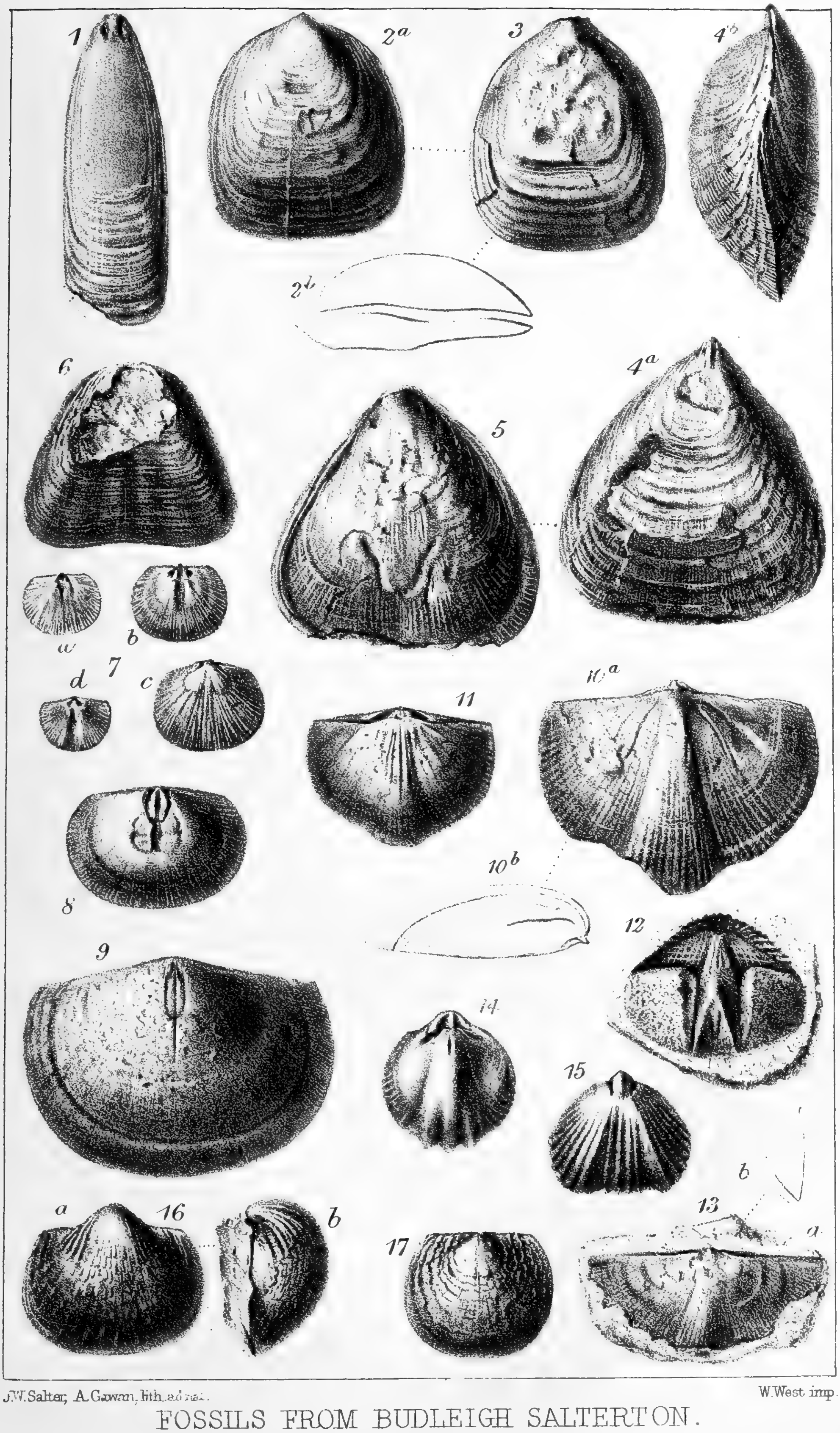

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 13, 1864.

James Cope, Esq., Mining Engineer, Wolverhampton; The Rev. Burford Waring Gibsone, M.A. Cantab., B.Sc. Lond., F.C.S., Mercers' School, London; Dr. James Alexander Grant, of Ottawa, Canada; James Pilbrow, Esq., F.S.A., M.I.C.E., Somerset House, Guildford; and The Rev. J. L. Rome, Hull, Yorkshire, were elected Fellows.

The following communications were read:—

1. *Notes on the* Geology *and* Mines *of* Nevada Territory (Washoe Silver Region, U. S.). By William Phipps Blake, Esq.

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

Contents.

I. *Physical Geography.*—The territory of Nevada is limited by the following boundaries:—on the west by the State of California, following for a considerable distance the crest of the Sierra Nevada; on the north by Oregon, as far east as the Goose Creek Mountains;

and on the south by the northern line of New Mexico, or the parallel of 37°; it thus extends over about five degrees of latitude and longitude, and contains more than 65,000 square miles.

This territory comprises a large part of the great basin of Fremont, the general physical characters of which have been so often described. It is an elevated semi-desert region, its surface being a constant succession of longitudinal mountain-ranges, with intermediate valleys and plains, most of which are independent basins, hemmed in by mountains on all sides; and the whole system is without drainage to the sea. The general elevation of these valleys is over 4500 feet above the sea, and the mountains rise from 1000 to 4000 feet, and in some instances, perhaps, to 8000 feet higher.

The Humboldt is the principal range in the eastern part of the territory, and is probably even more lofty than the Sierra Nevada. This and the Goose Creek Range, together with most of the others, run in a north and south direction, and have rugged and precipitous slopes. The Washoe or Silver Range, upon the flanks of which the principal gold- and silver-veins have been discovered, extends for nearly fifteen miles parallel with the Sierra Nevada, and about twenty miles east of it. The included valley is partly occupied by Washoe Lake, and is known as Washoe Valley.

II. *Geology.*—Very little is yet known of the geology of the Nevada Territory, and it presents a most interesting and promising field for future exploration. We may say, generally, that it is a region of intense igneous disturbance and metamorphism, and that the prevailing rocks are granitic, metamorphic, and porphyritic, with trap, basalt, and lava, the porphyries and igneous rocks being very common. Carboniferous limestones and sandstones have been observed in the Humboldt Mountains, and in the ranges eastward to the Great Salt Lake. The extent of this formation is not known.

In the absence of further general information upon the geology of Nevada, the following notes made upon the route from California to the principal mines are presented to the Society. On entering the Territory from California by the route up the south fork of the American River from Racerville, we find a compact homogeneous granite of a grey colour, extending on both sides of Truckee or Bigler Lake, and forming the main bulk of the double crest of the Sierra Nevada. One of these crests is within the limits of Nevada, and stretches far to the north and south in a line of summits, which are covered with snow for the greater part of the year. From the summit of Daggett's Pass, an elevation of more than 6000 feet, there is a fine view of the valley of Carson River, which is about 2000 feet below. The descent is rapid, and by a fine road, or grade, cut zigzag in the half-decomposed granite of the steep slope. On reaching the valley, the road is over the drift-accumulation from the mountains, and along the borders of the later alluvial deposits of Carson River, until the town of Genoa is reached, where the rocks change and the surface is covered by boulders and fragments of metamorphosed rocks (of sandstone and clay-slate), which skirt the base of the granite-mountains. In a line with them, further north in Washoe Valley, beds of limestone have been found. Parallel with these rocks and with the mountains, thermal springs rise in a line through the drift and superficial deposits, sending their waters into the marshes of the low ground, in the middle of the valley.

From Genoa to Carson City the road follows an alluvial and sandy plain. Near Carson there are outcrops of horizontal strata of coarse-grained sandstone, thickly bedded, showing the action of rapid currents during its formation, and probably of Tertiary age. These strata are quarried for building-stone. A few miles beyond there is an outcrop of massive porphyritic conglomerate, of ancient date and highly inclined stratification; it is composed of boulders, coarse gravel, and angular masses, all very firmly cemented together; it is evidently much metamorphosed, and may be a portion of an extended formation. Outcrops of a bluish-grey rock, like a metamorphic sandstone, were seen at a short distance beyond. A coarse porphyritic conglomerate, similar to that described, is extensively developed in the silver region of Arizona.

Leaving these ridges, and traversing a dusty plain, horizontal strata make their appearance on the sides of a slight declivity, called Chalk Mountains, by which the road descends to a lower plain. These strata are white and very soft. Similar rocks occur in other parts of the Territory, and are compact, smooth, and soft, so that they may be cut and carved like meerschaum. Some fragments of this rock placed under a microscope did not, however, show any traces of organized structures. This white formation is probably conformable with, and lies above, the horizontal sandstones at the springs near Carson.

Near the lower part of Gold Cañon, below Silver City, the road deflects from the Overland Mail Route, or Old Emigrant Road, and ascends the lower slopes of the south end of the Washoe or Silver Range. Here rugged outcrops of a compact, light-coloured, felspathic porphyry are numerous, and their débris covers the ground. These porphyries are traversed by many veins of quartz with their crystals pointing inwards, as in true fissure-veins; they are very numerous, and from a few inches to many feet in width. The ground is in every direction covered with their fragments, which have been broken out by weathering, or by the gradual decay of the enveloping porphyry. The size and number of these loose veinstones increase as Gold Cañon is ascended, up to its head on the side of Mount Davidson.

Mount Davidson is the principal peak of the Washoe Range, and a central point and landmark of the Washoe Region. The Comstock Lode, Goldhill Lode, and others cut its eastern flank towards the base, the latter at the head of Gold Cañon, and the former a mile or two beyond, at the head of Six-mile Cañon, extending eastwardly to the plains of the Carson. The whole of this mountain, and, indeed, the greater part of the Washoe Range, between Virginia City and Washoe Lake, are composed of fine-grained, light-coloured felspar-porphyry, quartz-porphyry, and porphyritic greenstones, with some basalts and overlying volcanic rocks. So also, on either side of Six-mile Cañon, from Virginia City to the desert-plains of Carson Valley, we find porphyry with occasional belts of greenstone, and heavy ledges of quartz vein-stone. The sides of this cañon are very rugged and abrupt, and the porphyry forms sharp serrated spurs and ridges, with overhanging cliffs. This is also the case at intervals along Gold Cañon, especially at Silver City and the narrow passage called the Devil's Gate, where two opposite spurs nearly close the cañon, leaving scarcely room for a roadway.

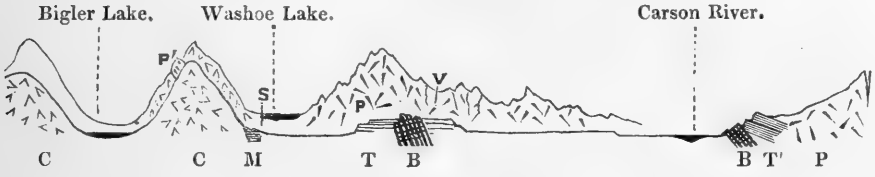
These porphyries weather very unequally: in some places the cliffs are surrounded by a talus of small angular fragments, often laminated; in others the fragments are solid rounded blocks, or long oval-shaped masses. Some of the larger outcrops on Mount Davidson have a rude columnar structure, with the columns tapering to a blunt rounded point, much like the porphyries of Western Texas, about Fort Davis. In general there is no distinct trend, nor any signs of bedding in these masses; but cleavage-planes appear to extend in many different directions, and are much more developed at some points than at others. Careful observation, however, will show, here and there, what appear to be traces of original stratification, and an obscure granular structure, like that of a partially changed sandstone, and at other points finer and more compact varieties, such, for example, as rise up into laminated fragments, which may once have been clay-slate. A large portion of the porphyry is quartzose, the siliceous grains being glassy, and without distinct forms of crystallization. The weathered outcrops are nearly all of a light drab or yellowish colour, with a reddish or rose tinge. Below the water-level in the mines on the Cornstock Lode, the colour is generally olive-green, or greyish green of various shades.

An outcrop of porphyry, different from these and very interesting in its character, occurs in the midst of the granite of the Sierra Nevada, between Carson and Bigler Lake, on the New Lake Road. It is not very extensive, but is composed of distinct and often well-formed crystals of felspar a quarter of an inch or more in length, and of crystals of black mica, in hexagonal prisms, imbedded in a lilac-coloured matrix. The outer portions are comparatively soft, and the crystals of mica and felspar may be detached by the aid of a hammer. Mr. Pampelly has seen a porphyry similar to this in the Silver Region of Arizona, thus affording the second point of similarity noted between the rocks of the two regions.

The rocks forming the mountains on the southern side of the Carson Desert, and on the right bank of the river, are similar to those around Virginia City and Mount Davidson, at least on the north side; but they have not been much explored. At one place, near where Colonel Whitmans discovered coal, I observed a semi-metamorphic porphyritic conglomerate similar to that seen between Carson and Chalk Hill. There are also regular strata of clay-shales and of sandstones, with bituminous shales and beds of brown coal, not fully opened at the time of my visit. These strata are probably Tertiary.

The formations which have been successively noticed are shown in their relative positions in the annexed sketch-section across the region from Lake Bigler to the mountains beyond the Carson.

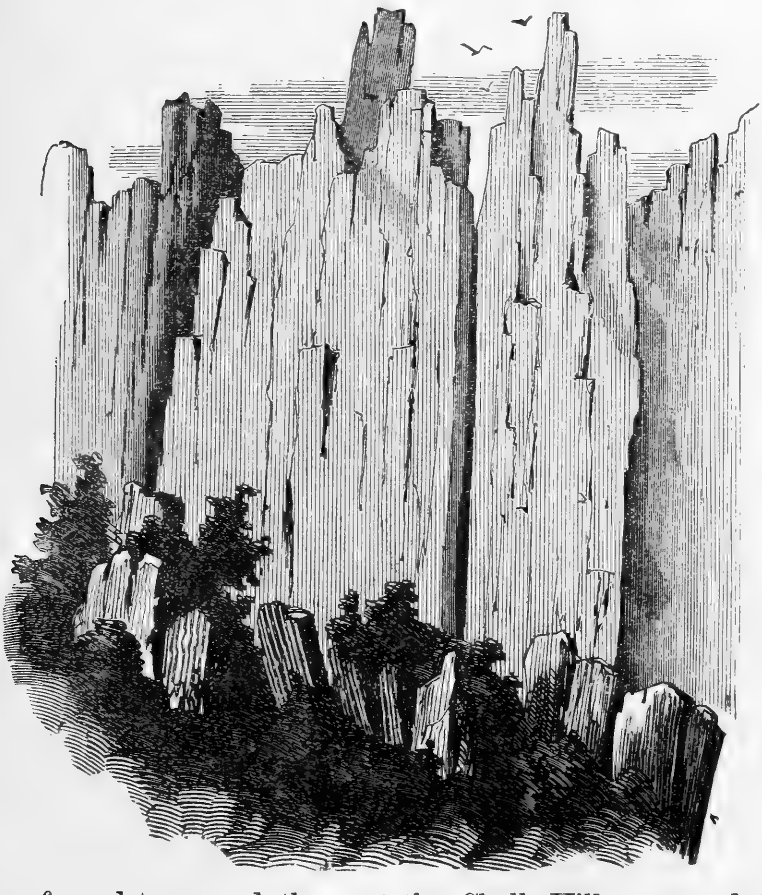
Fig. 1.—*Section from Lake Bigler to the Mountains beyond Carson River.*



C. Granite.
P. Porphyry.
P'. Porphyry of Sierra Nevada.
B. Porphyry-conglomerate and breccia.
T. Horizontal sandstone-strata of Chalk Hill.
T'. Clay-slate, with bitumen and brown coal.
S. Line of Thermal Springs.
V. Virginia City and Cornstock Lode.
M. Metamorphic rocks near Genoa.

In this section, the plains along the course of the Carson are shown in the foreground, with the slight exposures of the horizontal

Fig. 2.—*Sketch of Granite-masses near Carson.*

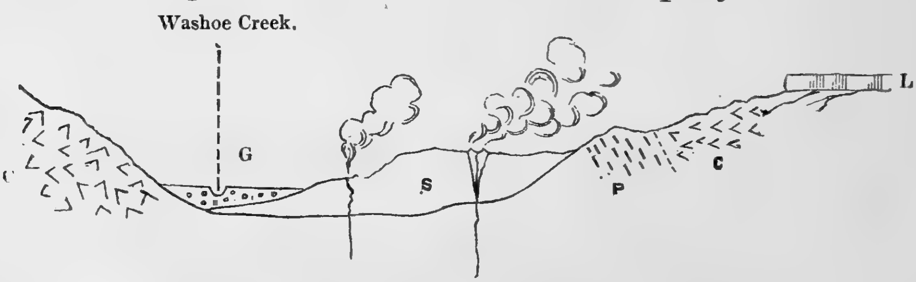


strata of sandstone, and those at the Chalk Hill, supposed to be Tertiary, together with the outcrop of porphyritic conglomerate unconformable to them. Mount Davidson and a part of the second range or summit of the Sierra are sketched in the background, so as to show as nearly as possible their position relatively to the section on the plain. The porphyritic conglomerate probably extends through the Mount Davidson and Washoe Ranges, but it was not seen there. The second outcrop to the right of Carson River would seem, from the section, to sustain the relation of a dyke to the tilted beds containing the brown coal, but it is merely intended to indicate their nonconformity. In describing the granite of the western slope of the Sierra Nevada, near the plains of the Great Basin, it should have been observed, in addition to the description of the outcrops of metamorphic rocks near Genoa, that in the pass to Lake Bigler, a few miles south of Carson, the lower exposures and ridges of the granite present some remarkable evidences of former stratification, as seen in the accompanying outline-sketch (fig. 2). These vertical masses of rock rise from 50 to 150 feet above the crests of the ridges. This structure is brought out more clearly by weathering.

III. *Hot Springs.*—Thermal springs of considerable volume are numerous in various parts of the Territory; but the most extensive and interesting are, probably, those known as the Steamboat Springs, about ten miles north-west of Virginia City, and bordering on Washoe Creek.

The position of these springs is marked by columns of steam rising in a line above a white mound, about a quarter of a mile long and forty or fifty feet higher than the bed of the creek. Two or three fissures extend through the centre of the whole length of the mound, and it is from these, at different points, that jets of steam ascend. The section (fig. 3) will show the form of the mound and the relation of the springs to the adjoining rocks.

Fig. 3.—*Section across the Steamboat Springs.*



C. Granite. G. Gravel. L. Limestone. P. Porphyry.
S. Deposit from the springs.

The direction of the fissures is 15° to 20° N. of W., apparently following the line of division between compact grey granite, like that of the Sierra Nevada, and a bed of porphyry; though this could not be ascertained with any certainty, owing to the thick deposit produced by the springs and the alluvium beyond. They vary from three to twelve inches in width, and are vertical; but they are so irregular and rugged at the sides that they cannot be probed or sounded to any great depth. A constant gurgling sound is heard, like water boiling, and the ebullition may be seen in some places about ten feet below the surface of the crest. The steam does not rise equally along the whole length of the fissure, but escapes at intervals, as if it were confined in tube-like channels or pipes below, and with a puffing noise like that of a steam-engine—whence their name.

The water appears to stand and cool in the fissures, while the steam bubbles through it at different points. At the extreme ends of the mound, and on its flank, there are several basin-shaped springs or caldrons, from which hot water and steam rise together, some of them spouting upwards and overflowing at intervals. In one of the largest of these intermittent springs the water stands quietly about two feet below the top of the basin, and, at regular intervals of about four minutes, suddenly rises in violent ebullition and flows out.

This mound, some two or three acres in extent, and as white as chalk, consists chiefly of silica (siliceous sinter), deposited by the water in an amorphous granular state. The deposition in the basin-shaped springs is very rapid, and forms elevated annular mounds. Where the water stands in pools, the silex forms crusts like ice around the edges. In trickling down it forms stalactites, or partly covers the currents running over slopes. Layer after layer is deposited on inclined surfaces, and some very good examples of the formation of banded agate and chalcedony were seen, the colour being given by oxide of iron and by organic matters, though in general the deposit was white. At some of the springs a thin black film-like oxide of manganese is deposited in the basin, where the heat is greatest, while the water that flows away deposits sesquioxide of iron beyond. Neither the specimens of the deposits nor of the water have yet been analysed.

Sulphur is abundantly produced and deposited among the cavities and fissures of the siliceous crust, especially around some of the steam-jets when the escape is through the fragments or loose débris of the fissure. It occurs largely in crusts, and in small crystals coating the fragments.

There are several remains of old basins upon the upper level of the mound, where the former overflowing of the springs is evident. These are now cut through by the fissures, so that the water falls to the level of the lower springs, and overflows at these only. The new fissure appears to have followed the line of the principal jets; and this change must have taken place within a few years, for the old basins are yet very perfect in form, half being on one side of the fissure and half on the other. This cracking of the superficial deposits is evidently the result of the widening of the ancient fissure in the rock below.

We may regard the whole as a fine example of the formation of a quartz vein along a fissure; for there is little doubt that, if the superficial deposits were swept away down to the granite or porphyry, we should find a fissure lined with quartz, and perhaps with sulphurets of the metals.

These springs are nearly in the line of prolongation of the hot springs at the base of the Sierra, near Genoa, and those at Carson City, already noticed; and they indicate an extensive fissure, or line of disruption, extending north and south and parallel with that chain.

Other hot springs are found along the Humboldt Mountains, and in the valley of Walker's River, near the Emigrant-trail. At the head of Honey Lake there are springs remarkable for their volume, and for the constant boiling of the water. This locality, although said to be within the limits of California, is in the Great Basin, and has all its surrounding physical features in common with those of Nevada. The occurrence of a bed of basaltic lava capping the slight knoll near the Steamboat Springs is interesting, and may have some connexion with their origin. The extent and source of this lava were not ascertained.

Extinct craters and beds of lava are reported to exist in various parts of the Territory; but no high volcanic cones, extinct or active, have yet been ascertained to exist*.

In conclusion, I may say that the facts presented, together with those about to be given upon the mineral veins, although scanty, corroborate the statement that the lithology and mineralogy of this Territory are very similar to those of the table-land of Arizona, Sonora, and Mexico.

IV. *Principal Mines and Veins.*—The presence of gold in places on the eastern side of the Sierra Nevada, about Carson Valley and Genoa, was well known before 1858.

The Virginia mining-district is established upon the Cornstock vein, and includes all the mines on the eastern slope of Mount Davidson and those on Mount Cedar, an adjoining elevation to the north. The Cornstock vein is subdivided into sixteen claims, the principal of which will now be examined in detail.

1. *Ophir Mine.*—The general characters of the Cornstock lode are shown to better advantage in this claim than in either of the others, owing to the greater amount of mining upon it. It is here seen to cut through the porphyry of Mount Davidson in a nearly north and south direction, with a westerly dip of about 70°. It rises to the surface within the limits of Virginia City. There was no outcrop visible, or but a slight one at intervals, the gangue or vein-stone being so soft and friable that it was completely broken down and mingled with the soil. The bold outcrop of the Virginia ledge is, however, directly above it, and is like a dyke curving over the summits of the spurs from the mountains. The Ophir Mine is worked to a depth of 200 feet: the general structure of the vein is shown by the accompanying section from wall to wall.

* J. C. Fremont traversed considerable portions of this Territory in his explorations across the continent, and observations on the rock-formations he saw may be found in his Report. Some will also be found in the Report of Lieut. Bickwith and Dr. Schiel, in the volume of the U. S. Pacific R. R. Expl. and Surveys. I have not been able to obtain access to either of these works.

Fig. 4.—*Section of the Cornstock Lode.*

It is divided into two portions at the level by a porphyritic mass, or "horse," which will probably thin out in depth, and the two parts of the vein will then become united in one. The walls on each side are compact porphyry of an olive or greyish-green colour, mottled with white, and charged in many places with iron-pyrites. The eastern part of the vein, which, for the past year, has been most worked, is 30 feet wide at the lower level, and consists of white granular quartz, so complely shattered or broken up that it may be crumbled with the hand, and requires to be carefully supported by timbers as the excavations progress. Portions of it are in a sandy or powdered state, and are traversed or intermingled with harder and more compact masses, and with a greenish porphyritic rock, like that of the central mass or "horse."

This great mass of friable quartz is traversed in almost every direction by veins or streaks of the richest sulphurets of silver, both brittle and sectile, and with free gold in irregular ragged grains. These veins or masses seldom reach a thickness of more than two or three inches, and are often merely crusts, or coatings, or seams in the quartz, and are from one-tenth to one-eighth of an inch thick. It is more common to find the silver ore ramified irregularly through the broken quartz, holding it together, and bearing the imprint of the flat surfaces of the irregularly crystalline mass. Galena and copper-pyrites, with white iron-pyrites, are associated with these sulphurets. In some of these irregular veins, and in cavities connected with them, beautiful crystals of *stephanite* (the brittle sulphuret of silver) occur. I also found one single fragment of ruby silver with the stephanite, but it is very rare. Filaments of native silver are frequently found; but in this soft ore gold is the most generally diffused metal, and is found in bright irregular particles among the sulphurets, or mingled with the friable quartz. It is entirely free, and may be collected and separated from the rest of the ore by washing in a pan. These patches and irregular veins of ore and metal in the soft quartz do not have, apparently, any prevailing direction, or connexion with the direction of the walls; but they have not been studied and mapped upon the plans with reference to this important practical point. They incline at various angles, and are frequently bent and shifted by local faults, or slides, from a few inches to several feet in extent. The ore is also found in isolated bunches or pockets in the midst of the white quartz, or irregularly sprinkled in grains through it; so that the whole may be profitably extracted.

Portions are granular mixtures of galena and sulphuret of silver, which minerals crumble into black powder in the hand, but are very rich. The other or eastern side of the vein, above the "horse," is very different; it is compact and hard, and has the usual character of fissure-veins. The quartz is firm and crystalline, and extends in a layer on each side of the ore, frequently including masses or nodules of it. This is one of the peculiarities of the vein throughout its extent, that small masses of ore (the sulphurets of lead, iron, and silver) form nodules or nuclei for the crystallization of the quartz. The mixed sulphurets (the ore of this part of the mine) are hard and compact, break with a granular sparkling fracture, and consist of galena with blende, iron-, and copper-pyrites, charged in varying degrees with sulphuret of silver, and in places with native silver and gold.

Some specimens, taken from the sides of cavities, exhibit very fine crystals of stephanite, from one quarter of an inch to two inches in length. The large crystals are irregular, and seldom have flat smooth surfaces, but are much striated, and, in form, lustre, and general appearance, very closely resemble the crystals of vitreous sulphuret of copper from the Bristol copper-mine in Connecticut. They are sometimes coated with filaments of native silver, and the metal is common in that part of the vein, especially, where the sulphurets abound.

In connexion with this west part of the lode, there is a layer or course of ore composed chiefly of galena, blende, and pyrites, forming a granular sparkling ore, but which is comparatively free from silver or gold.

2. *Gold Hill Vein.*—The vein of this name, south of Virginia City, though but little known beyond the territory of California, is, perhaps, the most important and promising of the whole region. The outcrop is a great mass of quartz vein-stone, standing up like a dyke or wall above the rugged exposures of bare porphyry around. It is at the head of Gold Cañon, near to, or on the slope of, the division between it and the head of Six-mile Cañon at Virginia City, being thus nearly in the line of prolongation of the Comstock and Virginia lodes. This quartz outcrop is nearly 100 feet wide, and forms the crest of the hill from which the place takes its name. The rich portion underlies the compact quartz, and, as far as yet

developed, consists of a mixture of crystalline quartz in aggregations and irregular seams, with a soft mass rich in free silver and gold. The ore corresponds to that called *colorado* in Mexico.

In width, the lode varies from 12 to 40 feet. In some specimens of the ore, free gold in fine grains is very thickly implanted over a rough surface of quartz stained with iron-rust; in others, the native silver forms a light bronze-like powder in cavities of the quartz. Chloride of silver is reported, but no distinct specimens came under my notice.

3. *Daney Lode.*—About five miles south of Silver City, and a mile south of the overland-mail route, the outcrop of a quartz-vein was discovered by Mr. Daney in 1860 and 1861, and has been shown to be very rich and promising. The outcrop is on the slope of a low porphyritic hill rising above the general level of the plains of Cañon Valley.

Shafts sunk proved that the vein was very regular, with a width of 12 to 13 feet, and an inclination north-easterly, its course being 65° N. to 80° W. The walls are regular, and consist of a compact felspathic porphyry of a dark-green colour below, and drab or yellowish at the outcrop. The vein-stone is quartz, and breaks out in hard rounded masses, looking like ordinary boulders, while between them the vein is soft, and the whole is much stained by the decomposition of a pyrites which is abundant, and seems to have softened the ore. The hard masses, when broken up, show a breccia of very small fragments, but thoroughly cemented, so as to be very hard and unyielding, yet full of small angular cavities lined with minute quartz crystals, and in those parts least affected by decomposition with pyrites. This pyrites appears to be rich in gold, and this metal is plainly seen in a large portion of the rusted ore. In one of these hard masses of quartz, taken to San Francisco early in 1861, I found isolated grains and patches of dark-red silver ore, or ruby silver, dispersed throughout the brecciated mass, giving it a greyish colour. The same was afterwards found abundantly at the mine, besides some small crystals of silver glance (sulphuret of silver), and threads of white native silver, together with native gold. The gold contains a large portion of silver, and is in granular masses adhering to and penetrating the quartz. It is most abundant in the soft clayey ore, which is, moreover, the most available for working.

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2. *On the* Hunstanton Red Rock. By Harry Seeley, Esq., F.G.S., of the Woodwardian Museum, Cambridge.

[Abstract.]

In the 'Annals of Natural History' for April 1861*, the author discussed what others had written on the age of the Red Rock, and in this paper he gave such account of the bed, where seen in the Huns'ton section, as subsequent observation had enabled him to prepare †.

* 3rd ser. vol. vii. p. 233.

† The notes and sections for this paper were made in March 1863.

The cliff is a curve, partly running nearly due north and south, and partly facing more to the east; so, as the deposit rises from the beach at the eastern end, its dip is south-easterly.

All observers concur in making its thickness about four feet, which is maintained from one end of the section to the other. But this is not all one layer; for throughout the cliff the Red Rock is seen to consist of three subdivisions of about equal thickness, and in many places so well parted by bedding as to form, by falling of the cliff, three overhanging cornices, the uppermost of which is often similarly overhung by the white sponge-rock band above.

Into the lower of these beds (which I will call No. 3), as in the others, the little brown and black shining pebbles, which form so conspicuous a feature in the Carstone sands, pass up, and are almost as numerous in the Huns'ton Red Rock as in the underlying beds. In slipping and falling, too, the Red Rock almost invariably goes with the Carstone, as though they were one formation, while cracks and fissures in the chalk do not affect the red beds. The sponge-band always follows the jointing of the other white chalk.

The uppermost of the three layers has the physical characters of chalk, breaking by joints, which present, on the cliff-face, long flat surfaces. The middle bed (No. 2) has a remarkable nodular concretionary character, which makes its surface on the cliff rugged. These concretions are of phosphate of lime; one of them, analyzed by Professor Liveing, yielded 11 per cent. of that substance. The lower layer is sandy, and not more clearly separated from the Carstone below than from the concretionary layer above; for the line of junction is only marked by colour, being otherwise quite indistinguishable, and not affected by weathering.

The upper bed is divided into two by a bedding which is not smooth, but nodular. As the colour is due to glauconite, it is possible the bedding may be owing to the same cause. The top surface is wrinkled and subnodular.

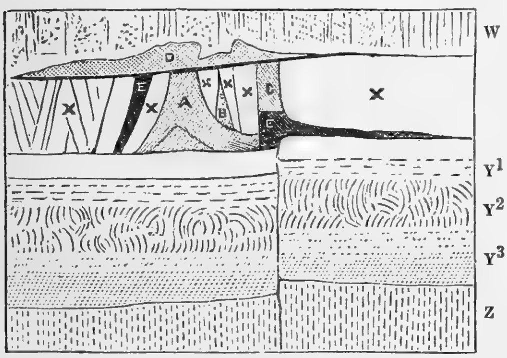
The prevailing character of colour in bed No. 1, in which the ramose sponge chiefly abounds, is mottled, and, by weathering, large patches of it become quite white. It nearly resembles in structure the sponge-stratum above, differing chiefly in being something more compact, and divided by larger and cleaner joints.

Sometimes the sponge-layer quite touches the Red Rock; but often there is a thin soapy seam of deep-red matter, less than an inch thick, parting them; and at intervals this enlarges into nest-like burrows, which penetrate far, and extend several inches up into the sponge-rock, without affecting the level top of the Red Rock. Most commonly these spaces are filled with soft matter of a deep-red tinge, but sometimes with sand; and when this is washed out by the surf, the holes are seen to anastomose. The nests do not affect the colour of the bed underneath; and where the red matter, soft or concretionary, joins the white sponge-band, the limit of the colour is sharp and clean.

The sand and coloured soapy matter are far from being confined to the top of the Red Rock; for they occur at the top of the white sponge-rock, though only in patches. There are many fissures in this stratum and in the chalk, which pass down to the top of the Red Rock; they are filled with black and red colouring-matter, often largely mixed with reddish-brown sand. At the base the red matter thickens, and generally enlarges into nests.

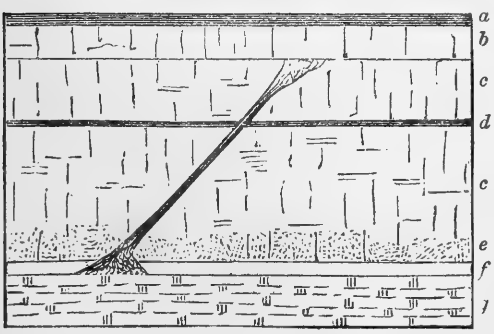
Bearing on this subject is the section (fig. 1), showing a slight slip in the Red Rock and Carstone, which has not affected the chalk, except by shivering it, and by forming fissures which are filled in as shown in the figure. The top of the sponge-rock is merely curved; and where the Red Rock is in the middle of the cliff is the section given in fig. 2. Under 8 inches of top earth are about 9 feet of reconstructed chalk, quite white, and seemingly without any foreign substance. Below this is about 20 feet of chalk, then the sponge-band, and finally the Red Rock. From the top of this latter up to the reconstructed chalk extends a straight but obliquely inclined fissure, which expands at the top, trumpet-like, to a width of at least 3 feet, and similarly expands at the base to a length of 4 feet, forming a triangular mass which displaces the sponge-band entirely, and some of the grey sandy chalk. This fissure and its expansions are filled with red matter, which is darkest in the line of the fissure and at its base.

Fig. 1.—*Section showing a fault in the Red Rock and Carstone, the Sponge-bed being shattered.*



A. Fine drab-coloured sand.
B. Yellow sand with black particles.
C, D. Ochreous sand with black particles.
E. Deep-red matter.
W. Grey sandy chalk.
X. Sponge-bed.
Y^1, Y^2, Y^3. Red Rock.
Z. Carstone.

Fig. 2.—*Section showing a fissure in the Chalk of Hunstanton containing red matter.*



a. Earth.
b. Reconstructed chalk, 4 ft. thick.
c. White chalk.
d. Band of red chalk.
e. Grey sandy chalk.
f. Sponge-bed.
g. Red Rock.

In the upper third of this white chalk, cut through by the fissure, is a pale mottled layer, about 15 to 18 inches thick. Thus there is a layer of red chalk fairly enclosed in the white chalk; it is not to be traced very far, but, curiously enough, to about an equal distance on each side of the fissure.

Where the Huns'ton Rock leaves the cliff, it may be seen that the reconstructed chalk, although broken up, has never been removed from its original site; for the Red Rock is similarly broken, and is still in its natural position. Thus, at the top of the incline there has been, ever since the middle of the Drift-period, and perhaps earlier, a large surface of the Red Limestone exposed to the action of weather and rain. Its carbonate of lime would be dissolved and carried away, but the alumina could only be carried down the incline with the iron and manganese. This drainage-material would be engulfed by any fissures, and, the chalk acting as a filter, much of the insoluble matter would be precipitated at the top, and the remainder carried down. The author supposes the circumstance of the Red Rock never having been hollowed out under one of these cracks to be owing to the thin film of iron deposited on its top. The sand, too, may have had the same origin as the red matter; for it has quite the character of the sandy particles abounding in bed No. 3, and may have been carried down the cracks by heavy rains, or by the sea or tidal waters when the land was lower.

As so many of these cracks are visible along the cliff, the number that would be visible on a large horizontal surface would probably be great; and the waters draining down them must have made channels to flow in, since the deposited iron and alumina would have made the floor comparatively impervious; hence the waters would still be excavating channels reaching up into the sponge-rock. Many figures might be given, showing that the nest-like enlargements are in immediate connexion with the bases of cracks; so the nest may indicate numerous other fissures which are not seen.

It has been supposed that the colour of the Huns'ton Rock might be owing to this layer of red matter just described, which appears to have been introduced under the sponge-rock at a very recent period. But it nowhere affects the colour of the chalk in which it is contained. Though it is singular that the fissure in fig. 2 passes through the subordinate band of red chalk, capillary absorption could scarcely have tinted the thin band with a substance which it is almost impossible could have permeated its mass. Here too, as in the Red Rock, the tinge is probably due to decomposed glauconite.

What in the whole section is most remarkable is the physical resemblance between the sponge-stratum and bed No. 1 of the Red Rock, on the one hand, and between many parts of bed No. 3 and the Carstone on the other; so that there is something very like a gradual passage from the Carstone up to the chalk; and the natural inference is that there is no break in time. If it were also inferred that the Carstone represents the Shanklin sands, then it would follow that part of the Red Rock replaces the Gault.

But there are no data for assuming that the old Cretaceous lands sank down more uniformly than we see them descending now. Every one knows the irregularity of the rise of Sweden, South America, and other countries; and it appears more than possible that the thick rock of one place and the thin bed of another are often consequences of such a cause as this, and therefore that a deposit may have been wholly built up in one district before even its foundation-stone was dropped in another. Hence it must sometimes happen, from a gradational movement in the sea-bottom, that the rock of one age will continue to be deposited during a succeeding period. In a former paper* the author endeavoured to show that the sand at Huns'ton, like the clay at Speeton, represents two formations, and therefore that the formation Carstone is not merely Shanklin sands, but Gault too.

When the upper part of the Red Rock is compared with the sponge-layer above, the difficulties are not so great; for, besides mineral resemblance, there is in both beds an organic growth, known as *Spongia paradoxica*, which seems to point conclusively to the upper bed being immediately subsequent in time. In one place I thought I traced an individual growing out of the lower bed into the upper one; and if the existence of this fossil, which forms no small part of the bulk of both beds, may be taken as evidence that both bed No. 1 and the sponge-rock belong to the same geological formation, the sponge-rock must be regarded as a subordinate bed of the Huns'ton Rock. All that sections like fig. 1, where the sponge-rock seems to be part of the chalk, can indicate is that, at the time when those agencies which produced the cracks and slips were operating, there already existed a film of yielding matter between the red and white sponge-beds, allowing the latter less compact deposit space to bend rather than break.

The thin band of red chalk enclosed in the white does not indicate that it and the intervening chalk must be grouped with the Red Rock below. Yet, as the agencies producing the colour appear to have been the same, it may indicate that they continued operating in other seas for ages after the consolidation of the inferior strata, and therefore that they may be a link between the Huns'ton Rock and the Chalk. But, after all, it is of very little importance; and occasional shifting of the sand on the shore exposes a band of bright red clay in the Carstone, of unknown thickness, but certainly limited extent, which might be regarded as having a relation to the Huns'ton Rock similar to that of the red chalk.

In another paper† I have endeavoured to show that the Gault is unconformable to the Shanklin sands in this district, and that the Upper Greensand is not conformable to the Gault. The Chalk and Upper Greensand are perfectly conformable. By the help of these facts the age of the Huns'ton Red Rock may be gathered.

* "On the Significance of Rocks and Fossils." Read before the Cambridge Philosophical Society.

† "On a Section discovering the Cretaceous Beds at Ely." Read before the Cambridge Philosophical Society.

The subjacent deposits consist of sands and conglomerate like ordinary Shanklin sands, which we will assume it to be, though it has already been seen that the upper part is newer.

The chalk above is ordinary lower chalk, with *Pecten Beaveri* and a multitude of characteristic Shells; hence it might be concluded that the Huns'ton Rock represents both Gault and Greensand. But as in this district the Gault is the thin end of a wedge which has almost disappeared, the chances for Gault being there are not so great as are those for the presence of Greensand; and since the Gault is unconformable with the Greensand, if the two formations be there, there should be a physical break which ought to be visible. But at Huns'ton there is nothing resembling Gault, nothing in the Red Rock approaching to heterogeneity; while the bed is quite homogeneous, and has the character of being one formation. This may be Gault or Upper Greensand. If it be Gault, it would be unconformable both with the beds above and those below; but of this the section shows nothing. Again, if it were Gault, the Upper Greensand would have thinned away; but it, though thin, is the most constant of the Cretaceous beds. And if the bed be unconformable, it is remarkable that the sponge-rock should so resemble both Chalk and the Red Rock as to make it uncertain how it should be classed. While if the argument that the colour be due to glauconite is held as established, it is singular that a deposit that has taken on so many other characteristics of Greensand, without belonging to that formation, should have this also.

Under these circumstances, when the material of the rock, its conformability, its thickness, its colour, and other features present points linking it with Upper Greensand, while there is nothing to suggest that it should not be that deposit, and when, in composition, physical relations, and colour, it presents aspects which have only been observed in the Gault separately in a few isolated localities, while there are both *à priori* and *à fortiori* reasons for supposing the Gault would thin out, the point seems evident that on stratilogical data the Huns'ton Rock must be placed with the Upper Greensand.

In conclusion the author gave a list of the fossils occurring in the Red Rock, with their range in the several divisions of the Cretaceous system, describing in full the new and more remarkable species.

April 27, 1864.

Dale Knapping, Esq., Blackheath Park; Archibald Travers, Esq., St. Swithin's Lane, London; John Plant, Esq., Peel Park, Salford; and Searles Valentine Wood, jun., Esq., Brentwood, Essex, were elected Fellows.

The following communications were read:—

1. *On the* Geology *of* Arisaig, Nova Scotia.

By the Rev. D. Honeyman, F.G.S.

Contents.

§ 1. *Introduction.*

The district which is the subject of this paper is situated on the north-east side of Nova Scotia, on the Gulf of St. Lawrence, and from ten to fourteen miles south-west of Cape St. George. Several years since, this locality was brought under the notice of the Society by Dr. J. W. Dawson.

Its characteristic strata were then considered by him to be of Silurian age (Quart. Journ. Geol. Soc. vol. vi. p. 347). Subsequently in his 'Acadian Geology,' guided by the opinion of Sir Charles Lyell, he pronounced these deposits to be equivalent to the Hamilton and Chemung (U. S.) groups, and consequently to be of Devonian age.

Having made the locality a special study for a great part of two years, and having compared the fossils obtained from the strata occurring there with those figured in Sir R. I. Murchison's 'Siluria,' I was convinced, beyond all doubt, that they were for the most part equivalent to the Upper Ludlow *. In the following year Dr. Dawson communicated a paper to the same Society, "On the Geology of Nova Scotia," in which, besides confirming my opinion, he separated the strata in question into an upper and a lower series †. Further progress was afterwards made by Professor Hall's determination of many of the Arisaig fossils ‡.

Professor Hall and Dr. Dawson have again confirmed my opinion in regard to the age of the upper member of this series, pronouncing it to be the equivalent of the Lower Helderberg group, and the lower to be the equivalent of the Clinton, U. S.; for one of its characteristic organisms is a Graptolite, not distinguishable, according to Professor Hall, from *Graptolithus Clintonensis*, Hall.

Having examined another locality somewhat particularly, at the East River, I found, *in situ*, fossils similar to those of the upper member of the Arisaig series; and others, also *in situ*, which I considered were of a different age. I had found organisms similar to the latter, in boulders on the Arisaig shore, in abundance. I was therefore led to infer the existence of a member of the Arisaig series between the equivalents of the Upper Ludlow and the Clinton, which I considered to be equivalent to the Wenlock. This belief

* See my paper "On the Fossiliferous Rocks of Arisaig," Trans. Lit. and Sci. Soc. Nova Scotia, 1859.

† Trans., &c., 1860.

‡ See Hall's Appendix to Dawson's Paper "On the Silurian and Devonian Rocks of Nova Scotia," Canadian Naturalist and Geologist, vol. v. pp. 144 *et seq.*

was confirmed by my examination of new localities, in one of which occurred Upper Ludlow and Lower Helderberg and Clinton strata, without the intermediate formation; in another occurred Upper Arisaig beds, and strata which had not been found in any of the other localities, but which I considered as possibly also of Wenlock age. In a paper on these new localities, read in 1860 before the Natural History Society of Montreal, this opinion was expressed by me. Dr. Dawson suggested that the new fossils were possibly Devonian*. In the same paper I announced the discovery of fossils in a part of the Arisaig series which was before considered as non-fossiliferous, and in a position considered by Dr. Dawson and myself as lower than the Clinton group. Still later I discovered at Arisaig, *in situ,* and in a position somewhat perplexing, fossils similar to those which I had considered as doubtfully Wenlock, and Dr. Dawson as possibly Devonian. Another perplexing circumstance was stated by Dr. Dawson, in the note referred to, namely, that my newly discovered localities tended to confirm an opinion that he had elsewhere expressed, to the effect that the Silurian and Devonian strata, of which the Arisaig series formed a part, had been thrown into synclinal and anticlinal folds on the formation of the metamorphic mountain-ranges, on the skirts of which the various Silurian and Devonian localities are situated. Regarding this opinion as correct, it appeared to me that the dip of the Arisaig series was in the wrong direction, and diminished in proportion as it receded from the mountain-range, with the possible exception of the last-discovered part of the series. Supposing this last to be the upper bed, as it must be if its equivalent at the lately discovered locality, Lochaber, were Devonian, it should overlie the uppermost instead of the lowest member of the Silurian series.

This was the state of matters relative to this admirable and typical section in our Nova-Scotian geology, when I was engaged to make a collection of the rocks and fossils of our province for the International Exhibition of 1862. Sir Roderick Murchison, at my request, very kindly asked Mr. Salter to examine it, who accordingly inspected my divisions of fossils, and, studiously avoiding all inquiry into the opinions already entertained, he unhesitatingly referred my Upper Ludlow to the Ludlow Tilestone, my Wenlock (?) to the Aymestry Limestone, and Hall and Dawson's Clinton to a repetition of the Ludlow Tilestone. He could not decide on the fossils of No. 5 (?). With regard to No. 4, the equivalents of which had been regarded by Dr. Dawson as possibly Devonian, and by myself as possibly Wenlock, Mr. Salter at once referred them to the Mayhill Sandstone age, qualifying the whole with "*approximately.*" The matter was thus, to me at least, cleared of doubt, except on one point where a difference of opinion existed, arising chiefly, as it appeared to me, from a difference of opinion regarding the Graptolite already referred to,—Hall considering it as *Graptolithus Clintonensis*, and Salter as *G. Ludensis*, the containing strata being accordingly considered by the one as equivalent to the Clinton group, and by the

* See paper with Dawson's note, Canad. Nat. and Geol. vol. v. pp. 293 *et seq.*

other to the Ludlow Tilestone. So much light having been thrown upon the subject by Mr. Salter, the two uppermost and the lowest members of the series having been determined by him, it at once occurred to me that a thorough examination of the locality would now be sufficient to determine what still remained doubtful, and the results of that examination I now beg to lay before the Society.

§ 2. *General Description of the Arisaig District.*

The extreme length of the Silurian rocks at Arisaig is about three and a half miles, and their breadth three-quarters of a mile. The group is thoroughly representative of all the known Silurian localities in the eastern half of Nova Scotia, and, as far as I know, it is the only district in the eastern part of the province where every member of our Upper Silurian series exists *. Here we have the whole in an apparently uninterrupted succession, and easy of examination, much of it being exposed in vertical and horizontal sections, on a shore subject to violent storms, accumulations of ice, and other degrading agencies. It is also bounded and intersected to a considerable extent by streams, two of which rise in the elevated metamorphic range which bounds the group on the south. The general position of the Silurian strata here is that of a synclinal axis, although it appears to be altogether different from any of Dr. Dawson's synclinal and anticlinal folds. But I do not mean to say that an anticlinal never skirted the mountains that form the great southern boundary of our Silurian group. I would rather suppose that such had existed, and that it had been removed by denudation during the early part of the Carboniferous period. Possibly the detrital matter resulting from that process formed the Lower Carboniferous conglomerate which we find associated with limestone (D) at Doctor's Brook, and intervening between the said mountains and a considerable part of our Silurian strata. An examination of the natural section in the line of this stream, which proceeds, with its branches, from the mountains, and traverses the rear of the group, for fully one half of its length, in a deep valley, revealed no traces whatever of the supposed old anticlinal axis.

The formation of the present synclinal axis is evidently of still later date, these strata having been elevated and thrown into a synclinal fold by the augitic trap (*a* and *a'*, fig. 1), which has also altered and upheaved the adjoining Lower Carboniferous conglomerate and limestone.

The trap (*a*) on the north, or shore, side of the group extends in an almost continuous line from Black Point to Arisaig Pier. There is one interruption where a cove has been formed, and where the strata have been left comparatively unaltered. The trap-rocks may

* In England it is very common for the Llandovery group to be absent; but the rarest of all cases is to find the Wenlock (or Niagara) group missing. It is with us a thicker series than the Ludlow, and is often present where that is altogether absent. See Salter's Report on the Nova-Scotian Silurian collection. In the western part of the province, the equivalent of the Wenlock or Niagara Limestone exists, according to Hall and Dawson, at New Canaan. (Dawson's Paper, Canad. Nat. and Geol. vol. v. p. 139.)

Figs. 1–4.—*Map and Sections illustrating the Geology of Arisaig, Nova Scotia.*

Fig. 1.

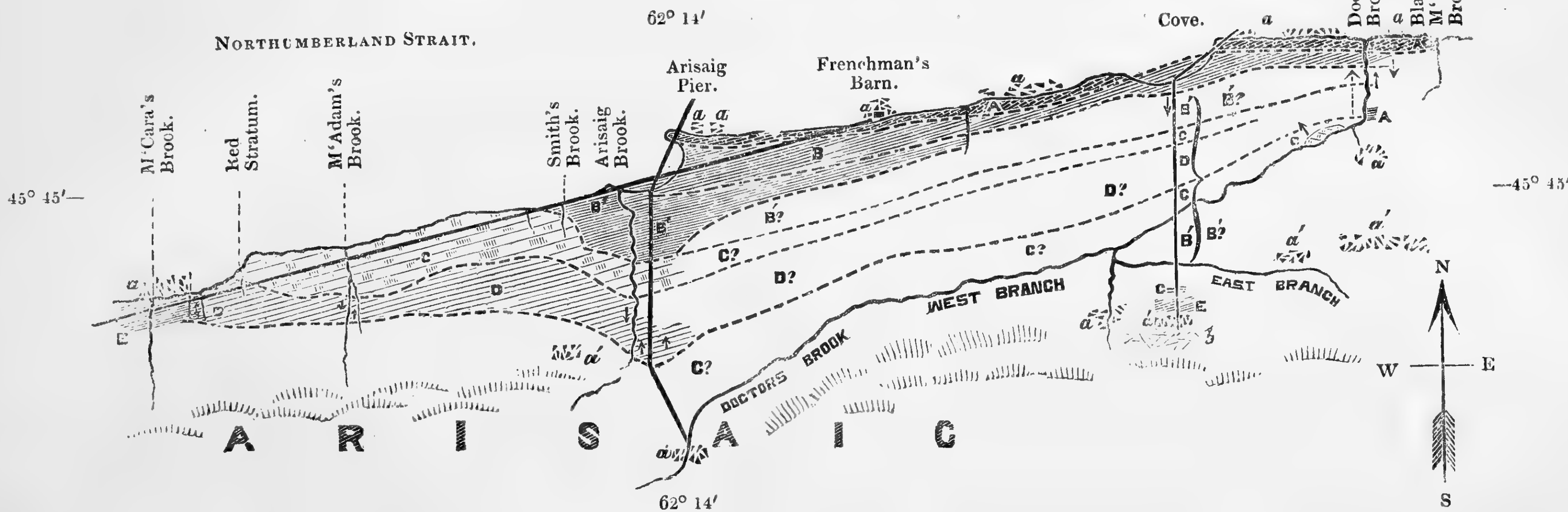


Fig. 2.

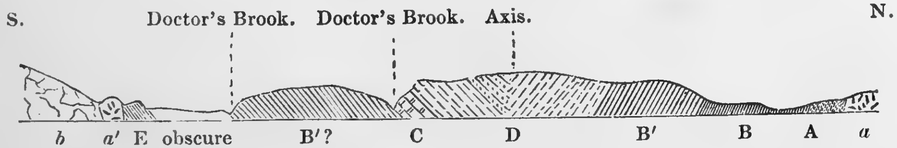


Fig. 3.

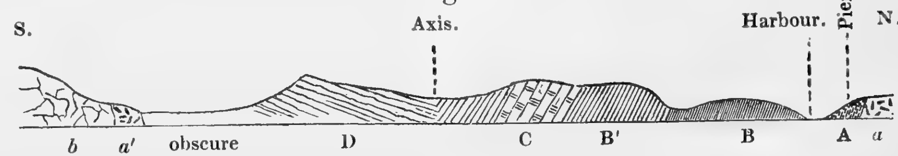
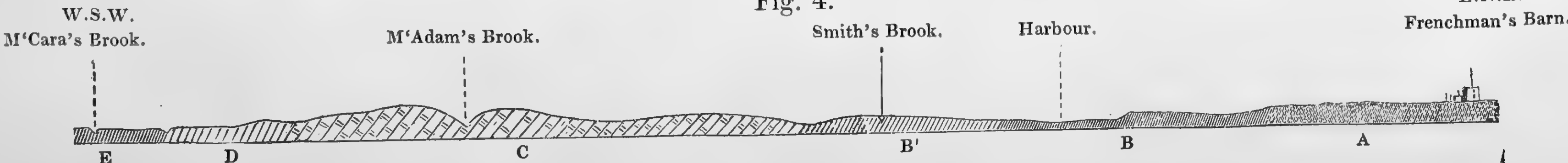


Fig. 4.



A. Mayhill Sandstone. B, B′. Lower Ludlow. C. Aymestry Limestone. D. Ludlow Tilestone. E. Lower Carboniferous. *a, a′*. Trap. *b*. Syenite. ↑ Dips.

be traced for some distance into the sea, making the shore rough and dangerous. To the west of Arisaig Pier the line of trap is interrupted, and a small bay has been formed by the denudation of the strata. The strata on the shore are consequently inclined more or less in proportion to their distance from the pier. At a certain distance they are inclined at low angles, and in some cases they are horizontal. About a mile from the pier, the strata on the shore again give evidence of disturbance, at no great distance seaward, although the cause is not visible. At the extreme of the group, south-west of the pier, trap (amygdaloid) again appears in immediate contact with strata of the uppermost member of the series, upheaving and overlying the strata at the point of contact. It again appears at intervals, constituting the shore-boundary of the Carboniferous formation: the trap (a') on the opposite side of the group appears between the mountain-range and the intervening Carboniferous conglomerate and limestone, and again between a part of the latter and our Silurian strata. I also observed it at other points on this side, between the strata and the mountain-range, as indicated in the Map. At varying distances from these intruded rocks I found the strata particularly disturbed, so that the group may be regarded, on the whole, as synclinal, the direction of the axis being very irregular and generally obscure; but the axis is seen approximately near the mouth of Doctor's Brook, at Arisaig Brook, and M'Adam's Brook. I purpose now to illustrate the subject more fully by means of three sections.

§ 3. *Section from North to South.*

The first section (fig. 2) intersects the district from north to south, at about one mile from its eastern side. The trap (a) of the north of the section is well exposed along the shore, and forms an interesting study. It is often vesicular, amygdaloidal, and porphyritic, and is frequently associated with tufa and tufaceous conglomerate, and interesting alterations of the sedimentary strata are seen at its various exposed points of contact with them. These sedimentary rocks lose all semblance of stratification, being sometimes hardly distinguishable from the trap itself, sometimes assuming a somewhat granitoid aspect, at others jaspideous, or beautifully turbinated, as if replete with organisms, in every case signs of organic existence being thoroughly obliterated.

The upper part of the bed A (fig. 2) has an interest of a different kind; it lies in the cove opposite the break in the line of trap, to which I have already referred, and, although tilted, the stratification is preserved, and contains many organisms. The lower part contains several patches of fossiliferous limestone; the vertical sections of these are generally plano-convex, with a maximum thickness of six inches. This limestone is very much hardened, and contains throughout beautiful crystals of iron-pyrites. These strata, which are about 200 feet thick, have, in addition to the fossils found in the beds just referred to, separate organisms, scattered abundantly through them from the bottom to the top. The fossils of this member of the group were first discovered by me in 1860, in the form of casts, at the top of the much-altered and disrupted strata at Doctor's Brook. The prolific portions of the strata of this section, and those to the west of it, were only discovered by me during the past summer. In the red-limestone beds of our section the fossils are abundant and in good preservation.

The following are the principal genera, &c., of this group:—*Orthoceras* (3 species); several species of *Murchisonia*, *Strophomena*, *Orthis*, and *Rhynchonella*; *Calymene*, *Crinoidea*, *Cornulites*, *Tentaculites*, *Petraia* (*Forresteri*, Salt.), and *Petraia*, sp.

The lithological characters of A and B of the section are so different that there is not the least difficulty in determining the termination of the one and the commencement of the other.

Strata A, where little altered, are generally hard, slaty, grey, argillaceous, and arenaceous, and therefore assume the variety of aspect already referred to when altered. Strata B are in the lower part shaly, black, ferruginous, and argillaceous, and in the upper part they are finely laminated. The horizontal section of them in the cove, which can generally be seen only at ebb-tide, is so black, that it has often been considered by the people of the district to indicate the existence of coal. A singular and characteristic feature of these rocks is the occurrence of concretions, lying often in beds conformable with the stratification, and contrasting strikingly with the finely laminated shale in which they are enclosed. These occur from the beginning to the end of the horizontal section in the cove, for a length of about 1848 feet. They also occur in the vertical section of the same strata at Doctor's Brook, and at Arisaig Pier, or through a total length of about two miles. The conditions under which strata B have been formed appear not to have been of the kind most favourable for the existence and development of life. The thickness of strata exposed in the line of section is 170 feet, yet, after a diligent search, I only found a few *Lingulæ* in nodules, and a specimen in one of the concretions already referred to, and one or two remarkable beds of Graptolites; of the latter I extracted several hundred specimens, more or less perfect. These Graptolites are of five or six forms, all different from *Graptolithus Clintonensis*, discovered by Dr. Dawson in the beds above the portion of the series under consideration. In the line of section we have also, beyond doubt, the upper members of the series B′, C, D of the other sections, obscured by drift. I found characteristic fossils of C, the equivalent of the Aymestry limestone, at Doctor's Brook, and of B′ in a very small brook to the west of the Frenchman's Barn; and in surface-stones in the line of section I found several specimens of *Avicula Honeymani*, Hall, which is only found in D of the series, or the equivalent of the Ludlow Tilestone. At the side of Doctor's Brook, in the same line, is a bluff, which has only yet yielded a few *Lingulæ*; they are not characteristic species. We have then another part of the group, which is also obscure. This is possibly a repetition of B′ of the series. The strata of the bluff, as well as of B′ (?), dip towards the north; and so do the others on this side, as has already been observed. It is obscure where we might have expected to find a repetition of B and A. Those formations only appear on this side of the synclinal, at the eastern part of Doctor's Brook, where its course is north and south.

We have now reached the boundary of the Silurian formation, and the section next passes through E, which is Lower Carboniferous. Here we have, first, compact limestone, and then hardened conglomerate, raised to a considerable elevation by an equally elevated mass of trap (a'), which succeeds it. This trap is pervaded by numerous veins of specular iron-ore, which are, however, too small to be of any economical value; succeeding this trap is (b) the syenite of the mountain-range.

§ 4. *Section from the East of Arisaig Pier to Doctor's Brook.*

The next section (fig. 3) begins at a point east of Arisaig Pier, and, after it reaches the south side of the harbour, its course is due south until it reaches Doctor's Brook Valley; it then passes on, and meets Doctor's Brook in the mountain. This section is very interesting, as it unquestionably passes through the whole group, and as there is very little uncertainty in the course which it traverses. We have first (a) a part of the line of trap, which is here amygdaloid. Succeeding this is an elevated mass of (A) the equivalent of the Mayhill sandstone, which has been very much altered by the trap. It is now a rock of porcellanous jasper, having often a beautiful riband-like appearance. To the westward are the pier-rocks, consisting of an elevated mass of A, in like manner converted into a jaspideous rock, and of a great mass of trap lying on the south-east of the former. Between the trap of the point of section and this there is a break, opposite to which we have strata of the group A, very little altered, consisting of layers of red and yellow sandy shale, evidently similar to the strata which on either side have been converted into jaspideous rock; after these we have a low section of the group B; this is the continuation of the black laminated and concretionary shale, with *Lingulæ* and *Graptolites*, already referred to. At ebb-tide we find this shale continued farther on the shore at the mouth of Arisaig Brook, on ascending which it is seen exposed in an interesting manner on the sides and bottom of the brook, being here black and ferruginous, and apparently destitute of organisms. This passes into the group B′, where the ground becomes elevated, the strata at the mill showing many specimens of a characteristic *Orthis*, associated with *Graptolithus Clintonensis* (?), Hall. The passage from B to B′ is very apparent here, as well as at Doctor's Brook. The shale of B′ is more compact than that of B; it is less ferruginous, being generally of a lighter colour, and it was probably deposited under conditions more favourable than the other for the existence of life.

The foregoing observations are of interest as they demonstrate the sequence, hitherto unknown, of the lowest members of the series, and prove the identity of the group A of the various sections, whether in its highly altered and apparently non-fossiliferous state or in its less altered and fossiliferous condition. Ascending we find on either side of Arisaig Brook lofty exposures of shale, with characteristic fossils of B′. Succeeding them are seen slate-rocks, forming hills of still greater elevation, on the summit of the highest of which is an outcrop of these strata, where I found *in situ* the largest *Lingula* that I have yet seen, and abundance of fragments of stems of Crinoids. I consider this to be the beginning of the equivalent of the Aymestry limestone (Salter), or the C member of our series. There is an interesting bed of this group exposed on the side of the brook; it is very ferruginous, almost constituting an ore of iron; it is from six to nine inches thick, and replete with casts of *Strophomena* (various species), *Athyris tumida*?, *Homalonotus*, *Cornulites*, &c. We now evidently approach the synclinal axis, as the strata exposed on the sides of the brook become distorted. A valley which extends from this part in a westerly direction appears to correspond with this axis. The ground through which our section now passes becomes removed from the brook; it begins to rise without exhibiting an outcrop of any importance until we reach the summit of a hill still higher than any through which the section has passed, and the highest formed by the Silurian strata. The strata outcropping on the top, and towards it, belong to the group D, or the Ludlow Tilestone (Salter), and are inclined at a low angle and with a northerly dip. Here I found *in situ* characteristic species of this member, namely, *Dalmania Logani*, Hall; *Phacops Downingiæ*, Salt.; *Homalonotus Dawsoni*, Hall; *H. Knightii*, Salt.; *Beyrichia*, sp.; *Crania Acadiensis*, Hall. The rocks which doubtless underlie the above do not appear in any way on the hill-side or in the valley, and there is no trace whatever of the old anticlinal; we have trap (a') at a considerable distance up Doctor's Brook, at the extreme of our section, succeeded by syenite.

§ 5. *Section from the Frenchman's Barn to M'Cara's Brook.*

This section (fig. 4) passes through all the members of the north side of the synclinal in an oblique direction, its course being from N.N.E. to S.S.W., corresponding generally with the section on the shore. It commences with what is known locally, and from maps of Nova Scotia, as the Frenchman's Barn, on the N.N.E., and terminates at M'Cara's Brook, or about $\frac{1}{8}$th of a mile beyond what I at present consider as the termination of the group. This is the most interesting of the three sections, as it includes the chief sphere of Dr. Dawson's researches and of my own. From localities embraced in this line of section the fossils have been derived which have enabled us to solve the problem of its relative age.

The Frenchman's Barn is a lofty oblong mass of jaspideous rock, with a broad and somewhat flat summit. North of this, trap is visible. On either side, similarly altered strata (A) are seen rising in bold and striking masses. Large and numerous blocks of these rocks are scattered on the surface. Sometimes they are transported to a considerable distance to the south, the whole deceiving the cursory observer into the belief that they are derived from the underlying rocks; but an examination of adjoining brooks, as well as of outcrops, shows that the underlying strata include B and B′ of the series. South of the pier we find equally large masses of similar rock, transported to as great a distance and to a still more elevated position, on a hill composed of the group B′. With regard to the distinction that I have made between B and B′, I may observe that I have not found any strata about the same parallel in other localities so strongly marked as the group B; so that I am disposed to consider the peculiar characteristics of B as local, and that the mark (′) of B′ may be dropped when the group is regarded as typical.

From the position of B and B′, and their general character, I have inferred that these members of the series are our approximate equivalent of the Lower Ludlow; they undoubtedly lie between the equivalents of the Mayhill Sandstone and of the Aymestry Limestone. B of our section is generally shaly, sometimes slaty; it is exposed on the shore in horizontal and vertical sections, and also in a small brook (Smith's Brook) which passes over them nearly in the line of their dip. In these strata the organisms often form thin beds of limestone; they are sufficiently numerous as individuals, but of few species; the variety that we find in a position parallel to this in another locality, Merigonish, being here wanting. The most highly developed organism that I found here is the Lamellibranch, *Grammysia*; it here makes its first appearance in the series. In the following table the principal fossils are given:—

Grammysia triangulata, *Salt.*	Calymene.
Grammysia cingulata, *Hisinger.*	Asaphus.
Isocardia?	Crinoidea.
Strophomena depressa, *Dalm.*	Tentaculites.
Orthis.	Graptolithus Clintonensis, *Hall.*
Chonetes.	Bryozoa?
Lingula.	Worm-tracks.

Above the Graptolite-strata there occur what I call the Crinoid- and Cornulite-strata, the lithological characters of which, as well as their fossils, are so different from those of the former that I am disposed to regard this as the commencement of the group C, or the equivalent of the Aymestry Limestone. The strata are so extremely hard that it is in general very difficult to extract the fossils from them. A distinguishing feature of these strata is the abundance of Crinoidal fragments and of unusually large Cornulites. It is from them, also, that I suppose we derived the beautiful *Palæaster* which was found in a water-worn boulder on this part of the shore. This interesting fossil, which I gave to Dr. Dawson, is now in his collection. It is also worthy of notice that the genera of Mollusca which, existing in *a*, had, according to our present knowledge, disappeared in B and B′ of this locality, reappear in these strata. It is also the earliest stage of the appearance of the genus *Bellerophon* in Nova Scotia. The following is a list of the principal fossils:—

Orthocerata.	Strophomena.
Bellerophon trilobatus, *Sow.* (*Bucania trilobata*, Hall.)	Rhynchonella.
Murchisonia.	Phacops.
Pleurotomaria.	Crinoidea.
Clidophorus.	Palæastræa parviuscula, *Billings.*
Avicula.	Cornulites.

Strata of the same character continue beautifully exposed in a horizontal section on the shore under high-water mark until we reach the mouth of M'Adam's Brook. In these I found only indistinct fossils until I reached this point, where there are many specimens of a large and peculiar species of *Orthis.* Up this brook the various strata above the last are seen, with their characteristic organisms, the synclinal axis being again approximately apparent. The strata of C under examination are not only exposed on the shore and in the brooks through which the line of section passes, but also in numerous and considerable outcrops throughout the breadth of the group. On the shore at the mouth of the brook, and a little above the bed with *Orthis,* there is a stratum with *Homalonotus,* Crinoids, and *Tentaculites.* Immediately above this, the strata at the brook, and onward to a considerable distance, become shaly, and contain numerous nodular blocks, generally of large size. These are often coated with fossils, especially *Strophomena.* Then we have hard, uniform, light-coloured argillaceous strata, which, on comparison with those of other localities, I am disposed to regard as the typical strata of the group C. A remarkable feature of these beds is the great development of a species of *Orthoceras.* It occurs here of a size unequalled either before or after, and unusually numerous. In the other locality referred to—East River, Pictou country—where this subdivision was first recognized by me, and on this horizon, I found the largest *Orthoceras* that has yet been found in Nova Scotia. In the same strata of our section there is also a characteristic species of *Homalonotus.*

The following is a list of the principal fossils:—

Orthoceras (several species).
Bellerophon expansus ?, *Sow.*
Bellerophon trilobatus, *Sow.*
Bellerophon carinatus, *Sow.*
Clidophorus.
Murchisonia.
Platyschisma helicites, *Sow.*
Acroculia haliotis, *Sow.*
Avicula, sp.
Strophomena, sp.
Athyris, very like *A. tumida,* Dalm.
Atrypa reticulata, finely and coarsely ribbed varieties.
Spirifer rugæcosta, *Hall.*
Rhynchonella Wilsoni, *Sow.* (*R. Saffordi,* Hall.)
Rhynchonella (other species).
Chonetes.
Orthis.
Discina.
Lingula.
Calymene.
Homalonotus.
Crinoidea (several species).
Favosites.
Stenopora.
Tentaculites.

A little above the Orthoceras-strata are beds with abundance of a species of *Rhynchonella* having coarse wavy ribs, and then we have a stratum of considerable thickness deeply coloured with oxide of iron; the latter may be considered as the line of demarcation between the groups C and D, as there are no characteristic fossils between this and the strata where the characteristic organisms of D become evident. An unknown organism characterizes these passage-(?) beds, and is the only fossil known in them. The strata have a varying strike above the beds B, B′, of the series. From this circumstance the vertical section on the shore appears somewhat perplexing, but the horizontal section shows very distinctly the ascending order of the strata. The undoubted group D, or the approximate equivalent of the Upper Ludlow, is distinguished by its beautiful and variegated stratification, the prevalent colours being red, grey, and green. The strata are inclined 40° S.W., except where the strike becomes east and west. This is the case with the uppermost strata, which have been thrown in this direction by the amygdaloid trap, by which it is partly overlain. Here our Silurian fauna has attained its greatest development as regards genera, species, and individuals. The fossils are not, however, so well preserved as in other parts of the series. Of the class *Cephalopoda*, individuals have diminished in size, while it has received many accessions in genera and species. *Heteropoda*, *Pteropoda*, and *Gasteropoda* abound, the *Gasteropoda* being generally of smaller size than they are in the group C. *Lamellibranchiata* occur in greater numbers than before, especially species of *Clidophorus*. *Brachiopoda* are now generally of smaller species. *Crustacea* are more numerous, both in genera and species, and *Homalonotus* and *Calymene* are of rather unusual size. One pygidium of *Homalonotus Dawsoni*, Hall, must have belonged to an individual six or seven inches in length. An entire *Calymene* is four inches in length, and a glabella of another individual indicates still larger proportions. *Entomostraca* appear here for the first time, and in considerable variety and numbers, near the top of the series. In the earlier members of the series the organisms were generally insulated; sometimes they occurred in small groups, and in thin and small beds of limestone; here they often form limestone-bands five or six inches in thickness, which appear to have been, to a considerable extent, formed of the débris of organisms. In this member of the series the fossils are generally fragmentary, entire specimens being very seldom found. The following list shows the character of the fauna of the group D:—

Lituites.
Phragmoceras.
Ormoceras ?
? long, tapering, and recurved.
Orthoceras nummulare, *Sow.*
Orthoceras, very like *O. bullatum*, Sow.
Orthoceras ibex, *Sow.*
Orthoceras exornatum, *Dawson.*
Orthoceras punctostriatum, *Hall.*
Orthoceras, 4 sp.
Bellerophon trilobatus, *Sow.*
Bellerophon carinatus, *Sow.*
Bellerophon striatus, *D' Orb.*
Bellerophon expansus, *Sow.*
Theca Forbesii, *Sharpe.*
Coleoprion ?, sp.
Murchisonia Arisaigensis, *Hall.*
Murchisonia aciculata, *Hall.*
Pleurotomaria.
Modiolopsis ? rhomboidea, *Hall.*
Modiolopsis subnasuta, *Hall.*
Clidophorus cuneatus, *Hall.*
Clidophorus concentricus, *Hall.*
Clidophorus erectus, *Hall.*
Clidophorus elongatus, *Hall.*
Clidophorus semiradiatus, *Hall.*
Clidophorus nuculiformis, *Hall.*
Clidophorus subovatus, *Hall.*
Avicula Honeymani, *Hall.*
Pterinea retroflexa.
Orthonota (like many Ludlow species, *Salter*).
Goniophora cymbæformis, *Sow.*
Chonetes Nova-Scotica, *Hall.*
Chonetes tenuistriata, *Hall.*
Orthis, 2 sp.
Spirifer subsulcatus, *Hall.*
Rhynchonella, 3 sp.
Discina rugata, *Sow.*
Discina ? lineata.
Discina ? tenuilamellata, *Hall.*
Crania Acadiensis, *Hall.*
Lingula, sp.
Homalonotus Dawsoni, *Hall.*
Homalonotus Knightii, *König.*
Dalmania Logani, *Hall.*
Phacops Downingiæ, *Salt.*

Calymene, different from *Blumenbachii*, Brong.
Proetus Stokesii ?
Beyrichia pustulosa, *Hall.*
Beyrichia equilatera, *Hall.*
Beyrichia, 2 sp.
Leperditia sinuata, *Hall.*
Crinoidea.
Tentaculites.
Cornulites serpularius.
Serpulites, n. sp. (in clusters on shell of *Orthoceras*).
Stenopora.
Heliopora fragilis, *var.* Acadiensis, *Hall.*

These Silurian strata (see fig. 4) are succeeded by Lower Carboniferous conglomerate.

§ 6. *Conclusion.*

I have thus directed attention to the results of a detailed examination of the Silurian strata of Arisaig. This being the undoubted type of a very considerable proportion of our Nova-Scotian Silurian system, and bearing so striking a resemblance, as regards its fauna, to the British Upper Silurian, is a sufficient reason for so directing attention to the subject.

The conclusion thus arrived at is, that the members of the series are respectively the approximate equivalents of the Mayhill Sandstone, Lower Ludlow, Aymestry Limestone, and Upper Ludlow. Mr. Salter suggested to me the propriety of distinguishing the respective members of our series by local names. I have not been able to act on the suggestion, on account of the mode of distribution of the several members of the group. I have therefore distinguished them as Arisaig A, B, B′, C, and D. I have not yet attempted to measure the entire thickness of the several strata. Supposing Dr. Dawson's estimate of the thickness of the groups B′, C, D to be correct, although I consider it much below the reality, we have of them about 500 feet; I found the thickness of B 170 feet, and of A 200 feet; total, 870 feet.

I have observed that strata A have a fauna well developed, too much so, indeed, to warrant the supposition that while there are sedimentary rocks in other parts of the province, which we have every reason to suppose are older than those of the Arisaig group, our A fauna is the first one represented in our Nova-Scotian geology. Before I consulted Sir R. I. Murchison and Mr. Salter, I supposed that certain unaltered strata which I had discovered in another locality, and which had, as their only fossils, hundreds of *Lingulæ*, beautifully preserved in small spherical and elliptical nodules, might be our Nova-Scotian Primordial zone. These appeared undoubtedly to be older than the equivalent in this locality of the Arisaig group B′, or the Clinton (U. S.) equivalent of Hall and Dawson. So that, regarding this determination as correct, I considered the Lingula-bed as Middle or, possibly, Lower Silurian. This bed appears to be about the equivalent of the bed B of Arisaig, and, therefore, is not Primordial. I believe, then, that we must look elsewhere for any earlier fauna than that of the Arisaig group A. The older slates of our Gold-fields, especially in the Peninsula of Halifax, bearing a striking resemblance to the Graptolitiferous slates of Victoria, in Australia, exhibited by Professor M'Coy in the International Exhibition of 1862, that was considered by me the proper region of our Primordial fauna. After a patient search, I believe that I have discovered evidence of the existence of the expected fauna in the capital of our province.

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2. *On some* Remains *of* Fish *and* Plants *from the* "Upper Limestone" *of the* Permian Series *of* Durham. By James W. Kirkby.

[Communicated by Thomas Davidson, Esq., F.R.S., F.G.S.]

[Plate XVIII.]

The object of the present paper is to record the discovery of Fish-remains in the Upper Magnesian Limestone of the Permian formation, the occurrence of these fossils in that subdivision being of interest in several respects, though more especially so on account of their having there been found at an horizon considerably higher in the Permian series than any vertebrate remains had been previously known to occur.

The fossils were first noticed by the workmen, in August 1861, in a newly opened quarry belonging to Sir Hedworth Williamson, Bart., at Fulwell, about a mile and a half to the north of Sunderland; and my attention was almost immediately drawn to them by Mr. Henry Abbs, of the latter town. From that period almost up to the present time, though chiefly during the autumn and winter of 1861, and the spring and summer of 1862, I have continued to collect specimens, and to pursue inquiries as to their palæontological and geological relations. In these researches I was joined by several scientific friends, who courteously allow me to use the results of their labours along with those of my own in this account of the fossils. Among these friends I ought specially to mention Mr. A. W. Dixon and Mr. W. M. Wake, of Sunderland, and Mr. R. Howse, of South Shields. I should also remark, that I am considerably indebted to the lessee of the quarry, Sir H. Williamson, with whose permission my inquiries were made; and I also owe much to the active assistance and careful observation of Mr. T. Foster, the overman of the quarry.

The quarry referred to is situated on the northern slope of Fulwell Hill, and is not far distant from another more extensive and much older quarry belonging to the same proprietor. In these quarries, as well as in others on the same hill, more to the west, the Magnesian Limestone is largely worked for lime-burning, as it has been in the older quarries for the last sixty years or more. During the whole of that period, up to 1861, no traces of any organic remains had ever been found in the limestone of this hill. But about the time named, or a little before, it became necessary, in order to keep the new quarry at its proper level, to cut through some underlying beds (brought up by an anticlinal), which had never yet been quarried on account of the unvendible quality of the limestone;

and it was in working these lower and inferior strata that the great bulk of the fossil Fish were discovered, most of them having been found in one bed, or zone of beds, of limestone; there, nevertheless, being several instances of their occurrence both above and below that horizon.

Soon after their discovery in the new quarry, another or the same anticlinal brought up the equivalent strata in the old quarry, about half a furlong to the south; and it was not long before the same fossils were met with there, besides other species that the first locality had not yielded.

The same Fish-bed would appear also to extend considerably to the north-east; for I have obtained the tail-half of a small fish from a stratum of limestone in Marsden Bay, occupying the same stratigraphical position as the Fulwell Fish-bed.

The Magnesian Limestone worked in the Fulwell quarries belongs to the higher portion of the Permian series, or, to speak with precision, to the "Upper Limestone" of the classification proposed by Mr. Howse, or to the Crystalline and Concretionary Limestone of Professor King's arrangement. But it must be further observed that the Upper Limestone of Durham is composed of two portions, the higher being yellow, friable, or compact, or oolitic, and thin-bedded, while the lower is of various shades of yellow and grey, highly concretionary, compact, or friable, and thick-bedded. It is the latter portion that is worked in the quarries of Fulwell Hill, that district being situate beyond the outcrop of the higher strata. The lower portion, which, for the sake of convenience, I shall term the Fulwell beds, has been further subdivided by the quarrymen into several minor groups. These it will be well to mention, as they serve to mark with greater exactness the vertical distribution of the fossils I am about to describe.

Below the higher thin-bedded yellow limestone is a series of thick beds of hard, subcrystalline, grey or whitish-grey limestone, associated with or passing into strata of conglomerated or botryoidal and very friable white limestone; this group is the "White Stone" of the Fulwell quarrymen. Immediately below is about three feet of dark-grey, highly crystalline, and conglomerated limestone, with beautiful (metastatic) crystals of calc-spar, and crystalloids of limestone; this is named the "Black Shell." Underlying it is generally a bed of soft friable limestone with conglobations; and then follows from twenty to twenty-five feet of thick-bedded crystalline and concretionary limestone, which, from its peculiar structure, is termed the "Honeycomb Limestone or Main Stone." Separated from the Main Stone by about two feet of conglobated limestone, follows nine feet of white or yellowish, very soft and friable limestone, which is the great "Marl Bed" of the quarrymen. Under it is about nine feet of thinner-bedded, often laminated, compact, yellow or brown limestone, called the "Dun Stone." This is underlain by eight feet of highly concretionary and crystalline, coralloidal, and laminated limestone, designated the "Grey Stone." Immediately under this is two feet of laminated limestone, which I

Fig. 1.—*Vertical Section of the Magnesian Limestone of Fulwell Hill.*

Scale 18 feet to the inch.

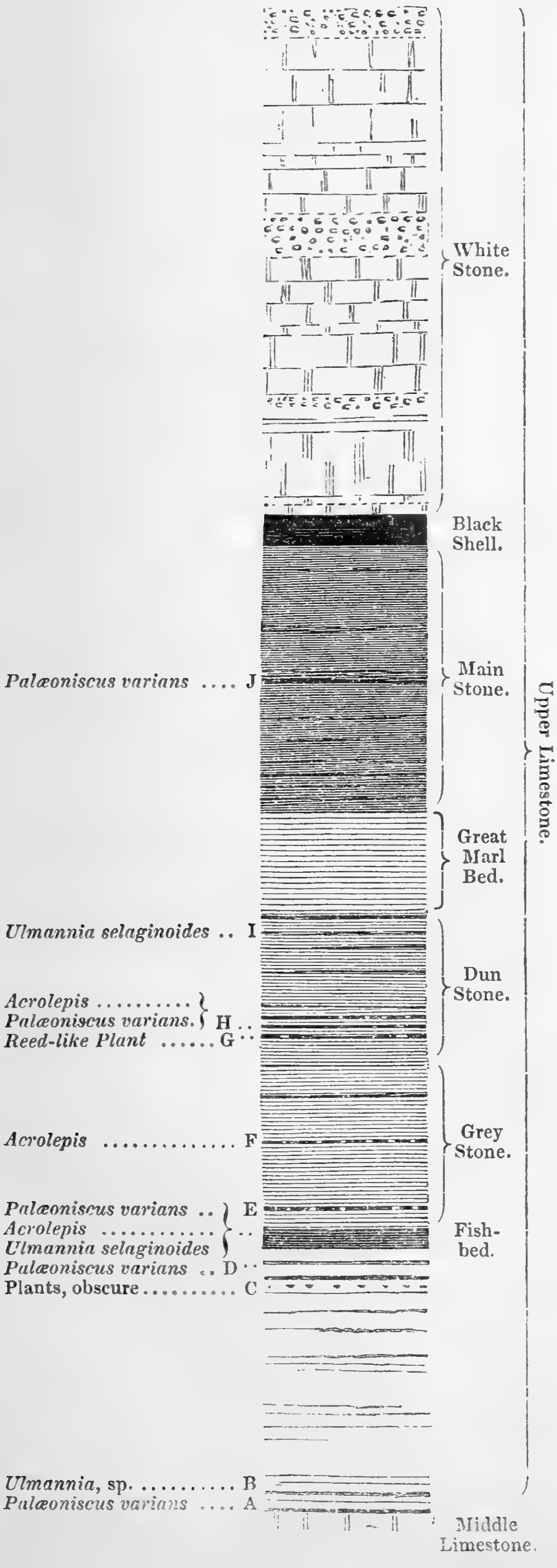
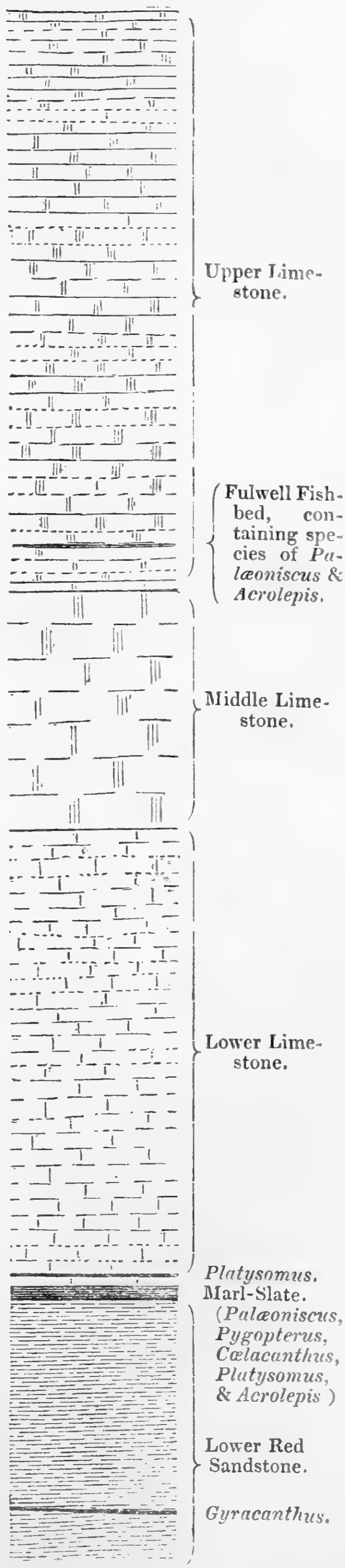


Fig. 2.—*Vertical Section of the Permian Strata of Durham.*

Scale 100 feet to the inch.



have already noticed as having yielded most of the Fish-remains; on this account I propose to call it the Fulwell Fish-bed. About eight feet of limestone underlie the Fish-bed, the uppermost being concretionary and laminated, and the lower laminated and argillaceous; the most inferior stratum passing into a bed of yellow-brown and white laminated marl and clay, one foot thick. The laminated marl rests upon the *Middle Limestone*, which at Fulwell assumes its pseudobrecciated phase, being light-coloured, friable with hard concretions, unstratified, and unfossiliferous.

The accompanying section (fig. 1) of the Fulwell limestone will, perhaps, render this account easier of comprehension; and the sequence of strata indicated may be seen, either wholly or in part, in the various quarries at Fulwell Hill, but more particularly in the old quarry of Sir H. Williamson. The basal beds of the *Upper Limestone*, and their junction with the *Middle Limestone*, are well exposed in the cutting on the North-Eastern Railway, at Fulwell.

The limestone of the Fish-bed in the new quarry, Fulwell, though difficult to describe in precise terms, on account of its liability to structural changes, is almost invariably laminated or slaty, the laminæ usually showing repeated alternations of crystalline, earthy, and compact textures. The crystalline laminæ are generally grey or brown in colour, and the earthy and compact laminæ of various shades of yellow. A band of soft and rather friable light-yellow limestone runs through the centre of the bed. In some places the limestone of this bed becomes generally more highly crystalline and somewhat concretionary in character; when this occurs, the plane surfaces are rough and more or less irregular. Otherwise the surfaces of the laminæ are usually smooth, forming a fine matrix for the fossils they enclose.

In the old quarry the bed decreases somewhat in thickness, is not so regularly laminated, and is softer and more earthy than in the new quarry.

At Marsden, the limestone which has yielded me Fish-remains is soft, yellow, and finely laminated, being, in fact, the well-known "flexible limestone" of geologists.

In the Fish-bed of the new quarry, and wherever else these fossils occur, the specimens almost invariably appear to have belonged to perfect individuals, or, at least, the dermoskeleton, fins, and bones of the head seem to have been unimpaired up to the period of deposition, though instances of distortion by subsequent compression are not unfrequent. The specimens are found on the surfaces of the laminæ, usually slightly in relief. They almost invariably retain the finely enamelled surface of the original ganoine, and are of a brown colour. Most of the examples found present a lateral view, with the dorsal, anal, and caudal fins outspread, and with the trunk uncontorted; examples with the trunk bent upon itself, or what is usually termed contorted, are comparatively rare. Individuals showing the dorsal and ventral aspects occasionally occur. Besides the scales, cephalic bones, and fin-rays, the interspinous bones of the fins are sometimes preserved; and very rarely traces of the vertebral processes. The specimens are sparingly distributed in the bed, occurring generally as isolated individuals; still, a pair of individuals, and sometimes a trio, are occasionally found together on a plane surface of a few square feet. Such instances, however, are exceptional; and, notwithstanding that probably some hundreds of specimens have been found since their first discovery, they cannot be described as common, the quantity of specimens obtained being due rather to extensive and close research than to their own abundance.

Fully nine-tenths of the specimens found belong to a single species of *Palæoniscus*. The remainder belong to two or probably three species of the same genus, and to a species of *Acrolepis*. All the *Palæonisci* are small, the largest of the forms being but little more than four inches in length. The *Acrolepis* seems to have attained a length of twelve inches.

Associated with the Fish-remains, there have also rarely occurred some fragments of Plants. These, though very imperfectly preserved, appear to be referable to three species, one of which is a *Calamites*, two *Ulmanniæ*, and the fourth is a large reed-like form, whose generic relations are difficult to determine from the discovered fragments. These are the only fossils that have been met with along with the Fish. No traces of Mollusca occur with them, nor, as yet, of Entomostraca or other microzoa, though several representatives of these classes are pretty commonly distributed in other parts of the Upper Limestone.

It has already been remarked that the fossils are not altogether confined to the stratum designated the Fish-bed; they are comparatively most abundant in that zone, and it is almost only there where there is a probability of finding them by personal search, their occurrence on other horizons being so rare as nearly always to be the result of accidental observation rather than the reward of direct investigation. Still, as they do occur at other horizons, it is important that we should place on record all that is known of their vertical range.

Commencing from below, the fossils first appear in the soft laminated marls at the base of the Upper Limestone, at the point marked A in fig. 1; from this horizon two imperfectly preserved examples of the common form, *Palæoniscus varians*, have been obtained. In the slaty argillaceous limestone immediately overlying the last-named bed, and marked B in the section, a single specimen of *Ulmannia*, sp. indet., has been met with; and in the soft yellow limestone, marked C in the section, about five or six feet higher in the series, several obscure fragments of vegetables have occurred. In the concretionary and lamino-concretionary beds marked D, lying between the last-named and the Fish-bed, several imperfect specimens of *P. varians* have been observed, and more particularly on the uppermost surface-plane on which the Fish-bed rests, where, besides *P. varians*, there have occurred specimens of *Acrolepis*. In the Fish-bed proper have been obtained the four *Palæonisci*, namely, *P. varians*, *P. altus*, *P. Abbsii*, and *P. angustus*?, the *Acrolepis*, and

Calamites arenaceus and *Ulmannia selaginoides*. In the laminated beds overlying the Fish-bed, and marked E in the section, *Acrolepis* has occurred, as it has also in the upper part of the grey stone about the horizon marked F. At or about the level marked G was also found the large reed-like Plant. At certain horizons of the Dun Stone, marked H and I in the section, examples of *Acrolepis*, *Ulmannia*, and *Palæoniscus varians* have occurred in the order indicated in the section. And, lastly, a single badly preserved, though determinable, specimen of *P. varians* in the Main or Honeycombe Limestone, at the point marked J—this being the highest horizon at which traces of Fish or any other fossils have as yet been met with at Fulwell. The space between the highest and lowest points of occurrence is about fifty-four feet; and, according to our present knowledge, this represents the vertical range of this small group of species.

To take a more comprehensive view of the position of these fish-bearing strata in the Permian formation, it may be observed that they are situated about 150 feet from the top of the *Upper Limestone*. In the north of Durham this member is the highest in the series; but in Yorkshire its equivalent subdivision (Brotherton Beds and Red Marls and Gypsum) is overlain by some marls and red sandstone of no great thickness, which some geologists refer to the Permian formation. Assuming that these latter deposits are thus rightly classified, the fish-bearing beds will not be more than 200 feet, probably less, from the Trias. On the other hand, they are separated from the Coal-measures by the Middle and Lower Limestones, Marl-slate, and Lower Red Sandstone, which represent an aggregate thickness of 460 feet. Previous to their discovery, the highest authenticated horizon on record for the occurrence of Fish in the Permian series of Durham was the inferior beds of the Lower Limestone, which had yielded a single specimen of *Platysomus striatus*,—the Marl-slate, however, being their chief and almost only horizon. The discovery of the Fulwell Fish has, therefore, carried the Permian Vertebrata from the lower beds of the Durham series high into the upper, and near enough to the Trias to give to their occurrence, perhaps, more than usual interest.

Descriptions of the Species.

Class PISCES.

Order Ganoidei.

Family 1. Sauroidei.

Acrolepis, sp.

A. Sedgwickii, Ag. Kirkby, Annals of Nat. Hist. 3 ser. vol. ix. p. 269.

About a dozen, or probably rather more, specimens of an *Acrolepis* have occurred, which may possibly belong to one of the forms of this genus already described from Permian rocks. All the specimens, with one exception, are fragments. The perfect specimen belongs to an individual about ten inches long; but I possess a fragment that has evidently belonged to an individual of a foot or more in length.

The maximum height of the ten-inch specimen is between the pectoral and ventral fins, and measures $1\frac{3}{4}$ inch. The head is $2\frac{11}{16}$ inches long, or nearly one-third of the length of the body. The anterior portion of the body is of a pretty uniform width, but from the ventral fins to the caudal it gradually attenuates to $\frac{3}{4}$ inch. The tail is strongly heterocercal.

The fins are large. The dorsal is five inches from the snout, and, though placed between the anal and ventrals, is partly over the latter; the ventrals are about $4\frac{1}{2}$ inches from the snout; the anal is 7 inches from the snout. The rays of the ventral fins are stout, and consist of twenty-three or twenty-four rays, which bifurcate twice in the terminal third of their length; their articulations, judging from the scales covering them, are short compared with their width, and irregular, except in the three basal joints, which are uniform in all the rays. The pectoral fins appear to have been similar in size to the ventrals, though numbering probably a few more rays. The anal is scarcely larger than the ventrals; it has thirty or thirty-one rays, not quite so stout as those of the ventrals, and with articulations proportionally longer. The dorsal, from what remains I have seen of it, seems to have been a little longer than the anal, and in both it and the latter the rays branch similarly to those of the ventrals. The caudal is large and deeply forked, each lobe being of nearly equal length; but, as the tail-margin slopes rapidly inwards ventrally, the rays of the ventral lobe are very much longer than those of the dorsal lobe, and they are also much stronger. The rays of the caudal fin are numerous, and similar in character to those of the others. Some of the basal ray-scales have the surface ornamentally furrowed or wrinkled, like the body-scales; in the other fins I have always observed that the ray-scales are smooth. The dorsal and ventral margins of this fin are fringed with fulcral scales, those of the dorsal lobe being longer than those of the ventral. Similar though smaller fulcrals protect the anterior margins of the dorsal, anal, ventrals, and pectorals.

The head is obtuse, and has the orbit placed far forwards; the jaws are powerful, and the gape is very large, being more than one-fifth of the length of the body; both upper and lower jaws are furnished with numerous smooth, conical, pointed teeth about one-fifteenth of an inch in length; these teeth are somewhat irregularly placed, and occasionally slightly bent towards the point, and appear to have a few minute teeth between them. The surface of the lower jaw is covered with a pustulate and wrinkled ornamentation; the surface of the rest of the bones of the head, including the opercular plates, has also a rugulose appearance. In one specimen there appear to be traces of branchiostegal rays.

The scales are small and rhomboidal, varying, however, considerably both in size and form. The dorso-ventral series are arranged in steeply sloping curves. The lateral thoracic scales are much larger than those of the dorsal, ventral, and caudal regions, being three times the size of some of the latter; these scales (lateral thoracic), by their great relative width and greater amount of overlap, appear more rectangular in outline than those of other parts of the body. The scales of the ventral region are by much the smallest. These latter and the scales of the caudal portion of the body are those which, by form and ornament, are most typical of the genus as established by Agassiz. The scales of the thoracic part of the body articulate by means of long, sharply pointed projections from the superior margin, which fit into sockets or depressions of the reverse and inferior portion of the overlapping scale above, as in *Palæoniscus* and so many other of the Lepidoidei. This system of articulation becomes obsolete towards the caudal extremity. The scales of the thoracic region, especially the ventral ones, overlap each other more than those of the caudal region. All these scales are thick and finely enamelled, and are ornamented with two or more converging furrows, which always terminate within the margin. Besides, however, the scales noticed, there are series of large, oval, pointed, bluntly lanceolate, and lanceolate scales, placed in advance of the dorsal, anal, and each lobe of the caudal fins. These scales, which Agassiz terms the *grosses écailles impaires,* attain the length of one-third of an inch, and number in each series from four to six; and they would appear to pass by gradations into the long pointed fulcral scales or spines that fringe the fins. The surface of these scales is closely covered with a similar ornamentation to the other scales, but more elaborate than it.

The lateral line is well marked by a series of deeply notched and channelled scales in the dorsal half of the body.

None of the specimens discovered show the slightest traces of the endoskeleton.

Nevertheless in one example we obtain some idea of the food of this Fish; for, intercalated between the scales of each flank, there may be seen portions of a *Palæoniscus varians,* which undoubtedly represent the remains of an undigested individual that had been captured and swallowed by the *Acrolepis* a short time previous to its death.

I at first identified this species with the *Acrolepis Sedgwickii* of Agassiz; but later comparisons of my specimens with Agassiz's descriptions and figures have shown me that it differs from that species in several particulars that appear of importance: for instance, the anal fin of *A. Sedgwickii* is described as being much greater than the dorsal, whereas, in the present species, the difference between these fins is only slight; the scales would also appear much more regular in size and shape in *A. Sedgwickii* than in the present species; and the former fish would appear to have been twice as large as the latter. I therefore cancel the identification I formerly made.

From *A. asper,* Ag., of the Kupferschiefer, the present species differs more than from *A. Sedgwickii.* But there are four species from the same formation, namely, *A. angustus,* Münster, *A. intermedius,* Münster, *A. giganteus,* Münster, and *A. exsculptus,* Germar, of which I have not been able to see either figures or specimens that may possibly approach more nearly than those I have just noticed. For these reasons it only seems judicious to refrain from attaching a specific name to this species, it being at the least possible that it may ultimately prove to belong to one of these last-mentioned forms.

The present species has occurred in the Fish-bed, in the Grey Stone overlying, and in the Dun Stone in the New Quarry at Fulwell; and I have taken a single example from the Fish-bed in the Old Quarry of the same place.

Family 2. Lepidoidei.

Palæoniscus varians, Kirkby. Pl. XVIII. fig. 2.
Annals of Nat. Hist. 3 ser. vol. ix. p. 267.

The maximum length of this Fish is from $3\frac{3}{4}$ to 4 inches. It usually occurs much less, often being only $1\frac{3}{4}$ inch long. Its maximum breadth is about an inch; but this is a point subject to much variation, the breadth of some specimens being one-third of the entire length, and of others only one-fifth. The body continues of similar width up to the dorsal and ventral fins; it then contracts somewhat rapidly to half the maximum width. The head varies in length from one-third to two-sevenths of the entire length, and its breadth is usually a little less than the greatest width of the body. The tail is moderately but decidedly heterocercal.

The fins are of median size. The pectoral, which is about half an inch long in mature examples, and placed at the junction of the ventral and median thirds of the body, consists of from 18 to 20 slender rays, with one or more short but strong spine-like rays in front. The ventrals are about $\frac{1}{16}$ inch shorter than the pectorals, and placed $1\frac{3}{4}$ inch from the snout; the rays are also less in number, though stouter, than those of the pectorals. The anal is $2\frac{5}{16}$ inches from the snout, or $\frac{9}{16}$ inch behind the ventrals; it numbers from 8 to 10 jointed rays, which are stronger and longer than those of the ventrals. The dorsal is placed about midway between the ventrals and the anal, or two inches from the snout; it is larger than the anal, being $\frac{5}{8}$ inch long, and it has from 10 to 12 jointed rays of similar strength to those of the anal. In advance of the longest rays of the anal and dorsal are two or three short, pointed, unarticulated rays; one or two similar rays are placed in front of the ventrals. The first segment of the articulate rays of the anal and dorsal is much longer than the succeeding segments—the succeeding segments being only about as long as wide. Each ray is covered by long unsegmented scales, which usually hide from view the ray-structure. The front margin of each of these fins is protected by sharply pointed, linear fulcral scales. The caudal is of moderate size and slightly forked, spreading out gently from a base half as wide as the maximum breadth of the body to fully two-thirds of that breadth; it is formed of 17 or 18 rays, as strong as those of the dorsal and anal, and the rays of the ventral lobe are, of course, the longest. The structure of the rays resembles that of the last-mentioned fins: the first segment is of considerable length, being fully four times as long as those that succeed it; the succeeding segments are slightly shorter than the equivalent segments in the anal and dorsal, so as to be wider than long. They appear to bifurcate rarely; and they are covered with longitudinal scales, like those of the fins just mentioned. Each lobe is protected along its dorsal and ventral borders with comparatively large fulcral scales. The rays of the caudal, at least those of the central and ventral portions of it, are affixed to long interspinous bones, two rays being attached to each. The rays of the anal and dorsal fins are also attached to interspinous bones, there being in these instances, however, an ossicle to support each ray.

In well-preserved examples the head is seen to be bluntly cone-shaped. The gape is comparatively small, and the orbit is large and oval. The opercular bones, which form the great bulk of the head, have a semicircular edge behind, and a surface with rugulose ornamentation. Below and behind the inferior maxillary are generally seen the branchiostegal rays, of which there appear to be nine.

The scales are large, comparatively thick, rhomboidal (variously modified), smooth to the eye, but finely shagreened when magnified, and with plain margins. The dorso-ventral series are arranged in sloping curves; there are 36 such series along each flank, and 14 or 15 scales in each series in the thoracic region. The lateral line is marked by a longitudinal series of notched scales, somewhat above the centre of the body; these scales are wider than any of the others on the flank; the scales above and below the lateral line decrease in size gradually, as they do also from the anterior portion of the body backward. Though the scales have been described as smooth to the eye, it should be mentioned that they are all marked, just within their exposed margins, with two or more lines of increment of great regularity. The overlap of the scales is considerable; their articulation is assisted also, as in other *Palæonisci*, &c., by teeth that project from the dorsal margin, and fit into sockets on the reverse of the ventral portion of the scales. In advance of each lobe of the caudal fin, and of the anal and dorsal, are placed four or five large scales, which are altogether different in form from the scales of the flank. They graduate from ovate or bluntly pointed scales to such as are lanceolate; and those of the latter form pass by insensible modifications into the fulcral scales or rays of the fin-borders.

There is more than one species to which this *Palæoniscus* has some resemblance; *P. Voltzii*, *P. fultus*, *P. angustus*, and *P. Vratislaviensis*, for instance, all appear related, though apparently distinct, forms. Perhaps the Fish that this species most nearly resembles is *Palæoniscus glaphyrus*, Ag., of the Marl-slate. It resembles it in size, largeness of scales, smallness of gape, size of orbit, and in position and structure of fins; but it differs from it in having a comparatively larger head—the head of *P. glaphyrus* being only one-fifth of the entire length, whereas that of *P. varians* reaches one-third—and in having a large operculum, scales that vary more in size, and in having them with plain margins, while *P. glaphyrus* has them deeply serrated. *P. glaphyrus*, moreover, does not appear to have possessed the large notched scales that mark the lateral line in *P. varians*. With these differences before me, I have not hesitated to describe the present form as a distinct species.

P. varians has occurred in the laminated marls at the base of the Upper Limestone, in the strata immediately underlying the Fish-bed, in the Dun Stone, and in the Main or Honeycomb Stone in the New Quarry at Fulwell; also in the Fish-bed in the Old Quarry, Fulwell. And the fragment of a Fish that I met with in the laminated limestone of Marsden apparently belongs to this species.

Palæoniscus Abbsii, Kirkby. Pl. XVIII. figs. 3*a*, 3*b*.
Annals of Nat. Hist. 3 ser. vol. ix. p. 268.

Length from snout to end of caudal fin rather more than 4 inches; length of body $3\frac{5}{8}$ inches. Greatest width, which is a little in advance of the ventral fin, $\frac{5}{8}$ inch; from this point the body contracts gradually to $\frac{3}{16}$ inch. From these measurements it will be seen that this species is an elongated form, the length of body being nearly six times the maximum width.

The head is an inch in length, and half an inch in breadth. The fins are of moderate size. The pectorals are about $\frac{5}{16}$ inch in length, and consist apparently of about 20 slender rays, with two short spine-like rays in front. The ventrals, which are comparatively small, are situated $1\frac{7}{8}$ inch from the snout; the anal is $2\frac{1}{2}$ inches from the snout; and the dorsal is placed midway between the ventrals and the anal, or $2\frac{1}{4}$ inches from the snout. Of the anal and dorsal, the latter is the larger; but none of the specimens found show either these fins or the ventrals in a condition that permits the rays to be counted. The caudal fin springs from a tail apparently more heterocercal than in *P. varians*; it consists of 15 or 16 stout rays, that are margined on each lobe by numerous pointed fulcral scales.

The scales resemble those of *P. varians*, except in being longer compared with their breadth. They are arranged in more inclined dorso-ventral series than in *P. varians*, and there are about 12 in each series; but the scales are generally so much dislocated and confused as to render their numeration a matter of difficulty.

The distinguishing feature of this Fish is its elongated form; and, except in being so much longer, it differs little from the preceding species.

From another elongated form of the same genus, *P. longissimus*, Ag., it differs in having much larger scales, and in their being smooth and unserrated at the margin; also in the relative position of the dorsal and ventral fins being different in the two species. From *P. Kablikœ*, another elongate Permian species, described by Dr. Geinitz, it differs in having a much blunter snout and smaller fins, as well as in a less elegant general form.

Examples, chiefly fragments of about half-a-dozen individuals, have occurred in the Fish-bed of the Old Quarry at Fulwell.

Palæoniscus altus, Kirkby. Pl. XVIII. fig. 1.

P. latus, Kirkby, Annals of Nat. Hist. 3 ser. vol. ix. p. 268*.

Greatest length $2\frac{5}{8}$ inches; length of body 2 inches; maximum breadth rather more than 1 inch, or more than one-half of the length of the body; breadth of tail $\frac{1}{2}$ inch; head $\frac{5}{8}$ inch long, and the same in width.

The general form of this fish is gibbous; the tail is only slightly heterocercal. The pectoral fins are small and slender; the ventrals, which are also small, are placed $1\frac{1}{16}$ inch from the snout, and the anal is $1\frac{7}{16}$ from the same point; the dorsal, which is the most robust of the fins mentioned, is situated at a point between the anal and the ventrals. The caudal is wide, and has about 24 strong rays: both lobes of this fin, as well as the anterior borders of the dorsal and anal, are protected by fulcral scales as in both the preceding species; and in advance of the fulcrals are the large "écailles impaires," which so generally accompany them.

The scales of the flanks are of the same type as those of *P. varians*, but are comparatively wider and shorter. They are robust, and smooth except in having marginal lines of growth, and are arranged in steeply sloping dorso-ventral series.

The bones of the head are ornamented with the same kind of rugulose sculpturing as that which characterizes *P. varians*. The orbit is also large.

I do not know of any species of *Palæoniscus* that approaches *P. altus* in its great relative width of body, although in general form of scales, in fin-structure, and in ornamentation of the bones of the head it differs little from the two preceding species.

One or two examples of this species have been found in the Fish-bed of the Old Quarry, Fulwell.

Palæoniscus angustus ?, Agassiz.

Along with the *Palæonisci* previously described has occurred a specimen of what appears to be another species. It is chiefly distinguished by its large fins and produced snout, and in general appearance has much resemblance to *P. angustus*, Ag., to which I provisionally refer it.

The specimen is in the possession of Mr. W. M. Wake, and was found in the Old Quarry, Fulwell.

PLANTÆ.

Ulmannia selaginoides, King.

Several specimens have occurred, usually more or less fragmentary, of a vegetable that evidently belongs to the above species. The specimens are generally impressions, with traces of carbonaceous matter, the nervation of the leaves being occasionally shown on the impressed surface. The finest example, in the cabinet of Mr. Wake, is eleven inches long, with a branch of three and a half inches.

* At the suggestion of Sir Philip Egerton, I adopt the term *altus* for this species, *latus* having been already applied to another species of *Palæoniscus*.

Ulmannia, sp.?

I have also examples of another Plant, belonging apparently to the same genus as the preceding, but they are not sufficiently perfect to allow me to describe from them.

Calamites arenaceus?, Brongn.

Among the vegetable remains are two specimens of a Calamite, which, on Mr. Howse's suggestion, I doubtfully refer to this species. The specimen in my possession is $4\frac{1}{4}$ inches in length and nearly an inch in width. It shows two joints, $1\frac{1}{2}$ inch distant from each other; and the impressed surface is rather finely striated longitudinally.

Besides the preceding species, a single specimen has occurred of a large reed-like Plant which I have not been able to identify. It is 21 inches long and 1 inch broad, rather coarsely striate longitudinally, and without any indications of constrictions or joints. The specimen is in the collection of Mr. Arthur Dixon.

I have to acknowledge the assistance of Mr. Howse in determining the Plants.

So far as may be judged from the fossils I have described, the physical conditions that prevailed during the deposition of the Fulwell Fish-bed were similar to those that obtained during the accumulation of the Marl-slate towards the commencement of the Permian era. The characteristic fossils of the Marl-slate are Fishes belonging to the genera *Palæoniscus, Acrolepis, Pygopterus, Platysomus,* and *Cœlacanthus,* the species of the first genus being by far the most common. With the Fish occur the remains of Plants, chiefly belonging to *Ulmannia selaginoides*; and, rarely, examples of *Lingula, Discina,* and *Myalina.* The facies of this small fauna seems to me to be decidedly estuarine, though with a greater tendency to approach freshwater than marine conditions; for while the vegetable remains, which indicate terrestrial and freshwater conditions, are distributed generally throughout the whole of the Marl-slate, the Mollusca, which seem as certainly to indicate marine conditions, are confined to a very limited area in the same deposit. In the Fulwell Fish-bed we have Fish belonging to the same genera, and Plants belonging to the same species, as those that occur in the Marl-slate, besides other Plants whose occurrence there is not recorded. In this bed there are no Mollusca, nor is there, as I have before observed, a single trace of any marine organism. It would, therefore, seem as if the physical conditions of the Fulwell Bed had been even less marine than those of the Marl-slate; so that it is not unlikely that in its small group of species we see part of a freshwater fauna of the Permian period.

Another inference appears warrantable in respect to the Fish; that is, that the presence of so predaceous-looking a Fish as *Acrolepis* among small and comparatively harmless *Palæonisci* evidently indicates that the latter were pursued and preyed upon by it. The association merely of these Fish suffices to justify this inference; but the occasional presence of undigested remains of the *Palæonisci* between the scales of the abdominal region of the *Acrolepis* would as certainly seem to prove it. The occurrence of so many uninjured individuals of the *Palæonisci* along with the *Acrolepis* would further indicate that both the pursuers and the pursued were ultimately overtaken by circumstances that rendered powerless their instincts in one common catastrophe.

In conclusion I would remark, that though these fossils form, as it were, a distinct group in the Permian life-system, they are yet, on the one hand, connected with those of earlier Permian date by *Ulmannia selaginoides*, and probably by the *Acrolepis* and the *Palæoniscus* I have referred to *P. angustus*, which occur either in the Marl-slate of Durham or the Brandschiefer of Saxony; and, on the other hand, they would appear to be connected with the Triassic life-groups by the Calamite referred to *C. arenaceus*. Should the identification in this case prove correct, we then shall have at last a connecting link of species between the life-systems of the Palæozoic and Mesozoic eras. It would be premature, however, as yet to distinctly assert that such a connecting link exists; for though the tendency of the evidence that may be deduced from the fragments of the Calamite discovered may be in that direction, the evidence is, nevertheless, too imperfect to allow the decision to be clear of doubt.

EXPLANATION OF PLATE XVIII.

Fig. 1. *Palæoniscus altus*, Kirkby. Natural size. Old Quarry, Fulwell Hill.
2. *Palæoniscus varians*, Kirkby. Natural size. New Quarry, Fulwell Hill.
3. *Palæoniscus Abbsii*, Kirkby. *a*, anterior portion; *b*, posterior portion of the same fish. Natural size. Old Quarry, Fulwell Hill.

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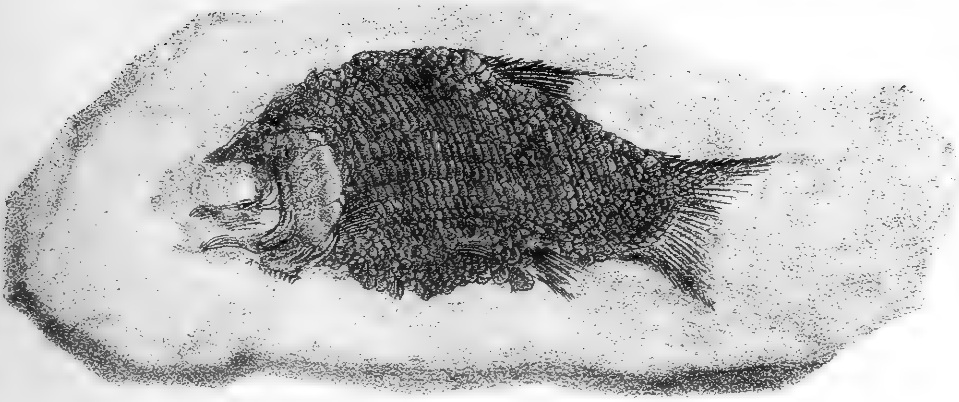
3. *On the* Fossil Corals *of the* West Indian Islands. Part III. By P. Martin Duncan, M.B. (Lond.), Sec. G.S.

Contents.

§ I. Introduction.

It has been remarked with great truth, that the fossil condition of the Antiguan corals renders their specific determination very

1


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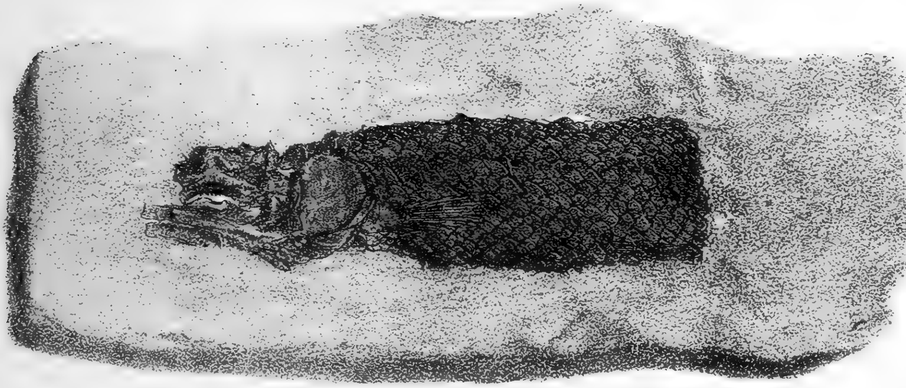

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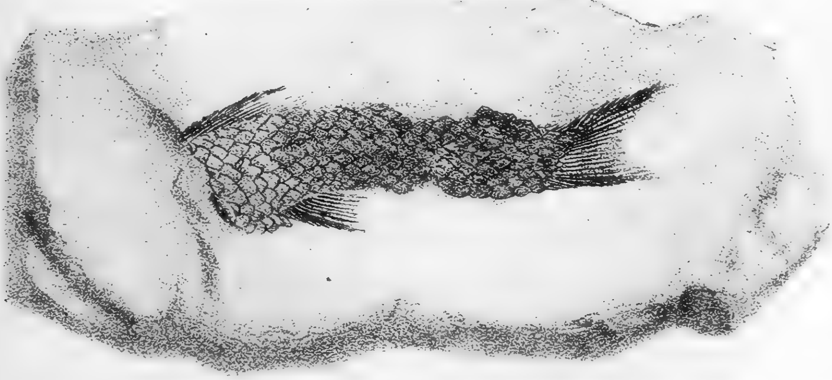


J. W. Dinkel lith.

M & N Hanhart imp.

PERMIAN FISHES.

difficult. Many of the species of the genus *Astræa* (*Heliastræa*, Edwards and Haime), described in the first part of this communication *, can only be determined after a careful examination of their mineralization, so altered are the structures in their relative appearance, colour, and preservation. The difficulty is to decide which parts, in a calcareous, calcareo-siliceous, or siliceous corallum, represent the former hard parts, and which the interspaces; what relation casts may bear to the original forms; and, amidst opaque or very transparent, opalescent or highly-coloured silica, how much of the loss of the finer details must be considered the result of mineralization. Both Dr. Nugent and Mr. Parkinson attributed their failure in the classification and description of the siliceous corals to the great variety of their forms of mineralization.

The corals of every age, from the Silurian to the Quaternary, present great alterations in the appearance of the sclerenchyma, and are therefore not always readily classified and distinguished; the Oolitic species are particularly affected by mineralization; but it is certainly true that, as a whole, the West Indian Miocene fossil corals are the most recondite in their fossilization.

The corals of the Chert and Marl of Antigua are readily distinguished both from each other and from the fossils of the other islands: occasionally a siliceous coral is found in the Nivajé shale and in the beds of the smaller islands; but the majority of the Jamaican and San-Domingan specimens are either a little harder than during life, and calcareous, or have been more or less altered during a process of silicification, which has been rarely completed. It is obvious that the form of mineralization cannot be received as an evidence of the age of the strata containing the corals; for the Marl of Antigua is not older than the Jamaican or Nivajé deposits, yet its corals are more intensely silicified, and, moreover, the condition of specimens taken from these last is often the same as of those which are to be obtained from the dense limestone of recent reefs. Nevertheless perfect silicification is a proof of a Mid-tertiary age in West Indian fossil corals.

The anatomy of the stony corals is very simple, and the only difficulty which can arise in reference to the various forms of mineralization is the relation which the interspaces, or the parts included by the sclerenchyma, bear to it. It must be remembered that the hard parts are more or less traversed by fine pores during life, and in one great family this porosity is in excess; and that the lower parts of simple corals are frequently filled up by a dense tissue before death, just as the intermural spaces of compound forms are in some species. The sclerenchyma consists of the Wall, Costæ, Exotheca, Epitheca, Septa, Pali, Columella, and Endotheca; the Exotheca comprehends the costal dissepiments and the Cœnenchyma; and the Endotheca, the septal dissepiments, synapticulæ, and tabulæ. The interspaces, during life, contain the soft tissues, and admit the sea-water; but, as growth progresses, many of them remote from

* Quart. Journ. Geol. Soc. vol. xix. pp. 412 *et seq.*

the surface become closed and empty; they consist of the calicular fossa and fossula, the interseptal loculi, the more or less cellular spaces between the septal and costal dissepiments, and cœnenchymal tissue, and, in porose corals, of the pores and reticulations.

I now propose to consider and to describe the processes which in modern reefs succeed, as they doubtless did in the ancient, the displacement and death of masses of coral; to notice how these processes may possibly have influenced the mineralization of fossil corals; to tabulate the forms of the mineral condition of the West Indian Miocene corals, and to describe those forms in detail.

§ II. Changes in recently Dead Corals.

In the coral-seas, the physical causes which assist, induce, and stimulate chemical affinity are strongly and constantly in operation. The solar light and heat are intense, and the temperature of the sea is high and equable. The strong swell and surf are highly aërated, and teem with minute organisms. The decomposition of the dead Zoophytes and Mollusca is therefore very rapid, but it varies considerably in its effects upon their calcareous parts, according to the position of the coral or shell during the post-mortem changes.

Living corals, which have been broken off the parent mass, or separated from their basal attachments, are liable to be swept upwards and carried high and dry by the force of the waves. In many instances they may either remain in their original position, by becoming entangled in the neighbouring corals, or they may at once fall to the bottom of the sea and rest on the surface of the mud which forms beneath and amidst all coral-reefs and banks. Each of these accidents would appear to be followed by a particular series of physical and chemical changes, which must have occurred during the former great coral-eras as at the present time, and which appear to have influenced the subsequent mineralization of the dead sclerenchymal structure in certain definite modes.

1. *By the action of the sea.*—Simple corals, or compound forms, which may have been cast up high and dry immediately after their separation from a reef or bank, are covered with soft dermal structures, and contain the digestive and ovarian tissues. Death of the polypes speedily occurs, and either their soft tissues are washed out of the sclerenchyma during the process of rolling, which must happen during the recession of the tide, or they decompose with greater or less rapidity on reaching very shallow water or the dry shore. It would appear to be a rule that the minuter structural details of corals are best preserved when the animal tissues have been well washed out by the sea, and that the loss of these details bears a relation to the length of time the decomposing soft membranes remain in contact with the sclerenchyma. The indestructibility of corals, whose soft parts have been washed out before decomposition has commenced, is well known; and it is a well-established fact that the sclerenchyma of such corals becomes harder by exposure: the perfection of their details is of course limited by the effects of roll-

ing after separation from the reef, and by the ravages of *Lithodomi* and Parrot-fish before death.

2. *By decomposition of the soft parts.*—When a recently dead coral retains its soft parts sufficiently long for decomposition to set in, and it is exposed to the direct rays of the sun, the superficial tissues become diffluent and fœtid: if the decomposing membranes be not speedily washed off, they become dry, black, and hard; but if the tide, or accidental moisture of any kind, remove the superficial and wash out the deep decomposing polype-tissue, the coral is but little affected as regards the condition of its sclerenchyma. Beneath the dry blackened membranes the sclerenchyma appears invariably softer than during life; moreover, where stained, it crumbles, and to a certain depth, even when there is no discoloration, it has less cohesion and a different fracture than formerly. The fracture is of an opaque, saccharoid, white colour, and the texture is more or less chalky and granular: a new chemical compound exists in the sclerenchyma, and is the result of the action of phosphates and chlorides upon the carbonates of lime and magnesia of the living coral. Corals thus altered are very destructible, and as simple subaërial wear and tear rub off their minuter structural details, so more powerful influences destroy all the parts which offer the characteristics for classification. The most recently formed parts of the sclerenchyma of corals are the most porous and the most in contact with the soft parts: the edges of the septa and the lateral granules of their laminæ are, for this reason, the details most readily affected by the chemistry of decomposition, and deformed calices, with bent and collapsed margins, are commonly seen on recently decomposed corallum-surfaces; moreover these conditions are seen in the fossil state, the deformities being permanently transmitted by siliceous transposition*. The decomposition of the deeply seated tissues in tall Astræans, and other corallites with long tubes, appears to be very destructive to the sclerenchyma in the immediate neighbourhood; it can hardly be prevented or controlled by the contact of moisture, and it therefore often happens that a large mass of coral may be very perfect in its calicular details, but very imperfect lower down. This condition is also transmitted in the fossil state.

Induration proceeds in the sclerenchyma which has been out of the range of decomposition; and all the cast-away masses, their débris, and also huge masses of reefs, elevated during the frequent changes of level of such localities, have a tendency to harden, and, when in contact, to form limestones or coral breccias †. The influence of the wash of the tide or of spray on these masses must be remembered, especially as the sea is charged with atmospheric air, and contains both silica and carbonate of lime in minute quantities, as well as siliceous organisms.

3. *By fracture from the parent mass.*—When a living coral is broken from its base, or separated from its parent mass, or removed

* See deformed calices of an *Astræa* from Antigua, Coll. Geol. Soc. no. 32. This state is associated with the formation of casts and destructive silicification.

† The results of the observations of Dana, Darwin, Jukes, and others.

from its habitable zone by oscillations of level, and not ejected by the sea, it either remains entangled in a position where death ensues sooner or later, or it falls to the sea-bottom and plunges into the soft chalky coral-mud. In the first instance the soft tissues are soon washed away by the force of the sea, and the bare sclerenchyma becomes covered with living Corals, Bryozoa, &c. The structural details are well preserved, and it is difficult to imagine the possibility of the occurrence of decomposition.

4. *By prefossil accidents attending the imbedding of Corals.*—When the mass of coral falls to the sea-bottom and reaches the coral-mud, it must come under the destructive influences of all the various decompositions which are constantly in progress there. This mud performs a most important function in the economy of a coral-reef, and is equally worthy of study when raised up and forming part of a coral-formation. It is formed by the natural wear and tear of the reef above: on to its surface fall the dead and dying organisms which lived in and about the corals and their excreta, and it teems with Foraminifera. The mud is ever on the increase; and although nothing is known about the manner in which it is brought about, still its depths undergo a geologic chemistry, which produces even in recent coral-areas the appearances of clay, chalk, and even oolitic grains *. The decomposing corals are soon crammed with the calcareous mud, and this is ever under the influence of a warm and highly aërated sea †. The Marl of Antigua is a Miocene coral-mud, so is the base of the Nivajé deposit in San Domingo, and every coral in them is, or has been, stuffed with carbonate of lime and Foraminifera. It does not require much imagination to admit that a coral, with decomposing soft parts, falling into the mud, is likely to be differently affected from one whose sclerenchyma happened to be free from its membranes. In the first the particles of mud would, after filling the corallites, come in contact with the decomposing tissues and the softening sclerenchyma; they would participate in the effects of the decomposition, and, of course, the greater the amount of chemical action, the greater would be the alteration of the enclosed mud. When there was no membrane, the coral would simply be filled with mud, which would retain its own peculiar mineralogical characters. Now, it would appear that the greater number of the peculiar appearances of the Antiguan corals are to be traced to these last prefossil accidents, and that the perfect silicification of the corals supervenes on a filling up of the interstices of the sclerenchyma by coral-mud, and the greater or less alteration of this and the sclerenchyma in contact with it, the silica replacing a salt of lime by ordinary chemical transposition.

These prefossil accidents are evidently the same which occurred formerly, for their results can be traced in the fossil condition of corals of all ages. The formation of one kind of cast, which is

* See specimens of recent coral-mud in Geol. Soc. Coll., Captain Nelson's Collection.

† The fœtidity of exposed coral-mud is well known.

also common in all the coral-formations, occurs amongst the Pacific and West Indian reefs; and the dense limestone described by Darwin and other observers is produced wherever there is much coral-detritus, and it is not to be distinguished from infinitely older limestone-rock. The common recent saccharoid cast is formed by the hardening of the calcareous infiltrations of the interstices of the corals, and by the subsequent disintegration and solution of the hard parts; it is a form of cast constantly seen either in the calcareous or siliceous form of mineralization. The consideration of these post-mortem changes and prefossil accidents, which are now occurring, thus brings many of the structural peculiarities of fossil corals within our comprehension; some of these changes are perfectly represented in the fossil condition, and others are supposed to influence the gradual transposition of elements, or the molecular alteration of the original salts, which occur during the lapse of ages. There are then, as data for our guidance in the appreciation of such fossil changes, post-mortem and prefossil accidents and chemical changes, various media, which include the organism, and which have various chemical changes constantly progressing in their mass, an aërated sea containing various minerals and salts in solution, varying temperatures, time, oscillations of level, and alterations in the fossilizing materials, drainage, and pressure.

§ III. Table of the Forms of Mineralization.

1.	Calcareous	2 varieties.
2.	Siliceous	4 „
3.	Siliceous and crystalline	2 „
4.	Siliceous and destructive	4 „
5.	Siliceous cast	2 „
6.	Calcareo-siliceous	5 „
7.	Calcareo-siliceous and destructive	3 „
8.	Calcareo-siliceous cast	3 „

§ IV. Description of the Forms and Varieties *.

1. *Calcareous.*—The sclerenchyma is more or less perfect; it consists of the usual coral-salts, but it is very indurated. The inter-

* The specimens of these forms of mineralization are amongst the fossil West Indian Corals in the Geological Society's Museum; they are numbered as follows. It is necessary to observe that certain specimens may illustrate more than one form at once, and that all the fossil corals are not marked.

Forms—Siliceous, nos. 1, 2, 3, 4.
„ Siliceous and crystalline, nos. 5, 6, 7, 8, 9, 19.
„ Siliceous casts, no. 20.
„ Siliceous and destructive, nos. 10, 11, 12, 13, 14, 15, 16, 17, 18.
„ Calcareous, no. 21.
„ Calcareo-siliceous, nos. 22, 23, 24, 25, 26, 27.
„ Calcareo-siliceous and destructive, nos. 28, 29.
„ Calcareo-siliceous casts, nos. 30, 31.
„ Deformed calices fossilized, no. 32.
„ Indurated and rolled recent fossils, nos. 34, 35, 36, 37, 38.
„ Softened recent coral with dry polype-tissues, no. 39.

spaces are empty. Allowance must be made for prefossil wear and tear in increasing the dimensions of the interspaces, and also for that natural thickening of the walls, which tends to the obliteration of interspaces in many genera.

The calcareous form of fossilization is seen to the greatest advantage in a mass of shells and pieces of coral from the coral-limestone of Barbuda. The details of the coral, which is a Cyphastræan, are well preserved, and its texture is very dense and hard. There is not more silica in the specimen than is usually found in recent corals.

In a specimen of the same species from the Nivajé shale of St. Domingo, this form of calcareous induration is well seen in portions of the mass, but not on the calicular surface. The density, increased specific gravity, and more or less opaque-white fracture of these specimens distinguish them from recent corals, and from those of reefs raised during the existence of the present distribution of the Zoantharia in the West Indies. The later Tertiary corals of the Antilles present appearances greatly resembling those recently dead, but generally there is an evident gain in weight and hardness. This form is not found in the Chert and lower part of the Marl at Antigua, but is common enough at St. Domingo, where the specimens are more or less tinted by the matrix, and have generally suffered from considerable wear and tear.

The impressions of calices so frequently found, consisting of indurated matrix, probably result from the disintegration and solution of the calcareous fossil subsequently to the hardening of the beds. The second variety occurs in Jamaica, at Bowden, where crystalline carbonate of lime fills up the interspaces of some dendroid corals.

2. *Siliceous.* Variety 1.—The sclerenchyma is perfect; it consists of homogeneous silica, which is generally opaque and straw-coloured externally, but more or less transparent below the surface. The interspaces are empty.

Variety 2.—The sclerenchyma either resembles the condition of the first variety, or it may be more or less of a transparent grey colour, but occasionally the silica is white and opaque. The interspaces are filled with homogeneous, transparent, and variously coloured silica.

Variety 3.—The sclerenchyma resembles that of the last variety. The interspaces are either filled with opaque silica, which is often jasperoid, opalescent, and porcellanous, or with semi-opaque silica, whose tints are red, grey, and black.

Variety 4.—The sclerenchyma is either like that of the former varieties, or it is much coloured by the former influence of bitumen and salts of iron. The interspaces are here and there empty.

The first variety of siliceous fossilization, where the coral, instead of being formed of its usual chemical constituents, consists entirely of silica, is so common that its specimens are readily distinguished and their specific affinities easily determined.

The second variety constitutes the bulk of the silicified corals of

Antigua, and is a form well known in European collections. The replacement of the original sclerenchyma by silica, sometimes transparent, but usually of the exact tint of the original texture, is evidently of the same date as the filling up of the interspaces with homogeneous and differently tinted silica; the probable filling up of the interseptal loculi and exothecal cells, in the first instance, with carbonate of lime, and its gradual silicification by transposition, will be noticed in considering the calcareo-siliceous fossils of the latest Antiguan formation.

It is very common to find the granules on the septa, their spines, and the exothecal and endothecal dissepiments deficient, in some of the most perfect specimens, and a general wasting of the walls also. The space occupied formerly by these details is filled up with the variously coloured silica of the interspaces, so that an originally stout Astræan may be presented as a very delicate form*. It is impossible to determine how much of this loss has been of prefossil date, but some of it occurs during the replacement of the calcareous by the siliceous particles. This variety of fossilization affects the fossil woods of many West Indian islands, preserving their details with considerable accuracy in some instances, but producing much destruction of them in others.

The third variety particularly affects two genera † of the Antiguan corals, and renders their diagnosis very difficult; in fact, longitudinal sections of masses thus silicified have been mistaken for the cut surfaces of Bryozoa. The colouring of the silica which fills up the interspaces is very bright and various in some specimens, and in others is complicated by the presence of much opaque-white chert, as well as of minute collections of crystalline quartz in the coloured silica. The silica is rarely transparent when brightly coloured, but is jasperoid and granular, or opalescent; when lighter in tint, it is more or less homogeneous and transparent; and it is by comparing the transparent with the opaque varieties of this form of silicification, and by mapping out the sclerenchyma, which is usually transparent, pale grey, or slightly opaque, that the coral can be determined to be a species of a genus well known under a very different form of fossilization in European Mid-tertiary collections. The transverse endothecal dissepiments which divide the coloured rectangular spaces in longitudinal sections, like the steps of a ladder, give the coral the appearance of a tabulate form; but it will be observed that the dissepiments of one interseptal space are not on the same plane as those of the others, and that the supposed tabulæ are not continued throughout the whole diameter of the corallite. The apparent quaternary arrangement of the principal septa is, moreover, very curious and deceptive ‡. There are many impressions of the calices of a species of this genus, and some nearly perfect calices also, in the collections of the Geological Society and British Museum.

* As in *Astræa endothecata*, nobis, vars. 1 and 2, Antigua.
† *Astrocœnia* and *Stylocœnia*.
‡ *Stylocœnia lobato-rotundata*, Edwards and Haime.

The calices usually have the interseptal loculi filled with white porcelain-looking silica, the septa being grey.

In a small Astræan * from the chert of Antigua, the septa, endotheca, and walls are of homogeneous flint, and the interseptal loculi and exothecal cells contain opal and porcellanous silica. The result is the production of a fossil second to none in beauty.

3. *Siliceous and Crystalline.* Variety 1.—The sclerenchyma consists of silica resembling the original tissue in colour; it is sometimes transparent, and often opaque and white. The interspaces contain crystalline quartz; the endothecal spaces are more or less empty; but the costæ, the cœnenchymal spaces, and the cells of the exotheca are replaced by radiating crystals of quartz.

Variety 2.—The sclerenchyma is like that of the last variety, but the costæ and exotheca exist; the corallites are often much deformed, and the septa are generally deficient. The exothecal and cœnenchymal spaces are empty, whilst the endothecal spaces and the interior of the corallites are filled with crystals of quartz, accompanied often by homogeneous silica.

The first variety is seen in the Astræans of the lower part of the Antiguan marl, and the second particularly affects the species *Astræa radiata*, var. *intermedia*, at Antigua; both have a relation to the next form of mineralization.

4. *Siliceous and Destructive.* Variety 1.—The sclerenchyma is much thinner than normal, the details are very defective, and the endotheca is usually wanting. The silica is variously coloured, and is either transparent and grey, or opaque and white, but it is often black. The interspaces are filled with transparent, opalescent, or opaque-white silica; they are larger than is normal from the loss of the substance of the original hard parts. The corallites are usually much deformed.

Variety 2.—The sclerenchyma is as in the last variety, but in some parts more or less of the walls and septa are wanting. The interspaces are as in the last variety.

Variety 3.—The sclerenchyma is very imperfect, and only remains here and there in a large silicified corallum. The silica may be opaque or nearly transparent. The interspaces are filled with chalcedony, agate, or more or less crystalline silica. In some specimens a simple dimple in the siliceous mass indicates a former corallite.

Variety 4.—The walls, septa, and endotheca are formed of rough granular silica, and all the minuter details are absent, whilst the endothecal structures are greatly deficient. The endothecal spaces are filled with homogeneous flint and granular silica.

In a very well-marked example of the third variety of this form of silicification, the destruction of the corallites and their replacement by semitransparent chalcedony cannot be accounted for by the prefossil loss of details; for the silicification has so altered the original substance of the corallum, that the corallites can only be recognized as dimple-shaped depressions in the siliceous mass. In one

* *Astræa cellulosa*, nobis.

large Astræan the superficial parts of the corallum are well preserved, but the centre and base of the mass are turned into dark, semitransparent, homogeneous flint, without a trace of structure. There are many grades of the destructive form of silicification between those just described and that which is so slight as to be distinguished with difficulty, or not at all, from the results of prefossil wear and tear. Simple loss of the septal granules, thinning of the septa, costæ, and of the wall, are very commonly observed; these conditions may have resulted from prefossil accidents; but when the wall is hardly distinguishable, the septa and costæ remaining as well proportioned as ever*, or when the dissepiments are wanting, the rest of the sclerenchyma being intact, something more than prefossil wear and tear must be considered in explanation. In some long corallites of a *Rhodaræa* or a *Stephanocœnia* the walls and septa do not exist; they have been absorbed and replaced by silica; but the columella and its attached pali, greatly thinned, are found in the centre of each corallite. This state of things must have been brought about after the infiltration of the interspaces; otherwise the corallites would have fallen to pieces. Again, the presence of imperfect corallites separated from the mass of perfectly silicified coral, and joined to it by opalescent or even nearly transparent homogeneous silica, is now and then seen in specimens where there is a greater amount of destruction of the walls and septa of the corallites than is consistent with the integrity of the mass when formed of its usual coral-salts. It is in these minor grades, especially where the siliceous replacement is in the transparent or slightly opalescent form, that the wavy lines of more opaque silica curve around and bound the parts where destructive silicification has been very decided. The parts beyond are often quite semitransparent, and the wavy lines or broad belts are generally singularly milky in colour. The occasional and general connexion of homogeneous black flint, and the wavy lines of agates and of more or less coloured siliceous stones, with the former existence of organized structures is very evident after the study of the Antiguan fossil corals.

The first variety of this kind of fossilization complicates the appearance of the corals greatly, on account of the interspaces being filled with opaque light-grey granular silica, the sclerenchyma having been thinned down to the utmost; probably both by prefossil wear and tear and by destructive silicification. The walls and septa of the corallites have lost half their thickness, the columella has not lost much; but all traces of endotheca and of costæ have gone: what remains is either transparent and pale grey, or opaque and jet-black. The exothecal cells have been filled and changed

* The best distinctions between the loss of sclerenchyma from prefossil wear and tear, and from destructive silicification, are as follows:—the latter is more decided in its effects, it acts unequally upon parts closely attached, and its effects are such as would tend, if the homogeneous flint or opalescent silica were removed, to the falling to pieces of the corallum. Both conditions have a relation to the effects of decomposing tissue on the sclerenchyma.

into a mineral like that of the interspaces, and thus a polygonal margin surrounds each corallite*.

The interspaces, enlarged by the loss of the thickness of the septa and walls, look very prominent in their dense white silica; and the coral may readily be mistaken for one with pentagonal walls, thick septa, and no columella. In reality, as may be made out with ease, the walls are circular, the septa very slender, and the columella large and occupying much space. Examples of this variety of fossilization are very common in Antigua, and the polygonal shape of the transverse sections of the corallites, with the opaque-white mineral which fills up the interspaces, are very characteristic. The more the sections of the corallites are aslant, and not at right angles to their long axis, the more the polygonal form is developed; it is, therefore, requisite to notice the nature of the section, especially in the specimens where the destructive silicification has affected the interspaces, but has not thinned the septa, the interseptal loculi being filled with opalescent silica. One large specimen of *Astræa megalaxona* affected by this variety has the central spot of each corallite, as seen in transverse sections, turned into a white form of silica. The columella is, therefore, fossilized white, the septa are of transparent and rather dark silica, the interspaces are of light brown silica, and all are indistinct, except the white central spots. Near the surface these spots are not seen, having decayed away, so that the coral, instead of being considered a species closely allied to *Astræa Pleiades*, may readily be taken for a Palæozoic form.

5. *Siliceous casts.* Variety 1.—The sclerenchyma is deficient, and the interspaces are filled with either opaque and variously coloured silica or with granular silica, which is white or red†.

Variety 2.—The sclerenchyma is deficient except as regards the septa, which are seen as thin radiating siliceous lines. The interspaces are as in the last variety, but they are often filled with transparent chalcedony. The siliceous casts of compound corals, so common in European Secondary formations, and the rarer casts of simple kinds are common enough in the West Indian limestones.

As the genus *Isastræa* is so usually found affected by this form of fossilization in the older coral-formations, so some genera allied to it in the polygonal shape of their calices and the delicacy of their walls are equally affected in the Antiguan Chert and Marl.

The casts in these formations are, however, on a very great scale; and not only are the surfaces of the masses found as casts, but the whole of large corals are thus seen. The relation of the second variety of destructive siliceous fossilization to the formation of casts is evident; they are produced by the absorption and destruction of the sclerenchyma subsequently to the infiltration of the interseptal loculi with an enduring mineral. The genera affected by the most perfect destruction of the sclerenchyma are those whose corallites are united by their walls without any intervening costæ and exo-

* *Astræa megalaxona*, nobis, of Antigua, Quart. Journ. Geol. Soc. vol. xix. pl. xiii. fig. 126.

† Quart. Journ. Geol. Soc. vol. xix. pl. xiv. figs. 6 & 8.

theca; consequently the interseptal loculi, which are filled from top to bottom with hard silica in the form of granules, semitransparent masses of more or less darkly coloured chalcedony, or jasper, remain in long prisms, slightly separate. The septa and the endotheca are wanting in one variety of cast, but in the second they exist more or less, and are found to consist of a silica different in colour from the rest.

A very likely mistake to occur in the diagnosis of some casts, where the calicular surface is lost and a transverse section of the mass can alone be had, is where the destruction of the outer third of the septa is complete, but not that of the inner third, the columella remaining*. In these instances, the outer parts of the interseptal loculi are so sharply rounded as to represent a costa, and to cause the specimen to be considered an Astræan instead of a species of a genus without costæ. The casts on the calicular surfaces are easily recognized by the projection instead of the natural depression of the central part of the calices, and an impression taken in gutta percha yields the normal appearance.

6. *Calcareo-siliceous.*—Variety 1. The sclerenchyma is perfect, and consists of the usual coral-salts, with an admixture of white granular silica. The interspaces are empty.

Variety 2.—The sclerenchyma is as in the last variety; but the silica exists as dark granules in the centre of the septal laminæ. The interspaces are filled with dense, granular, light-brown, light-grey, or dark-brown carbonate of lime.

Variety 3.—The sclerenchyma is more or less perfect, but it contains more silica than carbonate of lime, and the silica is homogeneous, semitransparent, and usually dark in colour. The interspaces are filled as in the last variety; but much granular silica exists in the carbonate of lime.

Variety 4.—The sclerenchyma is as in the last variety; but the colour of the flint is an opaque cherty white. The interspaces are filled with dark carbonate of lime and a little silica; but many corallites are empty, and some endothecal cells also†.

Variety 5.—The sclerenchyma is as in the third variety; but in many specimens the silica is granular and very brightly coloured. The interspaces are filled as in the third variety, but their contents are often brightly coloured. The calcareo-siliceous forms of mineralization are very common in all the raised coral-formations of the West Indies, except in the Inclined Beds and Chert of Antigua, where the siliceous form alone exists. In St. Domingo and Jamaica the silicification of the coral-salts of the sclerenchyma, and of the infiltrated carbonate of lime of the interspaces of the corals, is usually more or less incomplete. In the Antiguan Marl also, the great Astræans are found variously affected by incomplete silicification of their original and infiltrated salts. In some specimens no less than five grades of this form of fossilization are to be noticed, in others but one; and in the majority there are usually two or

* *Stephanocœnia tenuis*, nobis.

† Quart. Journ. Geol. Soc. vol. xix. pl. xiii. fig. 5.

three varieties, owing to the intensity of the siliceous change being most decided both at the calicular surface of the corallum and in the centre of the deeply seated corallites. There are examples of large Astræans in which only the original sclerenchyma is silicified, the calcareous and infiltrated salts of the interspaces still existing: in others the silicification of these last is more or less decided, and, in a specimen in the Museum of Practical Geology, perfect general silicification has occurred. The tendency of every grade of calcareo-siliceous mineralization is towards perfect silicification; and, as this is more or less attained, the destruction of the minute details of the coral is very constantly noticed.

The nature of these forms of mineralization is best seen in transverse section of large corals. The septa are white and saccharoid-looking in some corallites, where much carbonate of lime still exists*, and dark granules in the septal structures indicate the presence of silica; in other corallites the hard parts are of black ordinary flint, the interspaces being filled with light-coloured carbonate of lime and with granules of dark silica†, whilst in some perfect corals the reverse of the last case is seen—the septa being grey, and the interspaces black.

Between these conditions there are several which are determined by the greater or less amount of silica in the sclerenchyma, and its peculiar colour.

In some specimens the opaque-red, orange, opal, and black colours of the silica of the septa are rendered most prominent by the grey of the interspaces, whilst in others the similarity of colour between the interseptal loculi and the septa is very confusing.

In a few instances both the original hard parts and the interspaces are of the same yellow-ochre tint, and the details are perfectly undistinguishable before nitric acid is used to clear away the excess of the remaining carbonate of lime.

The silicification of the original hard parts is always in advance of that of the salts of the interspaces in the central parts of a corallum; and it can be seen that the silicification commences and radiates from the central parts of septa, and from the midst of the infiltrated salts.

The employment of nitric acid is, therefore, safe; for the interspaces are more or less cleared by it, except when their contents are perfectly silicified.

7. *Calcareo-siliceous and Destructive.* Variety 1.—The sclerenchyma resembles the condition of the various grades of the third variety of the last form of mineralization; but the minuter structural details are absent, and the septa are thin. The interspaces are filled as in the third variety just mentioned, but they occupy a little more space.

Variety 2.—The sclerenchyma is much thinner; the walls and exotheca are often wanting; the mineral is white in colour, and is nearly pure silica. The interspaces are filled with carbonate of

* Quart. Journ. Geol. Soc. vol. xix. pl. xiii. figs. 1*a*, 2*a*.
† *Ibid.* figs. 3, 4, 6.

lime and granular silica; so are the spaces formerly occupied by the walls and exotheca.

Variety 3.—The walls remain, and consist of saccharoid calcareo-silica; but the rest of the sclerenchyma is deficient. The interspaces are empty, and are encroached upon by the saccharoid mineral. Many corallites of the Barbadian Astræans have their walls and cœnenchyma turned into saccharoid-looking spar, all the rest being deficient. These honeycombed-looking masses consist of semi-crystalline carbonate of lime, with much silica; and doubtless much of the destruction of details was prefossil, for the species has very delicate septa and costæ*.

8. *Calcareo-siliceous casts.* Variety 1.—The sclerenchyma is deficient for some lines' depth from the calicular surface, but is present elsewhere, and consists of carbonate of lime, with more or less silica. The interspaces are filled with light reddish-brown silica for some depth below the former calicular margin; but below the spots where the sclerenchyma begins to be seen they are filled with dense carbonate of lime, which is of a light-brown or light-red colour.

Variety 2.—A few septa are all that remains of the sclerenchyma. The interspaces are filled with dense carbonate of lime: this salt fills up the reticulations in the walls of perforate corals, and is more or less mixed with silica, and varies greatly in colour.

Variety 3.—The columella and the septal ends attached, remain alone on the free surface of the corallum; below, all the sclerenchyma exists. The interseptal loculi are filled with saccharoid carbonate of lime and silica.

The largest casts of calices as yet known are those of the Astræans of the Marl of Antigua. The interspaces are seen as dense light-brown silica; the septa, calicular walls, and costæ are wanting for some lines' depth†; and even in transverse sections, made a little distance below the surface, the filled interseptal loculi are distinguished from the vacant spaces where septa have once been. The vacant spaces of the septa, in the casts, simulate interseptal loculi; and the dense silica of these, which is free from carbonate of lime, may be mistaken for septal structure. The siliceous interspaces are not continued down far into the corallum, for carbonate of lime soon exists in great proportion in them; and where the silicification of these interspaces becomes defective, there does the silicification of the septa begin to be intense, and the appearance of a cast then ceases. The intensity of the silicification on the surface is very evident; and that there was infiltration of the interseptal loculi by carbonate of lime and other salts prior to the loss of the septa is so also. It is most remarkable that the whole surface of a large corallum should be covered by casts of its calices, and that the sclerenchyma should be deficient for some depth; and it is difficult of explanation, unless the prefossil condition of the coral be admitted into the consideration of the subject.

The calicular ends of rapidly growing corallites are more delicate,

* The Trinidad (St. Croix) corals are generally found thus fossilized.

† Quart. Journ. Geol. Soc. vol. xix. pl. xiii. fig. 1*b*.

more permeated by the juices of the polypes, and infinitely more fragile than the deeper parts; they are covered during life by the polype-tissues which determine their nutrition and growth, and these processes are singularly active in luxuriant corals. In slow-growing corals this calicular fragility is not seen, and the lower parts of a corallite are nearly stony in hardness.

The larger Astræans, the Isastræans, and the Stephanocœnians were, probably, rapid growers, and unfavourable to the development of casts.

In some specimens the prefossil influence of decomposing membrane on tender calices is seen by the fossilization of deformed corallite-ends. It seems reasonable to account for the non-silicification and consequent non-preservation of the superficial hard parts by admitting the destructive influences of a decomposing membrane upon them, their molecular adhesion being slight, and their constitution mainly of carbonate of lime.

The sclerenchyma thus affected might be strong enough to last out the filling up of the interseptal loculi with carbonate of lime, but was not durable enough to withstand the secondary chemical changes which terminated in the replacement of the carbonate of lime in the loculi by silica.

Lower down the corallum, and out of the range of the superficial polype-tissues, the denser sclerenchyma was gradually replaced by a homogeneous dark flint, and lost but little of its details during the process; still a little loss is noticed, especially in prismatic corallites.

To account for this loss, of granules on the septa, of portions of the septa themselves, of endothecal dissepiments, and of more or less of the corallite-wall, we must recognize the influence of the decomposition of the delicate tissue which lines these parts, even deep in the corallum.

The loss of details must have occurred before the silicification of the interspaces (of their carbonate of lime), because the space formerly occupied by the deficient hard parts becomes filled up by an extension of the infiltrated carbonate, which is rarely so perfectly silicified as the rest*.

The most remarkable changes induced by loss of sclerenchyma, and persistence of the mineral infiltrated into the interspaces of a coral, are observed in the case of some perforate corals at Antigua and Jamaica. The corallum resembles that of an Astræan with separate corallites, and dentate costæ in regular series †; really the dentations are casts of the regular spaces between the network of the original corallite, whose walls and tissue have been lost. These casts are not perfectly siliceous, but contain much carbonate of lime; so that the destruction of the sclerenchyma, which developes a cast, occurs before silicification is complete. The later Tertiary corals are constantly found without their septa, or with their columellæ and part of their septa attached, the corallite-wall having been worn away: this is produced by prefossil wear and tear, as is also the loss of the details of some dendroid Astræans in the Jamaican limestone.

* Quart. Journ. Geol. Soc. vol. xix. pl. xiv. fig. 7. † *Op. cit.* pl. xiv. fig. 4*c*.

It is singular, and as yet not explained, that the epitheca or general envelope of many, but not all, of the genera is wanting in the fossil specimens. Doubtless many of the siliceous masses in which corallites can be detected have been rolled since their fossilization, but there are no evidences of epitheca in very perfect Astræans which have not been rolled. Finally, it may be taken as a rule that the most perfect replacement of the carbonate of lime of the corals by silica is found in the oldest beds.

§ V. Conclusion.

I believe that there is no truth in the hypothesis which asserts that the silicification of the West Indian fossil corals was the result of a volcanic outburst, which poured siliceous solutions over the depressed reefs of the Miocene age. The corals of the Inclined Beds and of the Chert of Antigua are silicified, so are the Woods and Mollusca; but the lower beds of the Marl contain both perfectly silicified Astræans and calcareo-siliceous corals also, whilst the upper part of the formation yields fossils in all stages of siliceous and calcareous mineralization. The neighbouring Barbudan limestone has no siliceous corals, yet it is of the same age as the Antiguan Marl. The San Domingan fossils are usually calcareous, but here and there siliceous specimens are met with in the same beds with the others. There is no evidence to prove that coral-growth ever ceased from the Miocene time to the present in the Caribbean Sea, although there has been a change in the facies of the fauna. These facts and remarks are very antagonistic to the hypothesis, and rather tend to prove that the silicification of the corals has been a slow process, which has had no other origin than in those chemical operations which are still in action, and that their greater or less intensity in certain favourable localities has produced siliceous fossils amongst those affected by the calcareous form of mineralization. Wherever a highly aërated sea, containing silica in solution, acts on calcareous fossils at considerable depth, and, therefore, under considerable pressure, there would appear to result a chemical transposition; and the presence of crystals of quartz, of homogeneous flint, of the hydrates of silica, and their coloured varieties is due to chemical influences which bear a relation to the geological changes in and about the reefs. It must be remembered that there is a small amount of silica in corals; and it will be observed in microscopic sections of Antiguan corals, in which silicification is incomplete, that the silica is usually deposited in molecules in the centre of the calcareous mass, and not on its superficies. The process of siliceous transposition is doubtless very slow; it is not always perfect, for the silica would appear to have an affinity for bodies formerly organized, and often to destroy the former tissues. Thus there is abundant carbonate of lime in which transposition is not going on around the siliceous fossils, and the persistence of some animal or vegetable organized tissue, decomposing more or less slowly, appears to determine the presence of certain forms of silica; moreover, the details of corals are often so destroyed by the deposition of homogeneous black flint, that this destruction must have commenced after the coral was imbedded.

In the course of this communication facts and hypotheses have been determined and propounded, which have led to the following conclusions:—

1. Silica, whether homogeneous, granular, or crystalline, does not appear to be deposited at first in the interspaces of corals, but replaces a salt of lime which was infiltrated partly in solution or partly in a state of mechanical suspension in a compound fluid. The replacement does not commence until the salt of lime has acquired a certain density, and it occurs first of all in the central parts of the loculi in the form of granular points*.

The combinations of the silica with water, the production of its hydrates, and the evolution of coloured varieties would appear to be determined by the presence of decomposing animal and vegetable matters, and of salts of iron, at the time of the entombment of the corallum in the bed of the detritus of the reef.

2. The opal lines, the opaque lines in agates, the broad wavy milky clouds in otherwise transparent flint, and the porcellanous opaque silica are found to have a very close relation with the form of silicification, in which much destruction of the hard parts of the corallum is noticed.

3. Every grade of a silicification which destroys the textures of corals and reduces them, at last, to pure homogeneous black flint, like that of the upper Chalk, is to be distinguished. Moreover, crystalline quartz, chalcedony, and every variety of transparent or opaque silica constantly replace the carbonate of lime or the usual coral-salts of part or of the whole of a corallum, without preserving the structural details.

These destructive siliceous fossilizations, not peculiar to the West Indian beds alone, form one of the causes of the deficiency of the geological record.

May 11, 1864.

Thomas Carrington, jun., Esq., Chesterfield, Derby; J. B. Even, Esq., C.E., Mem. Soc. Géol. Fr., 36 Rue Montagu, Brussels; The Rev. John Henry Timins, M.A., of Trinity College, Cambridge, Vicar of West Malling, Kent; and Henry Woodward, Esq., F.Z.S., of the British Museum, and 144 Leighton Road, N.W., were elected Fellows.

The following communications were read:—

1. *On a* Section *with* Mammalian Remains *near* Thame. By T. Codrington, Esq., F.G.S.

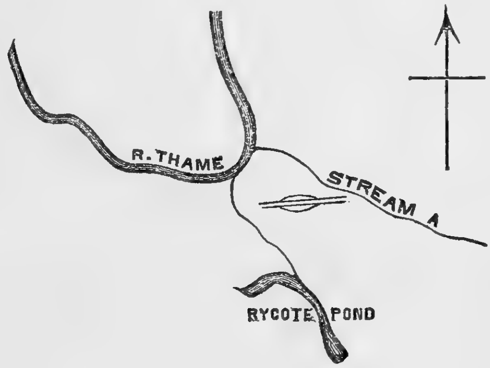
In excavating a cutting near Thame, on the Railway between Thame and Oxford, a section remarkable in itself and yielding a large

* The phenomena of orbicular silex in the silicified corals will form the subject of a future communication.

quantity of Mammalian remains has been exposed during the past summer.

Externally the undulation of the ground cut through by the Railway does not differ from that around it. It is detached on all sides, the Thame river and two small tributaries nearly surrounding it. The highest part, which is not far from the cutting, is not more than 25 feet above the water in the nearest stream, and from it the ground falls gradually with a rounded outline.

Fig. 1.—*Plan showing the position of the section with Mammalian remains, near Thame.*



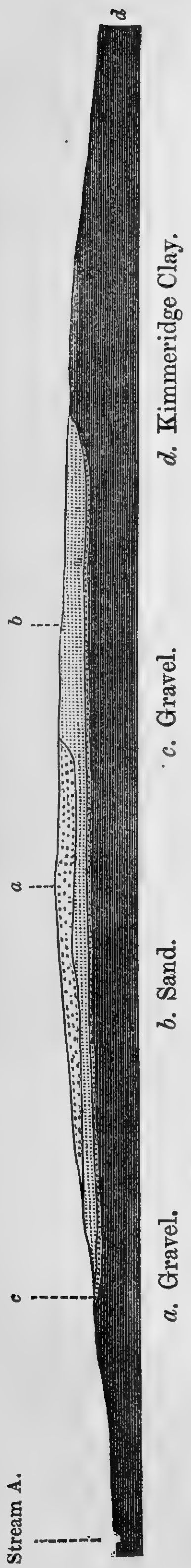


Fig. 2.—*Section with Mammalian remains, near Thame.*

The position of the cutting with relation to the existing streams is shown in the plan (fig. 1). The section (fig. 2) has the vertical heights exaggerated twice.

Resting on the Kimmeridge Clay is a bed of coarse gravel averaging 2 feet in thickness, abutting against a bank of undisturbed clay on the west, and gradually dipping eastward. The materials of the gravel are—angular chalk-flints (about 50 per cent. of the whole), quartz, hornstone, and ironstone, in pebbles or fragments more or less rounded, rolled lumps of chalk, and Tertiary pebbles. The order in which they are here mentioned is that of their relative abundance. Blocks of Sarsen or grey-wether sandstone, in size from half a cubic yard downwards, occur in the gravel.

The pebbles of quartz, and the hornstone and ironstone, may have been derived from the neighbouring Lower Greensand beds; but a fragment of mica-schist, which I obtained from the gravel, seems to point to the Northern Drift as the source of at least some of the materials.

Above the gravel lies a bed which for some distance from the eastern end of the section consists of a reddish-yellow sand, nearly pure, but containing small angular flints, and here and there a pebble of chalk. Towards the middle it passes into a blue sandy clay, and near the bank of Kimmeridge Clay it becomes a stiff blue clay with chalky seams. Some signs of stratification were apparent in the more clayey portion, and at the west end there was some contortion of the chalky seams.

The uppermost bed is a sandy clay with angular flints, pebbles, and subangular fragments, similar in a great measure to those in the gravel, but in many cases not so easily referred to the Lower Greensand. This bed was clearly defined after rain, standing out in relief over the sand below, but I could not trace it beyond the middle of the section.

In the bottom gravel are *Anodon*, *Unio litoralis* (?), *Cyclas*, *Pisidium* (all abundant), and *Ancylus fluviatilis*. The bed over the gravel contains these, with *Limnæa*, *Helix*, and *Planorbis*. In these two lower beds the Mammalian remains occur. The uppermost bed appears to be altogether barren.

It will be seen that this section exhibits the usual characteristics of a silted-up river. The gravel lies on the inferior formation as it was eroded by the action of the stream, and in the gravel are Shells of the species which inhabited the river when it flowed at that level. Above lies the finer "inundation mud" which was deposited during freshets after the river had formed a lower channel, and in it are found stagnant-water and land Shells, together with those proper to running water.

The Railway cuts the old river-bank nearly at right angles; and the course of the stream was probably from south to north, corresponding in this respect with the present drainage of the country.

The mean level of the gravel exposed in the section is about 5 feet above the stream at (*a*), and 23 feet above the stream to the westward of the cutting, flowing from Rycote Pond.

The Mammalian remains were found in great abundance. They were very soft while still saturated with water, so that the greater part were unavoidably much broken in the work of excavation. Many of those saved afterwards disappeared, being either destroyed by rough handling, or carried away altogether. The bones examined, therefore, form but a small proportion of those found in the cutting. I have, however, been able to identify portions of 6 or 7 Elephants, 13 Horses, 1 Rhinoceros, 1 Ox, 5 Deer, and a Carnivore.

That these are the least number of individuals represented may be seen by referring to the annexed list of some of the principal bones, &c., which have been identified.

List of Mammalian Remains from the Section near Thame.

Elephant.	No. of specimens.
Symphysis of lower jaw	6—7
Tusks	6
Molars ... at least	50
Acetabula	4
Femur	1
Tibiæ, left	2
,, right	3
Scapulæ	4
Ulnæ, left	2
Ulna, right	1
Rhinoceros.	
Acetabulum	1
Radius	1
Dorsal vertebra	1
Os calcis	1
Molar	1
Horse.	
Tibiæ of left leg	13
,, of right leg	8
Metacarpals of right leg	12
,, of left leg	9
Metatarsals of right leg	3
,, of left leg	5
Radii, right	5
,, left	5
Humeri, right	7
,, left	3
Femora, right	3
,, left	2
Molars, numerous.	
Ox.	
Humerus	1
Radius, right	1
,, left	1
Ulna	1
Tibia	1
Deer.	
Horns attached to skull, left ...	5
,, ,, ,, right...	3
Shed horns, numerous.	
Small Carnivore.	
Phalanx	1

In all the cases that fell under my observation the bones were detached, and not lying so as to form a part of a skeleton. Close against one side of a boulder a large quantity of Elephant-bones was found, giving one the impression that a carcase had been brought up by the stone while rolling down the river; but the bones were so much broken and scattered when I saw them, that I could not ascertain whether they all belonged to one skeleton or not.

In following up a tusk which I had traced for 5 feet 6 inches, a portion of the right side of an Elephant's pelvis was found; it consisted of the entire ilium, with the acetabulum and ischium, and was lying partly under the tusk. Under the ilium, and in contact with it, was a fine third upper molar, perfectly entire and unrolled; but there was no trace of the upper jaw or of the bones of the head. Close by was a tibia, somewhat worn at the ends; and in disinterring this, another complete half of an Elephant's pelvis was found. Like the first, it belonged to the right side. In opening out the ground for this, the radius of a large Ox was brought to light, and the point of an Elephant's tusk. Near it were the acetabulum and pubis of the left side of an Elephant's pelvis. These were all in the gravel, and in a space of 5 feet square.

No Flint Implements were found, though carefully looked for. The search, however, was very partial.

2. *On a* Deposit *at* Stroud *containing* Flint Implements, Land *and* Freshwater Shells, &c. By Edwin Witchell, Esq., F.G.S.

[Abstract.]

In the course of some excavations for the construction of a reservoir near the summit of the hill above the town of Stroud, made during the past summer, the author observed in the clay, at a depth of 2 feet from the surface, a deposit which, on examination, he found to be full of Land-shells, with a few freshwater Bivalves*. The deposit was a kind of tufa; it contained near its base numerous flat-stone fragments of the stony bands formed of the valves of *Ostrea acuminata* (a Shell which characterizes the upper portion of the Fuller's Earth), some of them being of considerable size; and the surface of the whole showed traces of erosive action. This deposit was traced up the slope of the hill to the extent of 126 feet, and along the hill-side about 60 feet; in the latter direction its extent was not disclosed by the works, but traces of it were found in a pit at a distance of 120 yards.

As the excavation proceeded, the author discovered in the deposit several flint flakes of the usual primitive type, flint nuclei, part of a flint arrow-head, fragments of an antler, a tusk, probably of a boar, with numerous small pieces of charcoal and small stones which had been subjected to the action of fire. Flint flakes, two flint arrow-heads, bones, &c., have been found by other persons visiting the spot.

In the overlying earth, which varied from 2 to 4 feet in thickness, a few pieces of pottery were found.

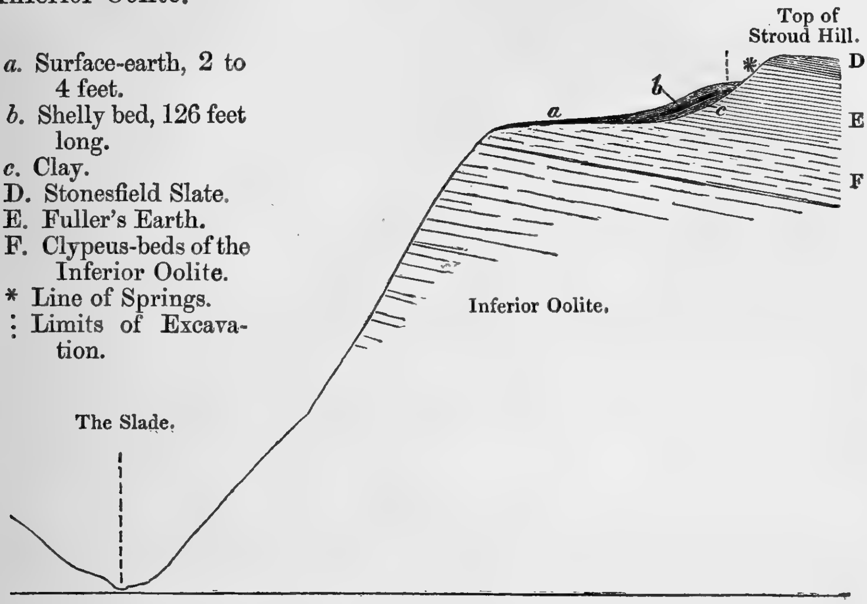
The position of the bed is singular, the ground falling away considerably towards the Slade Valley on the one side and towards Horn's Valley on the other, forming an elevated spur, somewhat rounded on its summit, with a deep valley on either side. The position of the shelly bed is at the end of the spur, where it joins the general elevated land of the district. Its elevation above the sea-level is about 650 feet, and that of the summit of the hill about 750 feet.

The formation on which the bed is deposited is clay derived from the Fuller's Earth, into which it passes downwards, and above, on the hill, is the western edge of the Stonesfield Slate. In the Fuller's Earth, about 50 yards higher up the hill than the shelly bed, is a line of small springs extending along the hill-side to a considerable distance. These springs issue from beneath a steep slope, forming

* These Shells have been collected and named by Mr. J. Jones, of Gloucester, who has written a paper upon the Deposit, claiming for it a period of great antiquity. They are as follows:—

Univalves.		
Helix nemoralis.	Zonites alliarius.	Limnæus truncatulus.
—— rotundata.	—— nitidulus.	Cyclostoma elegans.
—— umbilicata.	—— excavatus.	Carychium minimum.
—— fulva.	—— crystallinus.	Acme fusca.
—— pulchella.	Pupa umbilicata.	*Bivalves.*
—— lamellata.	Clausilia nigricans.	Pisidium pusillum,
—— lapicida.	Succinea putris.	—— ——, sp.
	Zua lubrica.	

the upper escarpment of the hill; and below the shelly beds, some 80 yards, is a second escarpment formed by the ragstone-beds of the Inferior Oolite.



The formation of the clay (*c*) was not the result of any great amount of disintegrating action, or it would be found to contain traces of the constituent parts of the beds forming the higher ground, which is not the case. The shelly bed is in immediate contact with the clay, there being no trace of any intermediate deposit, except the flat stones before referred to. These stones may have been carried down the slope from the higher beds by means of land-slips, and the finer and lighter particles having been washed away, the stones would be left scattered upon the surface, afterwards to become mixed with the shelly deposit as it accumulated.

To the same agency also (that of water and landslips) the shelly bed itself may perhaps owe its origin. Indeed it is difficult to account for its existence otherwise than upon the assumption that it took place in still water. It is in some places a mere sediment compressed by the overlying earth, and the slope on which it rests being at an incline of 13°, the smallest running stream would inevitably have carried it further down the hill, where the surface is comparatively level, and not have deposited it where the angle of inclination is greatest, but for the interposition of some considerable barrier similar to that which a landslip would produce.

The steep slope above the line of springs, already referred to as the upper escarpment, doubtless owes its present shape to landslips occasioned by the springs issuing from beneath; and if we suppose that at some distant period a slip of considerable magnitude took place from this slope, the material of which, after passing downwards to the more level surface above the lower escarpment, there for a time became stationary, we have a dam formed, and, as the springs followed the same course, a pond would be the result;

the Land-shells and sediment would be brought into it by means of the springs and land-floods, and the shelly bed is accounted for.

The formation of a pond as the consequence of a landslip is stated by the author to be not inconsistent with the known results of the action of springs issuing from the beds of the Fuller's Earth. Thus at Brimscombe, three miles distant, these springs have at some former period caused an extensive slip of Fuller's Earth, which is now found covering the bottom of the valley in a stratum of considerable thickness, its original position being at an elevation of at least 400 feet above the valley; and at Chalford, in the same locality, there is, at this time, and from the same cause, another mass of Fuller's Earth, covering a surface of about two acres, on its way downwards into the valley.

If it be conceded that a pond or small lake once existed upon the site of the shelly bed, it follows of course, from the contents of the deposit, that it was a place to which the inhabitants of the district resorted for various purposes, the animal-charcoal, which is found throughout the bed, even to its lowest part, proving that during the whole period of its formation the surrounding country was inhabited.

The changes which have taken place in the aspect of the slopes and the covering up of the deposit with vegetable mould, from 2–4 feet thick, must have been the work of a very long period, and there can be little doubt that the people by whom the Flint Implements were formed, and who left behind them other traces of their existence, were some of the earliest inhabitants of this country. In further proof of this opinion is the fact that *Helix lamellata* (one of the shells mentioned in the list) is not now an inhabitant of this part of the country, not being found south of Scarborough*.

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3. *On the* White Limestone *of* Jamaica, *and its associated intrusive* Rocks. By A. Lennox, Esq., F.G.S., late of the Geological Survey of Jamaica.

[Abstract.]

In this paper the author described the White Limestone of Jamaica and its associated eruptive rocks.

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4. Facts *and* Observations *connected with the* Earthquake *which occurred in* England *on the morning of the* 6th of October, 1863. By Fort-Major Thomas Austin, F.G.S.

[Abstract.]

Earthquakes in the British Isles, though not quite such rare events as is generally supposed, usually attract but little notice, but that

* On the authority of Mr. Jones before named.

which shook the country and alarmed the people on the 6th of October 1863, from its greater amount of violence, has aroused attention to the subject.

The disturbance may be defined as extending from a point in St. George's Channel 40 or 50 miles to the north-west of Pembrokeshire (it was felt by the captains and crews of more than one vessel when off the Welsh coast), to its eastern limit in Yorkshire, though there is some doubt if it extended quite so far in an easterly or northerly direction. It was certainly not felt at Scarborough in Yorkshire, nor at Ashford in Kent; but it was felt at Gad's Hill, near Rochester, which may therefore be considered as its eastern limit in the southern counties. The northern limit was not much beyond Clay Cross, near Chesterfield.

The earth-movement was experienced with different degrees of intensity over a great part of England, without any particular reference to the geological features, except that the western and older stratified rocks appear to have been most violently affected. The area affected includes rocks which extend from the lowest Cambrian to the Chalk and Tertiary beds inclusive.

It appears that the chief focus of disturbance originated in the bed of St. George's Channel, and extended through the ancient sedimentary rocks of Wales and Herefordshire, across the Severn, to Bristol, and from thence with gradually diminishing intensity eastward, until the earth-wave died out in Kent.

The bed of the Irish Channel was violently acted on, as adduced by the fact that a mass of agitated turbid water, four miles in diameter, was seen in Carmarthen Bay. The water was of a dark-brown colour, and appeared to be impelled forward, in the form of an elongated heap, towards Monkstone, and thence some miles out to sea. It was also observed at Tenby.

About the same time other portions of the earth's crust were under perturbation. On the 4th of October the shock of an earthquake was felt over a great part of Normandy; on the 6th, a new island was discovered on the Cherki Rocks or Reefs, off the coast of Africa (Tunis). The island is described as 120 metres in length, and situated in long. 8° 30′ E. and lat. 37° 50′ N. Earth-movements and strong shocks had also been felt at Tunis.

The earth-movement in England was clearly from about W.N.W. to E.S.E., with some little variation in its direction, according to geological peculiarities of structure; detached or corner houses facing any point from west to north were more violently shaken than those standing in the middle of a row.

Though the barometric and thermometric indications varied considerably in different localities, yet no material disturbance was recorded. "The sky was cloudless, the wind west, barometer stationary, and the temperature 31°. The motion of the earthquake-pendulum at Beeston was W.N.W. to E.S.E., and the displacement of the chalk by the thirty-feet rod was half an inch, the index-needle moving the chalk so as to leave an oval or, rather, a lengthened-oval hole," as reported by Mr. Lowe, Observatory, Beeston, who further considers that there must have been two shocks—the first at 2^h 35^m, and another at 3^h 30^m.

In some places four vibrations are said to have been felt, but in others one. No sound was heard in one locality, and loud explosions in others. The rocking of the ground appears to have continued for two minutes in one place, for one minute in others, and for only a few seconds in many localities. The latest shock is supposed to have been noticed at Swansea and Nailsworth, as late as 4 A.M., the earlier vibration having been felt at both places. The time at which the principal shock occurred at different places ranges from 3^h to 3^h 30^m; this discrepancy may be accounted for by the difference in the clocks at the various localities; and it is probable that some difference in the time of the shock may be attributed to the variations of the earth's structure in places distant from each other.

The concussion was severe at Hereford and its vicinity, Pontypool, Kingsdown and Redland (Bristol), Sedgely Beacon and Lyerney (Gloucestershire). It was likewise distinctly felt at Wellington and Taunton in Somersetshire.

The area disturbed is, in a direct line, about 250 miles in length by 180 miles in breadth.

The oscillations were something more than the "tremblores" so common in the volcanic districts of South America. The "tremblore" is a mere vibration or shaking of the earth, resembling in the sensations produced the exaggerated tremulous motion of a steam-vessel, whereas the shock of the 6th of October was an earth-wave, referable to a submarine outburst of igneous matter, or to a subsidence among rock-masses, or to a pulsation of the molten masses in the interior of the earth.

According to Prof. Perrey*, the mean horizontal direction of British earthquakes is "from south to north, veering more or less to the east or west, but having on the whole a direction passing through the probable focus of the Lisbon earthquake, and of the Canary Islands." The direction of the concussion on the 6th is a fact tending to confirm the conclusions referred to above, as was also the shock which occurred on the 3rd of April, 1852†, which, though less extensive in its effects, appears to have followed the same course.

May 25, 1864.

The Rev. J. Chadwick Bates, M.A., F.R.A.S., Incumbent of St. Martin's, Castleton Moor, near Manchester; William Brooke, Esq., Brook Street, Manchester; William Henry Nevill, Esq., Llangennech Park, Llanelly, Carmarthenshire; and John Pentecost, Esq., F.C.S., 1 Park Street, Torquay, were elected Fellows.

The following communications were read:—

* Rep. Brit. Assoc. 1858, p. 6.

† Austin, Quart. Journ. Geol. Soc. vol. viii. p. 233.

1. Geological Notes *on* Part *of the* North-western Himalayas. By Captain Godwin-Austen. *With* Notes *on the* Fossils; by T. Davidson, Esq., F.R.S., F.G.S., R. Etheridge, Esq., F.G.S., and S. P. Woodward, Esq., F.G.S.

[Communicated by R. A. C. Godwin-Austen, F.R.S., F.G.S.]

[Abstract.*]

The operations of the Trigonometrical Survey of India, under the superintendence of Capt. Montgomery, C.E., having been extended to the extreme north-western part of the Himalaya adjoining the Indus, and across the chain northwards to the Mustak range, Captain Godwin-Austen gives in this paper the results of his observations on the geology of the region, made during the course of the Survey. He refers the rocks observed to the following formations:—

1. The fluvio-lacustrine series, consisting of deposits from lakes fed by mountain-rivers.
2. The Siwalik series.
3. The Nummulitic series.
4. The Jurassic series.
5. The Carboniferous series.
6. The Palæozoic series.

1. *The Fluvio-lacustrine Series.*—The author first refers to a former communication†, in which the Karèwah deposits of the north-western extremity of the Kashmere valley were described, giving an abstract of the facts and opinions contained therein, such as their elevation above the present water-level of the valley, and the successive lower levels at which the lacustrine waters must have stood, as shown by the long lines of terraces one above the other. He also suggested that the masses of granitic rock which occur in the Jhelum valley-accumulations, outside the Baramoulah passage, as at Kuttai and elsewhere, had been brought down by glaciers, which descended the valleys from the outer slopes of the north-west Pinjal; as all the obstructions which from time to time have penned up the waters of the Kashmere valley have had their positions in the gorge of the Jhelum through the Pinjal range.

The author had never met with any Shells at high levels in the Karèwah deposits of the north-west portion of the valley. On the south-east, the lacustrine beds, there sloping inwards from the Pir-Pinjal at angles of 20° and upwards (though from what cause is uncertain), contain many species of Land- and Freshwater-shells ‡, together with Plants and minute Fish-scales. Measured in the usual way, at right angles to the dip, some of these lacustrine beds would have, by estimation, a thickness of 1400 feet: the author measured a vertical thickness of 700 feet, through the whole of

* As Captain Godwin-Austen is expected shortly to send a more complete account of the geology of the region described in this paper, together with a large collection of rocks and fossils, the present communication, and the notes by Mr. Davidson, Mr. Etheridge, and Mr. Woodward, are now published in abstract only, waiting the arrival of the larger memoir.

† Quart. Journ. Geol. Soc. vol. xv. p. 221.

‡ See note by S. P. Woodward, Esq., F.G.S.

which the shell-beds were repeated. What ages of time must therefore have been required for the accumulation of these beds! and if their inclined position be due to disturbance, how recent must have been the latest movements of the Pir-Pinjal range!

This great freshwater formation does not appear, however, to have been a continuous series of depositions, formed during a period when the Kashmere valley was permanently in the condition of lakes, as old terrestrial surfaces, now forming seams of coal or lignite, from 1 inch to 3 inches in thickness, occur throughout, some of them for horizontal distances of two miles and more, as may be seen in the ravine cut through by the Rainee.

Of the old lacustrine areas of the western Himalayas, that of the Kashmere valley, which received the waters of the Jhelum, must have been by far the broadest; but in just the same manner the valleys of the Upper Chenab are filled with thick accumulations of stratified detritus which have been subsequently cut through.

The author then mentions other valleys in which similar accumulations are seen, especially the Upper Indus and its great tributaries, and the valley of Skardo.

The valley of Skardo is a broad irregular area, where the Shigar River meets the Indus; the Rock of Skardo rises in the centre of the plain to a height of 800 feet. Against the slopes of the mountains which surround this area there are thick horizontal accumulations of sand, angular detritus, conglomerate, and vast boulders—torrential materials of every kind—at elevations overtopping the Rock of Skardo. The central portions of the valley are now free; but that their accumulations at one time stretched from side to side, and that they have been since removed, is obvious from an examination of the Rock itself, about and on the summit of which great blocks and remains of the fluviatile or lacustrine deposits are to be seen. At the period of this accumulation, the area of water in the Skardo valley must have been as much as 20 × 8 miles in the direction of the Indus valley; and as the level of the water must then have stood far above the Rock of Skardo, it must have been nearly 1000 feet higher than at present. About eight miles lower down, as at Kuardo, these accumulations attain a far greater elevation above the river.

At a much lower level than these accumulations, and referable to a time when the Skardo valley had been much excavated out, it was again the area of a large lake. The deposits of this stage have been cut through by the present drainage-lines of the valley; but its upper limit can be traced on every side at the same uniform level, from Kipchun (where it is best seen) across the valley to Kuardo, and thence up the Shigar valley to near the village of that name.

These lacustrine deposits contain alternations of long horizontal lines of vegetable matter, with sand and mud-beds like those of Kashmere,—grassy swampy surfaces separated by intervals of many feet of sediment full of Shells.

The formation of these lacustrine deposits the author accounts for by reference to causes which now act in these regions, and which there is reasonable ground for supposing may have acted at some former time on a greater scale than at present. Within the Glacier-region, the waters coming down one line of valley are intercepted by glaciers descending at right angles along another. In somewhat lower regions, the fall of great masses of rock, coupled with the form of these valleys (deep, with steep sides and exceedingly narrow), produce like results and pen back the waters.

He illustrates his theory by describing the formation of a lake, 200 yards broad, deep and long, caused by the obstruction of the discharge of the waters of the Kulgūni river through a valley by means of a landslip, which process he had actually seen in progress.

2. *The Siwalik Series.*—In the Jummoo and Bhimbar districts this formation presents low rounded hills of sandstone, conglomerates, and boulders, with thick loamy partings, the outer range being largely composed of the coarser materials; these can be identified as having been derived from the older rocks on the north, including those of the Nummulitic formation.

The whole of the sandstone-zone has been much disturbed, and presents numerous anticlinal and synclinal ridges and valleys. From sections taken at places across this country, combined with observations made by Captain Melville, R.E., it has been found that the anticlinal axis and valley of elevation of the Manoūr Lake extend from Jusrita on the east to the Rijouri River on the west, the direction being from north-west to south-east, or parallel with the main higher ranges, for a distance of 100 miles. The straightness of the ridges of the outer sandstone-formation is very remarkable, as for miles there is not the least deviation from a right line.

3. *The Nummulitic Series.*—Thick masses of dark compact limestone occur on the south of the Pir-Pinjal, on the rocks of which range it seems to lie unconformably. As these limestones occur here at elevations of many thousand feet above the place of the Nummulitic formation in the bottom of the valley of Kashmere, between the Wuller and Dul Lakes, and where their relation to other parts of the fossiliferous series is clear, it is not improbable that the rocks of the Pir-Pinjal may not be so old (Cambrian) as has been supposed. In other parts of this region, on the south-east and east, as also on the north, the Nummulitic limestone forms everywhere the uppermost portion of the great fossiliferous series, extending into Ladak and Little Thibet.

On the southern slopes of the Pir-Pinjal, a great sandstone-group is next met with above the Nummulitic limestone; in fact, the whole breadth of country from the limestones to the plain of the Punjab is a sandstone-formation; that portion, however, which is near the Pinjal must be far older than the outer ranges; the rocks are hard, highly indurated sandstones, with only a few pebbles, and are apparently non-fossiliferous.

Nearer to the plains there is a zone of sandstone-ranges of a wholly different character. To the older series the author refers the Rijaori country downwards beyond Chingus. Beyond that the composition of the sandstones becomes coarser and less coherent, and they are interstratified with beds of loam. In these beds the author found teeth and bones of large animals; also a portion of the back of a Crocodile, showing the palates very well.

4. *The Jurassic Series.*—The Jurassic formation of the Himalayas has been long known through the discoveries of Dr. Gerard, whose collection from Spiti has been recently examined by Mr. Blanford. After mentioning the detection by that palæontologist of English Liassic specimens in Dr. Gerard's collection, and noticing the labours of Mr. Theobald, who ascertained the presence in Spiti of Palæozoic (Carboniferous, as afterwards determined by Mr. Blanford), Triassic, and Jurassic deposits, as well as the previous researches of Mr. Vigne, he states that he had also obtained Jurassic fossils from beds of sandstone alternating with limestone, while working along the Jarrup River, which runs towards Zanskar.

5. *The Carboniferous Series.*—The author traced the Carboniferous Limestone, very full of fossils, all along the foot of the mountains of the north side of the Kashmere valley up to Islamabad; he made some good sections, and collected many fossils. Along this line the Carboniferous Limestone invariably rested on the older slates and hornblendic rocks of the valley, a bed of quartzite from 12 to 15 feet thick being always between the two. The beds in which the fossils were most abundant were low in the series, being from 50 to 80 feet from the quartzite.

Above these fossiliferous beds was a compact limestone, only sparingly fossiliferous, some 200 feet thick, and next in ascending order were beds full of Goniatites; what the author there found he refers to—

Cyathophyllum.	*Producta semireticulata.
Fenestella.	*—— gigantea.
Acanthocladia.	*—— longispina.
Athyris Roissyi.	Spirifer glaber.
Chonetes.	Terebratula hastata.
Leptæna.	Orthoceras.
Lingula.	Goniatites.
Orthis.	

6. *Older Rocks of the District.*—The age of the beds below the Carboniferous Limestone is stated to be very doubtful; they were seen in a great number of sections from the outer slopes of the Pir-Pinjal to the Mustak, but the author was never able to detect any fossils. On the south of the Pir-Pinjal they consist of hard slates and conglomerate beds of enormous thickness; these last occur at the base of the series, and indicate the existence of a line of shingle-beach, coinciding with the direction of the North-west Himalayas, at that early time.

There are three limestone-formations in this region—Palæozoic, Mesozoic, and Nummulitic, so like one another in appearance that without the aid of fossils it would be impossible to distinguish them; the Nummulitic limestones, perhaps, look the oldest. These often occur in superposition.

The Mesozoic series surmounts the Palæozoic in the mountains

* These had their spines most beautifully shown.

which form the Kashmere valley on the south, south-east, and east; but the way in which the Nummulitic Limestone comes in on part of the Pir-Pinjal, without the intermediate Palæozoic and Mesozoic series, is very puzzling.

Captain Godwin-Austen then describes the geographical extension of these various deposits, and concludes his paper with a short notice of the Granitic rocks of the area over which his notes extend.

The paper was illustrated by several sections, views, and maps, and also by the fossils referred to in the following notes.

NOTE *on the* CARBONIFEROUS *and* JURASSIC BRACHIOPODA *collected by* Captain GODWIN-AUSTEN. By T. DAVIDSON, Esq., F.R.S., F.G.S.

[Abstract.]

1. *Carboniferous Brachiopoda.*—The Carboniferous series is stated by Captain Godwin-Austen to consist of (1) Quartzites, (2) Limestone full of fossils, (3) an Argillaceous series, (4) Compact Limestone with fewer fossils, capped by a series of beds containing *Goniatites.*

Mr. Davidson remarks that the impure limestone (2), which appears in some parts to be a mass of organic remains, is of a darkish-grey colour, and bears much resemblance, lithologically and in its fossils, to deposits of a similar age in Great Britain. From this rock, at Shigar, near Skardo, Captain Godwin-Austen obtained six or seven species of Brachiopods, four only, however, being sufficiently perfect to admit of a satisfactory determination; they are as follows:—

1. Terebratula Austeniana, sp. nov.
2. Spirifer, sp.
3. Rhynchonella pleurodon, var. Davreuxiana, *De Kon.*
4. Orthis, sp.
5. Productus semireticulatus, *Martin.*
6. Chonetes Hardrensis, var.

2. *Jurassic Brachiopoda.*—The Jurassic strata of Kato, in Ladak, in the Suru country of Thibet, which are stated by Captain Godwin Austen to be there largely developed, have yielded two species of Brachiopoda, namely, *Terebratula Thibetensis* and *Rhynchonella Katoniensis,* sp. nov., which were obtained from a yellowish limestone, considered by Captain Godwin-Austen to be of Oxfordian age.

A compact light-grey limestone, in the same locality, also contains a *Terebratula* and a *Rhynchonella* in abundance; but Mr. Davidson has not been able to determine the species to which they belong.

NOTE *on the* JURASSIC FOSSILS *collected by* Captain GODWIN-AUSTEN. By R. ETHERIDGGE, Esq., F.G.S., F.R.S.E.

[Abstract.]

Mr. Etheridge notices the most prominent features of these Thibetan fossils, comparing them with species from British and Continental Jurassic rocks, to which he considers that they bear a remarkable resemblance; and he concludes that the age of the deposits from which they were obtained appears to be Middle Oolitic, the facies of the fauna determining it to be between the Cornbrash and the

Oxford Clay. This conclusion is stated to be more especially borne out by the Cephalopoda and Lamellibranchiata.

The following is a list of the fossils as determined by Mr. Etheridge:—

1. Belemnites, like *B. Blainvillei.*
2. ——, like *B. canaliculatus.*
3. ——, like *B. Beaumontianus.*
4. ——, like *B. hastatus.*
5. Ammonites, like *A. macrocephalus.*
6. Nerinæa, allied to *N. Goodhallii.*
7. Cerithium ?, like *C. muricatum.*
8. Phasianella tumida, sp. nov.
9. Pleurotomaria moniliformis, sp. nov.
10. Avicula Austeniana, sp. nov.
11. —— acuticosta, sp. nov.
12. Pecten Katoniensis, sp. nov.
13. ——, allied to *P. vagans.*

Note on the LAND *and* FRESHWATER SHELLS *collected by* Captain GODWIN-AUSTEN. By S. P. WOODWARD, Esq., F.G.S., A.L.S.

The Shells obtained by Captain Godwin-Austen from Kuardo very much resemble those collected by Dr. Thomson at Iskardo, Thibet, and reported upon in the Proc. Zool. Soc., July 8, 1858.

They are all apparently from the same fine grey marl, except one box containing *Helix hispida,* &c., in buff-coloured marl.

I have recognized the following species:—

1. Helix hispida.
2. —— costata, large and finely ribbed var.
3. —— pulchella.
4. Pupa eurina, *Benson.*
5. Zua lubrica.
6. Succinea putris.
7. Succinea oblonga.
8. Limnæa peregra.
9. —— palustris ?
10. —— truncatula.
11. Planorbis nanus.
12. Pisidium, sp.

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2. *On the* CETACEAN FOSSILS *termed* "ZIPHIUS" *by* CUVIER, *with a Notice of a* NEW SPECIES (Belemnoziphius compressus) *from the* RED CRAG. By THOMAS H. HUXLEY, Esq., F.R.S., F.G.S., Professor of Natural History in the Royal School of Mines.

(PLATE XIX.)

IN that section of the 'Recherches sur les Ossemens Fossiles' which is devoted to "The Fossil Remains of Narwhals and of Cetaceans allied to the Hyperoödons and Cachalots," Cuvier established a new genus, *Ziphius,* consisting of three species, *Z. cavirostris, Z. planirostris,* and *Z. longirostris.*

The materials upon which these species were founded consisted exclusively of more or less complete portions of crania, without lower jaws, the most perfect being that to which the trivial name of *cavirostris* is applied. Of this Cuvier says:—

"This skull obviously has close relations with the Cachalot, and still closer with the *Hyperoödon.* It differs from the latter only by the maxillaries not being produced into actual lamellæ at the sides of the snout, and in the circumstance that the sort of wall behind the nostrils not merely ascends vertically, but bends over to form a half-dome above those cavities."

This cranium was found by a peasant on the shore near the village of Fos, in the Department of the Bouches du Rhône; but it is said by Cuvier to be completely fossilized.

The less complete fragments of skulls distinguished by the specific name of *planirostris* were procured at Antwerp during the excavation of some docks.

As the figures show, and as Cuvier expressly states in the text, the "posterior wall of the nostrils," even in the more perfect of the two specimens of this species, is so mutilated that no judgment respecting its true form can be arrived at; and as the posterior part of the solitary specimen called *Ziphius longirostris* (of unknown origin) is equally deficient, it follows that the only positive character (apart from the close resemblance to *Hyperoödon*) attributed to the genus by Cuvier—the overhanging posterior wall of the nostrils—cannot be predicated, with certainty, of two of the three species included in it.

In 1846, Professor Van Beneden* published a note upon two fossils obtained during the Antwerp excavations, of which one exactly resembled the *Ziphius planirostris* of Cuvier, whilst the other was like *Z. longirostris*, but had the advantage of being more complete than Cuvier's specimen, the distal end being preserved.

"The end of the snout is much produced, and terminates in a very acute point. Towards the middle of its length it is compressed, and its height is almost double its width. These dimensions, on the other hand, hardly differ at its extremity."

After noting the differences between this specimen and the foregoing, Professor Van Beneden observes:—

"These differences indicate modifications of sufficient importance to lead us to suppose that these animals cannot belong to one and the same genus, and that, instead of a species, we have here a new genus."

Cuvier appears to have considered his *Ziphius* to be an extinct genus; but many attempts have since been made to refer existing species to it. Thus, at p. 26 of the 'Zoology of the Erebus and Terror' (Parts III. IV. & V., "Mammalia," 1846), Dr. Gray observes:—

"*Physeter bidens* (Sowerby) has been referred to this genus [*Hyperoödon*]; but the form of the head and the position of the fins, the teeth and the form of the skull, show it is a *Ziphius*."

But neither the form of the head, nor the position of the fins, nor the teeth of any species of Cuvier's *Ziphius* are known with certainty; so that Dr. Gray's reference of the *Physeter bidens* of Sowerby thereto must have been based upon the form of the skull only. The only Cuvierian *Ziphius* the skull of which is well preserved is *Z. cavirostris*, which differs widely from *Physeter bidens*.

Dr. Gray further considers the Dolphin from the Seychelle Islands, with a solid rostrum of ivory-like density, named by De Blainville *densirostris*, to be another species of *Ziphius* (*Z. Seychellensis*, Gray); and he affirms it to be "exactly like the fossil from D'Anvers" (*l. c.* p. 28), or Cuvier's *Z. planirostris*. With this identification, however, I can by no means concur, the structure of the beak of *Delphinus densirostris* being widely different from that of *Ziphius planirostris*.

* Bulletin de l'Académie Royale de Belgique, tom. xiii. 1[e] partie, p. 257.

Professor Eschricht's excellent memoir, entitled "Zoologisch-anatomisch-physiologische Untersuchungen über die nordischen Wallthiere," appeared in 1849, and contains, at p. 50, the following important remarks bearing on the present question:—

"While *Delphinus micropterus* * was still known only very imperfectly through Sowerby's observations, Cuvier had recognized certain much-mutilated fossil skulls (not only devoid of the lower jaw, but wanting the whole occiput, the pterygoids, and palatines), merely by the narrowing of the anterior part of the upper jaw and the absence of alveoli, to be skulls of Cetacea, nearly allied to the Bottlenose [*Hyperoödon*], though they lacked the osseous maxillary crests so characteristic of the latter. He called them all *Ziphius*, though the fragmentary specimens differed considerably from one another.

"By this beautiful discovery of Cuvier, therefore, among the few fossil Cetacea three species were made known, all of which belong to a little group at present represented by only two species. The Bottlenose and the *Delphinus micropterus* thus appear to be the scanty remnant of an ancient large group of Cetacea; and it is probably for this reason that they are at present so isolated. It is not without significance for the history of the ancient animal world, that this should be the case with a group which very definitely belongs to the *Teuthophaga*.

"This group, consisting of the Bottlenose, the *Delphinus micropterus*, and the different species of *Ziphius*, corresponds perfectly with the edentulous Dolphins of Schlegel and the *Hyperoödontina* of Gray."

Professor Eschricht then proposes the name of *Rhynchoceti*, or "beaked whales," for this group. "*Hyperoödon*" he changes into "*Chœnocetus*," as the "Bottlenose Whale" has, strictly speaking, no palatine teeth. But I cannot think this alteration is justifiable; for the palatine rugosities of the Bottlenose are sufficient to bear out the name; and even were it otherwise, the expediency of altering well-established generic names, on account of some error in their signification, appears to me to be very doubtful.

Professor A. Wagner had already proposed to distinguish *Delphinus micropterus* subgenerically under the name of *Micropterus*. This name Eschricht modifies, on etymological grounds, into "*Micropteron*," and concludes thus:—

"The fossil *Rhynchoceti* have hitherto all been called *Ziphius*; very probably, fuller knowledge will oblige us to range them in one of the two genera which are still living, viz. *Micropteron*. The name *Ziphius* should, probably, therefore be regarded only as a temporary one, unless, if the fossils should be identified generically with recent forms, the older Cuvierian name of *Ziphius* should be preferred to the new one."

Dr. Gray identifies *Ziphius* generically with the living *Physeter*

* Eschricht considers the *Physeter bidens* of Sowerby to be only the male *Delphinus micropterus*.

bidens; and Professor Eschricht, it will be observed, substantially agrees with him, inasmuch as he ranges Sowerby's Dolphin in *Micropteron*. M. Gervais, in his "Mémoire sur la Famille des Cétacés Ziphioides," published in the 'Annales des Sciences Naturelles' for 1850, brought forward a new series of considerations, tending to refer *Ziphius* to a recent type; and as M. Gervais entertains the conviction that no living species of mammal existed during any Tertiary epoch, his identification of Cuvier's *Ziphius cavirostris* with the living Mediterranean species of Cetacean stranded at Aresquiers, in the Department of Hérault, in May 1850, led him to dispute the truly fossil character of *Ziphius cavirostris*. M. Gervais justly draws attention to the differences between *Ziphius cavirostris* and the two other Cuvierian species, and indicates what he conceives to be the close analogy of *Ziphius longirostris* with the recent *Delphinus densirostris*, which he ranges in a distinct genus, under the name of *Dioplodon*.

At the same time he establishes the genus *Mesoplodon* for Sowerby's Dolphin; and he combines all these genera, namely, *Ziphius*, *Dioplodon*, and *Mesoplodon*, with *Hyperoödon*, into the family of *Cetacea Ziphioidea*.

But, as M. Gervais agrees with Eschricht in identifying Sowerby's Dolphin with *Delphinus micropterus*, he was bound to adopt Eschricht's name, *Micropteron*, instead of inventing a new one (*Mesoplodon*) to cover the same group; and, similarly, "*Cetacea Ziphioidea*" can only be regarded as a synonym of "*Rhynchoceti*" and "*Hyperoödontinæ*."

In the 'Annales des Sciences' for 1851, M. Duvernoy made public the results of his investigations into Cetacean osteology, in an essay, accompanied by excellent figures *.

Refusing to admit the identity of the Cetacean of Aresquiers with *Ziphius cavirostris* (Cuv.), M. Duvernoy considers it to be a *Hyperoödon* of a new species, which he terms *H. Gervaisii*.

The absence of the maxillary crest characteristic of *Hyperoödon*, and the difference in dentition between the Cetacean of Aresquiers and that genus, however, appear to me to be fatal obstacles in the way of this step. Further, M. Duvernoy substitutes for M. Gervais's two genera *Dioplodon* and *Mesoplodon*, one, *Mesodiodon*, which embraces the species *Delphinus Sowerbiensis*, *D. micropterus* (regarded as a distinct species), *D. densirostris*, and the fossil *Ziphius longirostris*.

But *Mesodiodon*, as thus composed, is clearly only a synonym of *Micropteron*.

Ziphius planirostris is made the type of a new genus, *Choneziphius*, distinguished by its large maxillary fossæ and by the union of the premaxillæ on the upper surface of the snout. *Ziphius cavirostris*, lastly, is retained as the type of the restricted genus *Ziphius*.

Thus Cuvier's three species of *Ziphius* are referred by Duvernoy, and I believe rightly, to as many genera; while for that group of Cetacea which contains these genera, *Hyperoödon*, and a new form,

* "Mémoires sur les Caractères ostéologiques des Genres nouveaux ou des Espèces nouvelles de Cétacés vivants ou fossiles," 'Annales des Sciences Naturelles,' sér. iii. tom. xv.

Berardius, M. Duvernoy employs the term *Heterodontes*, previously used by Desmarest and Lesson. In M. Gervais's subsequent publications* he reasserts the identity of *Ziphius cavirostris* with the Cetacean of Aresquiers. Not recognizing *Mesodiodon*, he includes in *Dioplodon* not only *D. densirostris*, but a new recent species, *D. Europæus*, and two fossil species—the *Ziphius longirostris* (Cuv.), and a new species, *D. Becanii*, founded on the specimen which had been regarded by M. Van Beneden as identical with *Ziphius longirostris* (*suprà*, p. 389).

M. Gervais adopts *Choneziphius* (Duv.); so that he agrees with M. Duvernoy in considering the three Cuvierian species of *Ziphius* as members of as many genera, and, further, in regarding *Ziphius longirostris* (Cuv.) as of the same genus with the recent *Delphinus densirostris*. And, so far as Cuvier's original species go, the only difference of opinion between M. Gervais and M. Duvernoy is whether "*Ziphius*" *longirostris* shall be called *Dioplodon* or *Mesodiodon*. But if the line of argument taken by M. Duvernoy is a correct one, and "*Ziphius*" *longirostris* is generically identical with *Delphinus micropterus*, then it is a *Micropteron* (Eschricht). On the other hand, if *Delphinus densirostris* has a claim to generic distinctness from *D. micropterus* and *D. Sowerbiensis*, as would seem to be the case, M. Gervais's name of *Dioplodon* must stand, and the question arises—is "*Ziphius*" *longirostris* a *Dioplodon*?

I am acquainted with the skull of *Dioplodon densirostris* only by the figures given by MM. Duvernoy and Gervais, there being no specimen of this rare animal in England, to my knowledge. But these figures clearly show (1) that the width of the vomer exposed on the upper face of the snout does not nearly attain one-third the whole width of that face, and (2) that the vomer terminates before reaching the end of the rostrum, the premaxillæ being separated beyond it by a well-marked notch or cleft, so that the end of the snout is bifid, as in Cetacea in general.

Now, in all the fossil rostra allied to "*Ziphius*" *longirostris* which I have examined, or seen figured, the vomer occupies fully a third of the width of the upper face of the rostrum; and in the few instances in which the extremity of the rostrum is entire, it is not bifid, but sharply pointed, almost like the end of the guard of a Belemnite, the vomer and premaxillæ seeming to coalesce into one solid terminal cone.

Taking into account these marked differences from any recent species, observable in the structure of the beaks of the fossil forms, and considering that we know nothing whatever of the mandibular dentition of the latter, I think they should be regarded as members of a distinct genus, to which the name of *Belemnoziphius* may be applied. And were there not, as I believe there are, sufficient zoological grounds for this step, I might urge as a palæontological argument in its favour, the great importance of not passing over too lightly any differences which may be observable between the Mammals of the Crag and those of the present day.

* Zoologie et Paléontologie Française, ed. 2, p. 287.

Up to this time only two species of *Belemnoziphius* have been described, *B. longirostris* (*Ziphius longirostris*, Cuv.) and *B. Becanii* (*Dioplodon Becanii*, Gervais and Van Beneden). In the British Museum, however, there is a fine collection of rostra belonging to Cetaceans of this genus, which have been named by Professor Owen *Ziphius angustus*, *Z. gibbus*, *Z. declivus*, *Z. angulatus*, *Z. planus*, and *Z. undatus*. Though, in the absence of any published description of these forms, the names have no authority, I should have been glad to adopt one of them for the species of which I am about to give an account, had any of the British Museum specimens appeared to be specifically identical with it. This, however, is not the case, and therefore I propose to confer upon the new specimen the name of *Belemnoziphius compressus*.

Belemnoziphius compressus, sp. nov. Pl. XIX. figs. A, B, C, D.

The fossil in question was obtained by George Tomline, Esq., M.P., from a quarry upon his estate, on the edge of "Blackheath," three miles east of Ipswich in Suffolk, which has been worked for the so-called "Coprolites"; and which, I am assured by Sir R. I. Murchison, is situated in the Red Crag.

The specimen is very heavy, and has the characteristic aspect of Crag fossils. It would appear to have lain at the bottom of the sea for some time before fossilization, as its surface is covered with superficial hemispherical pits, apparently *Pholas*-borings.

The singular density of the bony structure of the snout of the ancient Dolphin readily accounts for the relatively little wear and tear which it has undergone, and for the small success of the animals which attempted to tunnel it.

The specimen is 14·8 inches long, and is broken at both ends. Anteriorly it is flattened from side to side, and much deeper than wide; posteriorly, on the other hand, it is flattened from above downwards, and wider than it is deep. Its whole upper face is convex from side to side; but the convexity is but little marked posteriorly, where the upper face ends, at the junction of the upper and middle thirds of the depth of the bone, in a well-defined lateral ridge. The section of this part of the rostrum is a sort of triangle, with the base turned upwards. The lateral ridges descend as they pass forwards, until, about the middle of the length of the specimen, they are situated opposite the middle of its depth; beyond this point the direction of each ridge is continued by a well-marked groove, which already exists as a canal underneath the ridge, and opens on the fractured hinder extremity of the specimen. As the lateral ridges die away anteriorly, and the rostrum becomes more flattened from side to side, its section acquires a vertically elongated oval outline. Posteriorly the upper contour is slightly convex, and then sweeps, with a slight concavity, to its distal third, which has a well-defined upward convexity.

Inferiorly and anteriorly the longitudinal contour is convex; but in its posterior third it is sharply concave. The anterior third of the inferior surface is smooth, flattened, and triangular, the apex of the triangle being directed backwards. The hinder third of the inferior surface, rough and irregular, doubtless gave attachment to the palatine bones. It is separated by a curved shoulder-like projection, which fades away anteriorly into a slight linear depression, from the smooth lateral surface of the rostrum.

The upper face exhibits a central area, about 1 inch wide, and bounded by the well-defined parallel grooves, which end posteriorly in short covered ways. These terminate in the front walls of two canals (*aa*), which open above by somewhat funnel-shaped rounded apertures, looking a little backwards as well as upwards. The canals lead from these apertures, at first downwards and a little forwards, and then turn sharply backwards, to become much wider, and terminate on the posterior face of the specimen. Between these canals the same face exhibits a large and deep fossa.

About $2\frac{1}{4}$ inches in front of the upper apertures of the canals the "central area" exhibits the commencement of a slit (*b*), which deepens as it passes backwards, and becomes lost in an irregular fossa. The slit is not perfectly central or symmetrical. The left face of the specimen is more complete than the right. It exhibits the two grooves, ending behind in canals already mentioned, and the third slighter groove, which is continuous with the curved flange, or shoulder, against which the palatine bone fitted.

On the right side a good deal of the bone is broken away from the posterior half of its lateral face, and the canal under the ridge is laid open. About three-quarters of an inch below it there is another canal of the same size, and running parallel into the foregoing, which is filled with hard ferruginous matrix. It opens posteriorly on the palatine flange.

The ends of two canals, which would seem to be distinct from either of these, are seen in the middle of the fractured distal end of the specimen (fig. D).

It is probable (as Duvernoy has already pointed out) that the "central area" indicates the upper extent of the vomer, the only remains of its primitive trough-like cavity being the median slit above and the large fossa behind. Into the latter the remains of the cartilaginous ethmoidal septum doubtless fitted.

The lateral ridges, with the grooves, which continue their direction downwards and forwards, define the outer and lower margins of the premaxillæ in which the curved canals are situated; and between these ridges and grooves, the flange, and the sulcus into which it passes, the surface of the rostrum probably appertains to the maxilla.

Rather more than the anterior third of the under surface of the specimen has the form of a smooth area, narrower behind than in front, which probably belongs partly to the vomer and partly to the maxillæ.

It may conduce to clearness of conception of the relations of the solid-beaked Dolphins of the Crag with the allied species of Cetacea, if I now arrange the different known forms in a table, parallel with the genera into which they appear most conveniently to fall.

Order *CETACEA.*

Fam. Rhynchoceti (Eschricht).

Hyperoödontina (Gray), *Ziphioidea* (Gervais).
Heterodontes (Duvernoy).

	Species.	Genera.
Recent:—		
	Hyperoödon rostratum	Hyperoödon (Lacépède).
	Berardius Arnuxi	Berardius (Duvernoy).
	Delphinus micropterus *Delphinus Sowerbiensis*	Micropteron (Eschricht). *Mesoplodon* (Gervais). *Mesodiodon* (Duvernoy).
	Delphinus densirostris *Dioplodon Europæus*	Dioplodon (Gervais). *Mesodiodon* (Duvernoy).
	The Cetacean of Aresquiers	? Ziphius (Gervais).
Fossil:—		
	? *Ziphius cavirostris*	Ziphius (Cuvier).
Crag:—		
	Ziphius planirostris	Choneziphius (Duvernoy).
	Ziphius longirostris *Ziphius Becanii* *Belemnoziphius compressus*	Belemnoziphius (Huxley).
Prof. Owen, MS.	*Ziphius angustus* *Ziphius gibbus* *Ziphius declivus* *Ziphius angulatus* *Ziphius planus* *Ziphius undatus*	Belemnoziphius (Huxley).

1. Unless the Cetacean of Aresquiers be identical with *Ziphius cavirostris,* all the *Ziphii* of Cuvier belong to Cetacea generically distinct from those now living.

2. If the Cetacean of Aresquiers be identical with *Ziphius cavirostris,* it is not certain that the latter is truly fossil; nor, if it be so, have we any knowledge of its stratigraphical position.

3. Of the certainly fossil *Ziphii,* the stratigraphical position of *Belemnoziphius longirostris* is unknown; but all the other species of that genus and *Choneziphius planirostris* are derived from the English or Antwerp Crag, and are not known to occur out of it.

4. So that at present we are justified in regarding *Belemnoziphius* and *Choneziphius* as true Crag mammals.

Since the preceding pages were in type, Professor Van Beneden has had the goodness to send me his interesting and valuable memoirs, "Sur une nouvelle Espèce de *Ziphius*" and "On *Mesoplodon Sowerbiensis,*" published in the 'Bulletin' of the Belgian Academy for 1863, which had not reached me at the time these pages were written.

The new "*Ziphius indicus*" appears to be very closely allied to the Cetacean of Aresquiers, which Professor Van Beneden agrees with M. Gervais in identifying with Cuvier's *Z. cavirostris.* In the course of his memoir on this species, Professor Van Beneden refers incidentally to two other Ziphioid Cetaceans of new generic types—"Ziphirostre" and "Placocète"; the former of which had already been mentioned as the "*Dioplodon* of Hemixem" in a notice published by M. Van Beneden in the tenth volume of the second series of the 'Bulletin.' On referring to the page of that volume cited, I find, unfortunately, no statement of the distinctive characters of the *Ziphirostrum*; and the description of *Placocetus* also is not yet published.

EXPLANATION OF PLATE XIX.

Rostrum of *Belemnoziphius compressus*, one-third the natural size, viewed—A, laterally; B, from below; C, from above; D, the anterior fractured end.

JUNE 8, 1864.

Christopher Oakley, Esq., 10 Waterloo Place, Pall Mall, S.W.; George Edward Roberts, Esq., Geological Society, Somerset House, W.C., and 7 Caversham Road Villas, N.W.; and The Rev. Henry W. Watson, M.A., Harrow, were elected Fellows.

The following communications were read:—

1. *On the* RHÆTIC BEDS *and* WHITE LIAS *of* WESTERN *and* CENTRAL SOMERSET; *and on the* DISCOVERY *of a new* FOSSIL MAMMAL *in the* GREY MARLSTONES *beneath the* BONE-BED. By W. BOYD DAWKINS, Esq., B.A. (Oxon), F.G.S., of the Geological Survey of Great Britain.

CONTENTS.

PART I. *On the* RHÆTIC BEDS *and* WHITE LIAS *of* WESTERN *and* CENTRAL SOMERSET.

§ I. *Introduction.*

IN the year 1861 I spent some time in examining the interval between the Red Marls and the Upper Lias in Central and Western

G. West del. et lith.

M & N. Hanhart imp.

BELEMNOZIPHIUS COMPRESSUS. (Huxley)

Somerset, taking, in the course of my examination, upwards of seventy sections. The results of this exploration, so far as relates to the Rhætic beds and the White Lias, are embodied in the following paper.

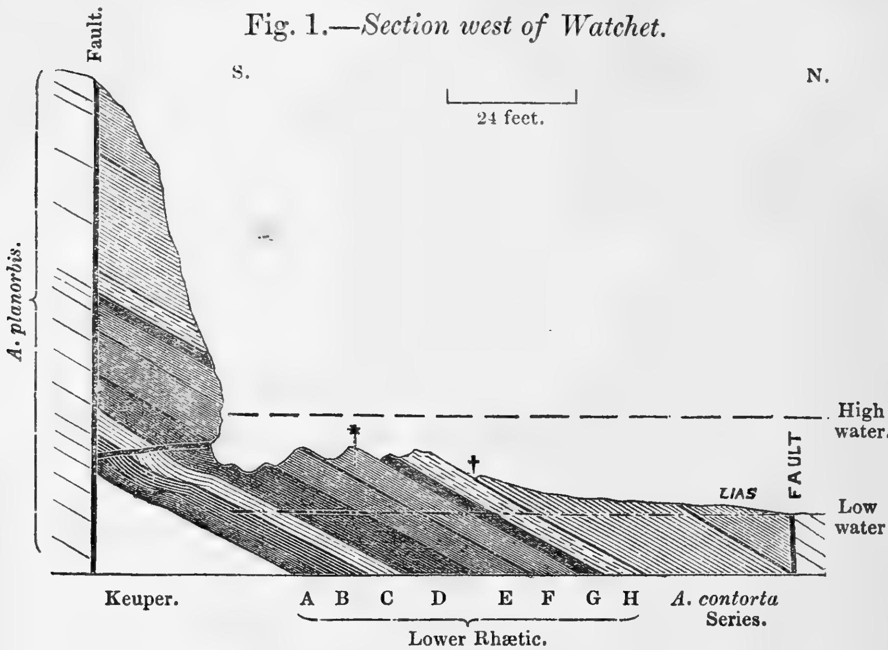
The suites of fossils collected, and numbered on the spot, have been examined by my friend Mr. Etheridge, F.G.S., without whose able assistance and corrections I should have felt diffident in my own determination of the Invertebrata.

§ II. *Description of the Sections.*

1. *West of Watchet.*—The sea-shore in the neighbourhood of Watchet, in West Somerset, affords perhaps one of the very best sections in England of the beds between the Red Marls and the zone of *Ammonites Bucklandi.* In the high cliffs the relations of the Gypsiferous and Red and Grey Marls are clearly shown. Seawards, the Rhætic beds, and the limestones of the zones of *Ammonites planorbis* and *A. Bucklandi*—here forming saddles, or with but gentle dip, there vertical and standing up like tombstones—afford suites of fossils remarkable for their beauty and their numbers. Immediately to the west of Watchet Harbour, the Watchet Fault appears, throwing down the Lias to the south, and causing the *Ammonites planorbis* shales, having a dip of 45° N.N.E., to abut against the Red Marls, which dip 25° S.S.W. Thence the fault runs nearly parallel to the coast-line, disappearing in the sea—westward at Blue Anchor, eastward in the Bay of Donniford. To the north of this, and near low-water mark, is a second, running parallel to the first, and throwing down the shales with *A. planorbis* to the north. Between these two faults lie the sections which I am about to describe—the one to the west, the other to the east of Watchet.

Immediately to the south of the *Ammonites planorbis* shales, on reaching the eastern side of the point that divides the small Blue Anchor Bay from that of Watchet, is a series of Red and Grey Marls, with a dip of 13° to the north, increasing westwards to 30°. The lowest of these, at the base of the cliff, is a soft slate-coloured marl (A), passing into black at the bottom: 4 feet. Above this are some dark-grey and black slaty beds (B), with layers of black shale, and highly charged with flesh-coloured gypsum, besides containing a little of the white fibrous variety: 4 feet. Then occurs a dark slate-coloured homogeneous marlstone (C), 4 feet thick, with a little flesh-coloured gypsum. The latter is deposited in the fissures, and, from their obliquity in some places, it gives the appearance of "false bedding." It occurs also in the true bedding. Above this is a coal-black shale (D), presenting a marked feature in the section, and containing gypsum: 10 feet. This is overlain by gypseous grey sandy marls (E), much indurated: 10 feet. Up to this point I was unable to detect the least fragment of any organism. In the grey, ripple-marked, fissile, sandy marlstones, 6 feet in thickness (F), immediately above, organic remains were very abundant. The Annelida are represented by very numerous holes and tracks; of the Mollusca, the Bivalves by *Modiola minima, Pecten Valoniensis, Myacites* *striatogranulata*, *Gervillia præcursor*, *Pullastra arenicola*, and *Cardium Rhæticum*, the Univalves by a cast of a *Chemnitzia* or *Turritella*,

Fig. 1.—*Section west of Watchet.*



* Mammalian tooth. † Bone-bed.

the Cephalopoda by the fragmentary pen of a dibranchiate octopod closely allied to the Liassic *Beloteuthis* (Münst.) or *Geoteuthis* (Münst.); of the Fishes, the Ganoids by *Saurichthys apicalis*, *Gyrolepis Alberti*, and *G. tenuistriatus*, the Sharks by *Acrodus minimus*; *Sargodon Tomicus* was also found. Two rolled fragments of large bones, of dense texture, indicate the presence of the Reptilia; while one crushed and hollow bone, in fineness of texture, polish of surface, and thinness of walls, reminds me of the Pterodactylian wing-bones of the Stonesfield slate. And lastly—to pass over the long branching casts, probably of Fucoids, and the fragments of fossil wood—the Mammalia are represented by a small animal closely allied to the Kangaroo-rat, which I purpose to describe in Part II. of this paper under the name of *Hypsiprymnopsis Rhæticus*. These beds are overlain by 2 feet of soft grey shaly (G) marlstone, without fossils. Above this again are 6 feet of a greenish-grey sandy fissile marlstone (H), containing numerous casts of Fucoids and trails of Annelids, with *Pullastra arenicola*, *Acrodus minimus*, *Gyrolepis tenuistriatus*, and *G. Alberti*. In this, as in the fossiliferous bed below, the ripple-marks indicate a littoral condition of deposit; and the surfaces of the beds into which the stone splits are traversed by irregular cracks from exposure (as it seems to me) to the heat of the sun. These were in many cases filled up with organic remains. Upon the water-worn upper surface are superimposed the limestones, sandstones, and shales of the *Avicula contorta* series, of which the following is a detailed section.

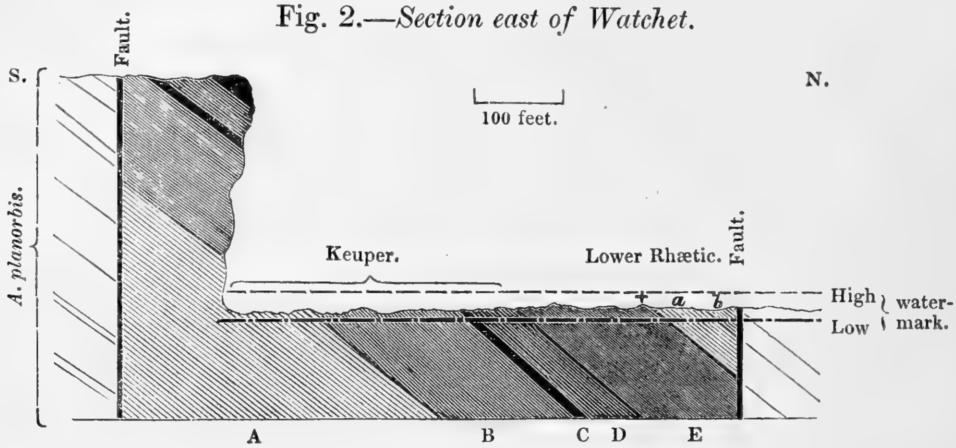
Section of Rhætic Beds to the West of Watchet.

No.	Thickness.	Description.	Fossils.
	Inches.		
1.	1	A thin film of conglomerate, composed of the pebbles of the rock below, and full of fossils.	*Desmacanthus cloacinus.* *Saurichthys apicalis.* *Acrodus minimus.* *Acrodus acutus.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.* *Avicula contorta.* *Cardinia?* *Anatina?*
2.	24	Greenish-grey indurated sandy marl, full of *Avicula contorta*, passing imperceptibly into the bone-bed.	Remains the same as No. 1, with the exception of the *Desmacanthus cloacinus* and the equivocal *Cardinia.*
3.	1	Hard, compact, grey limestone.	Fragments of shells. *Acrodus minimus.* *Acrodus acutus.*
4.	9	Black shale, containing nodules.	
5.		Compact grey micaceous sandstones.	*Axinus cloacinus.* *Axinus elongatus.* *Anatina præcursor.* *Pleurophorus elongatus.* *Cardium Rhæticum.* *Chemnitzia Henrici.*
6.		Indurated grey marl.	
7.		Dark micaceous sandstone.	*Acrodus minimus.* *Acrodus acutus.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.*
8.		Dark shale.	
9.		Limestone full of Shells: compact, dark, earthy, micaceous inferiorly.	*Avicula contorta.* *Axinus elongatus.* *Pleurophorus elongatus.*
10.	1	Black shale.	
11.	2	Grey limestone full of Shells, which occur in nests, very hard, and traversed with cracks filled with carbonate of lime.	Composed in great part of *Avicula contorta.* *Axinus cloacinus.* *Cylindrites elongatus.*
12.		Dark shale with calcareous nodules.	*Hybodus.*
13.	12	Earthy and sandy limestone, nodular, irregular, and micaceous.	
14.		Shale.	
15.	6	Hard, ripple-marked blue limestone, full of cracks filled with carbonate of lime, divided into irregular laminæ by shale.	*Pullastra arenicola.* *Axinus cloacinus.*
16.	24	Dark shale.	
17.	6	Hard, irregularly bedded micaceous and calcareous sandstone, pyritous, ripple-marked.	*Hybodus.* *Acrodus minimus.* *Acrodus acutus.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.* *Avicula contorta.* Hollow Pterodactylian bone.
18.	18	Dark shale.	
19.		Dark shelly limestone, with layers of fibrous carbonate of lime.	

From this point upwards to the fault, the beds are so dislocated that I was unable to determine their true sequence.

2. *East of Watchet.*—The second section, about a quarter of a mile to the east of Watchet Harbour, between high- and low-water marks, shows the higher beds, which I failed to make out to the west.

Fig. 2.—*Section east of Watchet.*



+. Bone-bed. *a. Avicula contorta* Series. *b.* White Lias.

	Thickness, feet.	
A.	70	At the base of the cliffs, and with a dip of 35° to the north, decreasing further eastwards to 15° or 20°; it is a deep-red marl with but few bands and spots of grey. In Watchet Harbour and Donniford Bay it abuts against the *Ammonites planorbis* shales that have been thrown down to the south.
B.	84	A series of red and grey marls. The former predominate; the latter are very much indurated.
C.	1	Black shale.
D.	30	Grey and red marls in nearly equal proportions.
E.	84	Grey indurated marlstones and black shales, with but two or three faint bands of red.

The latter of these, representing the fossiliferous beds F and H of fig. 1, yielded no fossils, perhaps from my being unable to devote so much time to its examination as in the former case. But its barrenness was amply compensated for by the richness of the strata above the bone-bed.

Section of Rhætic Beds and White Lias to the East of Watchet.

No.	Thickness.	Description.	Fossils.
	Inches.		
1.	1–2	Bone-bed—a thin film of conglomerate deposited upon the water-worn surface of a greenish-grey sandy marlstone, pebbles of which are included in it.	*Acrodus minimus.* *Acrodus acutus.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.* *Avicula contorta.*
2.	24	Sandy marl, passing into shale in its upper part.	Organic remains the same as 1.
3.	1–2	Shelly limestone, somewhat irregular.	*Pleurophorus elongatus.*

No.	Thick-ness.	Description.	Fossils.
	Inches.		
4.	6	Black shale.	
5.	4	Black muddy incoherent sandstone, ripple-marked, pyritous.	
6.	6	Black shale.	
7.	2	Limestone, with layers of fibrous carbonate of lime, hard, dark, pyritous, sandy.	
8.	6	Black shale.	
9.	1	Shelly limestone.	*A. contorta.* *Pleurophorus.*
10.	40	Black shale, containing nodules and calcareous seams.	
11.	3–4	Irregular shelly limestone.	*Avicula contorta.* *Modiola minima.*
12.		Black shale.	
13.	20	Six thin layers of arenaceous limestone, ripple-marked, micaceous, sandy, with layers of fibrous carbonate of lime.	*Avicula contorta.* *Pullastra arenicola.* *Pleurophorus elongatus.*
14.	2–3	Bone-bed, sandy, with quartz-pebbles and limestone-nodules. On tracing it, I found that it passed into an impure micaceous limestone.	*Acrodus minimus.* *Acrodus acutus.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.* *Axinus elongatus.* *Axinus depressus.*
15.		Black shale.	
16.	2-3	Bone-bed—a hard sandy limestone.	*Saurichthys apicalis.* *Saurichthys acuminatus.* *Sargodon Tomicus.* *Hybodus minor.* *Gyrolepis Alberti.* *Gyrolepis tenuistriatus.* *Acrodus minimus.* *Acrodus acutus.* *Lepidotus.* *Squaloraia.* *Pullastra arenicola.* *Myophoria postera.* *Axinus cloacinus.*
17.		Black shale.	
18.	1–2	*Pleurophorus* limestone.	*Pleurophorus angulatus.* *Pteromya Crowcombeia.* *Cardium Rhæticum.* *Chemnitzia nitida.*
19.		Black shale.	
20.	1–2	Earthy micaceous limestone, composed in great part of *Cardium Rhæticum.*	*Hybodus plicatilis.* *Hybodus pyramidalis.* *Avicula contorta.* *Avicula solitaria?* *Myophoria postera.* *Pleurophorus elongatus.* *Anatina Suessi.* *Cypricardia suevica.* *Cardium Rhæticum.* *Trigonia curvirostris.* *Pecten Rhæticus.*

No.	Thick-ness.	Description.	Fossils.
	Inches.		
21.	3–6	Dark shale, with comminuted Shells.	
22.		Earthy limestone, dark and irregular.	
23.		Dark shale, with shelly layers.	*Lima præcursor.* *Modiola minima.* *Avicula contorta.*
24.	24	Pecten-bed—dark earthy limestone, irregularly bedded, and containing irregular layers of fibrous carbonate of lime.	*Avicula contorta.* *Pecten Valoniensis.* *Placunopsis alpina.*
25.		Black shale.	
26.	3–4	Pecten-bed, passing into compact limestone.	*Avicula contorta.* *Pecten Valoniensis.* *Cardium Rhæticum.*
27.	24	Black shale.	
28.	24	Earthy limestone, black, with layers of fibrous carbonate of lime, capped with a fine earthy sandstone, ripple-marked, and containing Devonian pebbles.	*Pleurophorus elongatus.* *Pleurophorus angulatus.* *Axinus cloacinus.* *Pecten Valoniensis.* *Chemnitzia?* *Chemnitzia Henrici.*
29.		Black shale.	
30.	8	Hard blue limestone.	
31.	36	Dark shale, with nodules.	
32.	6	Two beds of grey lias.	
33.	4	Indurated shale.	
34.	8	Two beds of grey lias.	
35.	12	Shale.	
36.	13	Three beds of compact bluish-grey limestone.	
37.		Shale, with nodules.	
38.	9	Grey lias.	
39.		Shale.	
40.	7	Grey lias.	*Lima pectinoides.*
41.		Five beds of grey lias, alternating with dark shales.	

From this point to the fault the beds are too much disturbed to admit of any accurate determination. Those ranging from 32 to 41, inclusive, contrast strongly with the arenaceous beds below, in their poverty of organic remains, in the purity of the limestone, and the absence of sandstone. There can be little doubt that they represent the White Lias, the relative position of which they occupy, and to which they are lithologically allied.

3. *Coast to River Parrett.*—Along the coast further to the east the *Avicula contorta* series is exposed in the cliff at St. Audries, and yields *Acrodus minimus, A. acutus, Cardium Rhæticum,* and *Avicula contorta.* From this point to the mouth of the Parrett, though faults are very numerous, there are no good Rhætic sections exposed.

4. *Outliers of Wedmore and Pen Knowle.*—On the north-east side of the great triangular Liassic outlier of Wedmore we again meet

with the series, of which the deep sunken road, "Snake Lane," leading from Pamborough to Wedmore, affords an excellent section.

Section at Snake Lane.

		Thickness, inches.
A.	Deep-red marls.	
B.	Grey marls.	
C.	Fine-grained friable grey marlstone.	
1.	Grey shale "race"	48
2.	Dark shale "race"	48
3.	A hard shelly limestone of five or six irregular beds: "Wedmore stone"—*Avicula contorta*	36
4.	Grey-ferruginous and dark marls, sandy at the top, and highly charged with carbonaceous matter	48
5.	Compact blue limestone—*Cardium Rhæticum, Acrodus minimus*	4
6.	Grey marl	6
7.	Compact grey limestone	3
8.	Grey marl	5
9.	Compact grey micaceous limestone	1
10.	Dark and ferruginous shale, passing into a sandy, micaceous, laminated marl	48
11.	Irregularly bedded sandstone—*Acrodus minimus*	14
12.	Iron-grey and ferruginous marls	?

At this point the section is obscured; but at a distance of a few yards, in a field, the White Lias presents the following section:—

		Thickness, inches.
1.	Hard pinkish-grey compact lias, irregular at the top (old sea-bottom)	5
2.	Marly grey lias, soft and irregular: *Modiola minima, Cardium Rhæticum, Serpulæ, Lima* (sp.), *Ostrea interstriata*	5
3.	Two beds of compact limestone, blue inside, grey on exposed faces of joints: *Ostrea liassica, Modiola minima, Cardium Rhæticum, Astræa*	9
4.	Irregular grey marly stone, with *Modiola minima* and *Cardium Rhæticum*	?
5.	Hard grey lias	7
6.	Grey lias, hard and compact	2
7.	Light grey marly stone	36

The slight dip of the beds to the south-west, coupled with the few yards intervening between the two sections, proves that there is a very small gap between them.

Further to the west, between Sand and Wedmore, the *Avicula contorta* series, which is nearly horizontal, forms a spread; and the hard crystalline Wedmore Limestone is dug in the fields for road-material and building-purposes. Near Sand, and close to the windmill, the limestone, 3 feet in thickness, passes below into a greenish calcareous shale, full of *Avicula contorta.* It contains vertebræ of an undetermined Fish, and remains of *Acrodus minimus, A. acutus, Sargodon Tomicus, Saurichthys apicalis, Cardium Rhæticum,* and *Avicula contorta,* and rests upon a dark clay, as in Snake Lane. At the base of the southern scarp, also, near Mudgely, the beds are seen with the usual fossils.

To the east, near Wells, the summit of the small outlier of Pen Knowle is composed of White Lias. In exploring, in 1862, some of those equivocal remains of doubtful origin, use, and antiquity, which are usually termed "hut-circles," I exposed a section of the

White Lias some 8 feet in depth. It yielded the usual fossils, namely, *Modiola minima, Cardium Rhæticum,* and *Montlivaltia.* Among the débris thrown out from one "hut-circle" were fragments of the "bone-bed"—a quartz-conglomerate containing *Gyrolepis Alberti* and *Acrodus minimus,* which proved that the unknown quarrymen had passed some 16 or 20 feet into the *Avicula contorta* beds below. There can be no doubt in this case, as in the previous section at Snake Lane, that the White Lias rests immediately upon the Rhætic beds, without any trace of the *Ammonites-planorbis*-bearing rocks, or Saurian beds.

5. *Poulden Hills, Turn Hill, Langport, Hatch.*—Throughout the whole southern scarp of the Poulden Hills, from Dunball on the west, where there is a good section in the railway-cutting, past Moorlinch and Greinton, the White Lias is seen resting immediately on the *Avicula contorta* beds, the grey and variegated marls forming the lower two-thirds of the ancient Post-pliocene sea-cliff. Thence, after passing up the river Carey as far as Charlton Mackarel, and being brought up by a fault among the *Ammonites planorbis* shales near King Weston, it caps the promontory of Turn Hill, and forms a considerable portion of the Liassic spread from High Ham to Langport.

The ascent of Turn Hill presents a section which may be considered representative of the beds in the Vale of Bridgewater.

Section at Turn Hill.

		Feet.
A.	Red marl	
B.	Red and grey marls, red predominating	62
C.	Alternations of red and grey marls, the grey predominating	20
D.	Alternations of grey and black marls, with a few faint bands of red	20 ?

The section is here obscured by the detritus of the soft Lower *Avicula-contorta* shales.

		Thickness, feet.	inches.
1.	Hard shelly limestone, like Wedmore stone, with *A. contorta*		
2.	Grey marly shale	0	6
3.	Hard grey lias	0	6
4.	Grey marly shale	0	3
5.	Grey lias	0	5
6.	Grey marly shale	0	4
7.	Grey lias	0	3
8.	Grey marly shale	0	8
9.	Four layers of grey lias	1	9
10.	Grey shale	1	8
11.	Grey lias	0	6
12.	Grey shale	2	0
13.	Bluish lias	0	8
14.	Grey shale	2	0
15.	Blue lias	0	8
16.	Shale	0	?

The beds from 3 to 12 inclusive yielded the usual fossils of the White Lias, namely, *Modiola Hillana* (juv.), *M. minima, Cardium Rhæticum, Montlivaltia,* and *Ostrea interstriata,* together with an

Avicula and a *Pecten*. The three upper beds I consider to belong to the base of the zone of *Ammonites planorbis*, which, in a quarry at a short distance from the top of the scarp, yields *Ostrea liassica* and a small species of *Avicula*, and contrasts with the White Lias in the dark colour of its beds. The grey marls and black shales of C, non-gypsiferous in this section, are highly charged with both the varieties of gypsum a little distance to the north; and a gentleman of greater enterprise than prudence, imagining that it occurred in a vertical vein, spent £800 in discovering that it runs parallel with the bedding underneath his neighbour's land.

From Langport the *Avicula contorta* zone sweeps southward past Red Hill, as far as Hatch Park. Mr. Charles Moore, in his valuable paper on the Rhætic beds of Somerset, has taken away the need of my speaking of its occurrence at Beer Crowcombe and North Curry. To the extreme accuracy of his sections of the White Lias of Stoke, St. May, and Long Sutton, I can bear testimony. No. 3 of his section* at the latter place yielded the only *Pleurophorus* obtained from these beds.

6. *Summary of Sections.*—A comparison of the Rhætic sections, given above, with those of Dr. Wright† and Mr. Charles Moore, shows that, lithologically, hardly any two agree. Sometimes the calcareous element is wanting, as at North Curry; at others it is greatly developed, as at Watchet, where the thin beds of limestone split up the thick bed of marly shale which generally intervenes between the "Pecten-beds" and the "bone-bed." Sometimes the sandstones are absent (Bath Easton) or, as is more usually the case, are very well represented. This irregularity seems to me to indicate a deposit off-shore in comparatively shallow water, affected considerably by currents. The White Lias, on the contrary, appears to have been deposited in a sea of considerable though, as proved by its varying thickness, of variable depth, and out of the reach of litoral influences. In common with the Lower Lias series it contains no arenaceous beds; as compared with the beds below it, it is remarkable for the development of its white, pinkish, and grey limestones.

The sections taken to the east of Watchet, and at Turn Hill, that at Saltford given by Dr. Wright, and those of Mr. Charles Moore, prove beyond all doubt the true position of the White Lias—below the Saurian zone of the *Ammonites planorbis* group, and immediately above the *Avicula contorta* series.

§ III. *Palæontology.*

In the preceding sections I have paid particular attention to each Rhætic bed, to see whether, as on the Continent, well-defined zones of life are traceable. The following table, showing the range of each species, as far as the *A. planorbis* zone, is the result of the endeavour. It is by no means an exhaustive list, and represents merely the fossils that I have found myself.

* Quart. Journ. Geol. Soc. vol. xvii. p. 491.
† *Ibid.* vol. xvi. pp. 378 *et seq.*

1. *Range of Fossils of Rhætic Beds and White Lias.*

Name.	Grey marls beneath Bone-bed fig. 1.	*Avicula contorta* zone, W. Watchet.	*Avicula contorta* zone, E. Watchet.	White Lias.	*Ammonites planorbis* zone.
Hypsiprymnopsis Rhæticus, *Dawkins* ...	F				
Pterodactylus	F	17	16		
Acrodus minimus, *Ag.*	F H	1–17	1–16		
Acrodus acutus, *Ag.*	...	1–17	1–16		
Acrodus striatus	...	...	16		
Hybodus plicatilis, *Ag.*	...	...	20		
Hybodus pyramidalis, *Ag.*	...	...	20		
Gyrolepis Alberti, *Ag.*	F H	1–17	1–16		
Gyrolepis tenuistriatus, *Ag.*	F H	1–17	1–16		
Sargodon Tomicus, *Plien.*	F	1	16		
Saurichthys acuminatus, *Ag.*	...	...	16		
Saurichthys apicalis, *Ag.*	F	1	16		
Squaloraia, *Ag.*	...	...	16		
Desmacanthus cloacinus, *Quenst.*	...	1			
Belo- (Geo- ?) teuthis, sp.	F				
Chemnitzia nitida, *Moore*	...	...	18		
Chemnitzia Henrici, *Moore*	...	5	28		
Cylindrites elongatus, *Martin*	...	11	28		
Axinus cloacinus, *Op. & S.*	...	5–15	16–28		
Axinus elongatus, *Moore*	...	5–9	14		
Axinus depressus, *Moore*	...	...	14		
Anatina Suessi, *Op.*	...	...	20		
Anatina præcursor, *Quenst.*	...	5			
Pleurophorus, sp.	...	...	...	Long Sutton.	
Pleurophorus elongatus, *Moore*	...	5–9	3–28		
Pleurophorus angulatus, *Moore*	...	...	18–28		
Myophoria postera, *Quenst.*	...	...	16–20		
Pteromya Crowcombeia, *Moore*	...	...	18		
Avicula contorta, *Portl.*	...	1–17	1–24		
Avicula solitaria (?), *Moore*	...	...	20		
Lima præcursor, *Quenst.*	...	...	23		
Lima pectinoides, *Sow.*	...	...	...	Watchet.	Sharpham.
Modiola minima, *Sow.*	F	...	11–23	Turn Hill, &c.	Street.
Modiola Hillana, *Sow.*	...	...	...	Turn Hill.	Butleigh.
Placunopsis alpina, *Winkl.*	...	...	24		
Ostrea liassica, *Strickl.*	...	...	...	Snake Lane.	Street.
Ostrea interstriata, *Emmerich*	...	...	...	Turn Hill.	
Gervillia præcursor, *Quenst.*	F				
Pecten Valoniensis, *Defr.*	F				
Pecten Rhæticus, *Quenst.*	...	...	24–26		
Trigonia curvirostris, *Quenst.*	..	...	20		
Cypricardia suevica, *Oppel*	...	...	20		
Cardium Rhæticum, *Merian*	F	...	18–26	Turn Hill, &c.	
Pullastra arenicola, *Strickl.*	F H	15	13–16		
Myacites striatogranulata, *Moore*	F				
Annelidan tracks	F H				
Serpulæ	...	...	...	Snake Lane.	
Astræa	...	...	...	Snake Lane.	
Montlivaltia	...	...	...	Turn Hill, &c.	

2. *Palæontological Relations of the White Lias to the Beds above and below.*—If I have failed to make out distinct zones of Rhætic life, yet the preceding table throws great light upon the mutual relations of the beds, and especially with regard to the White Lias. Of the Fishes so abundant below, not one passes upwards; of the Saurians of the *Ammonites planorbis* group above, not one passes downwards. It has yielded, so far as I know, neither Vertebrates nor Ammonites*. Of its Mollusca, *Cardium Rhæticum* and *Modiola minima*, of the marlstones below the bone-bed, run side by side into its upper beds, where the former becomes extinct, while the latter ranges upwards into the zone of *Ammonites raricostatus.* Mr. Etheridge has identified one shell from Long Sutton as *Pleurophorus* (sp.), a genus peculiarly Rhætic. *Monotis* and *Ostrea interstriata*, on Mr. C. Moore's authority, are common to it and the beds below; *Ostrea liassica*† to the beds below and above. *Lima pectinoides* and *Pecten textorius* (Saltford), which are unknown below, range into the zone of *Ammonites Turneri* ; *Modiola Hillana, Pholadomya glabra*, and *Unicardium cardioides*—the two latter found by Mr. Sanders with *Pinna Hartmanni* at Saltford—into that of *Ammonites Bucklandi.* Passing over, therefore, the fossils common alike to the *Ammonites planorbis* group above and the Rhætic beds below, we have *Monotis* (Moore), *Cardium Rhæticum, Pleurophorus* (sp.), and *Ostrea interstriata* linking it to the former; *Modiola Hillana, Pecten textorius, Pholadomya glabra*, and *Unicardium cardioides* to the latter,—a mixture of forms which appears to me to indicate a border-land between two formations, belonging neither to the one nor the other. The sudden break in the succession of life between it and the zone of *Avicula contorta* indicates a lacuna, of greater or less magnitude, in the succession of the beds. In the absence of arenaceous deposits it contrasts with the beds below; in the great development of the calcareous element it resembles the beds above. And, until there be further evidence upon the subject, it will be far safer to consider it the passage-beds of the Lower Lias than, with Mr. Charles Moore, to assign it to the Rhætic formation, or, with Dr. Wright, putting the Saurian zone and the "firestone" beds beneath, to incorporate it with the *Ammonites planorbis* group above.

3. *Range of Fossils in Rhætic Beds.*—There are a few points worthy of note in the range of the Rhætic fossils. Of the Fishes found below the bone-bed, *Acrodus minimus, Sargodon Tomicus,*

* Dr. Wright, in his valuable section of the Street quarries (Quart. Journ. Geol. Soc. vol. xvi. pp. 389–391), considers that the "firestone" and bottom Saurian-bearing beds lie at the base of the group into which he has incorporated the White Lias. That he is mistaken in this view I have proved by actual survey. The lower Street Saurian beds extend westwards past Woolavington, as far as the Dunball Cement Works, where they occupy a position *above* the White Lias. Here, as at King Weston and West Hatch, they contain numerous Saurians, associated with *Myacites unionoides*, the latter of which characterizes the cement-shales of the lower zone of the *Ammonites planorbis* group. On the evidence, therefore, of the Street section, and still less of that at Saltford, I cannot admit that the fossils of the Saurian zone, or of the beds above it, have been proved to belong to the fauna of the White Lias.

† Quart. Journ. Geol. Soc. vol. xvii. p. 496.

Gyrolepis Alberti, *G. tenuistriatus*, and *Saurichthys apicalis*, the four latter extend downwards into the Muschelkalk; and, of the Mollusca, *Pecten Valoniensis* and *Pullastra arenicola* range high up into the Rhætic beds. *Gervillia præcursor*, *Myacites striatogranulata* (both found by Mr. Moore in the "flinty bed" at Beer), and *Beloteuthis* (*Geoteuthis*), sp., are peculiar, in the Watchet section, to the strata below the bone-bed, together with the Hypsiprymnoid tooth and the Annelidan tracks.

Of the species found above the bone-bed, *Pteromya Crowcombeia* occurs in the upper part, along with *Hybodus plicatilis*, *Anatina Suessi*, *Myophoria postera*, *Lima præcursor*, *Trigonia curvirostris*, and *Placunopsis alpina*. The "Pecten-beds" to the east of Watchet and the *Pleurophorus* limestone (No. 18) appear to be the best defined. Dr. Wright recognizes the former at Uphill.

§ IV. *Lower Boundary of the Rhætic Formation.*

The discovery of organic remains of Rhætic age in the grey sandy marlstones below the bone-bed thrusts downwards the lower boundary of the Rhætic formation into the grey marls usually considered to belong to the Keuper, the sole difference between the fossiliferous beds at Watchet and the non-fossiliferous beds elsewhere being the accidental preservation of the fossils in the former place. Lithologically, in colour and texture they are the same, and they were deposited under the same arenaceous conditions. Relying, therefore, on this evidence, I should include the grey marls and marlstones, and black shales, whether fossiliferous or not, in the Rhætic formation (see fig. 1, A to H; fig. 2, E), the lower boundary of which I should place in the red marls below, considering the alternations of red and grey marls the passage-beds between it and the Keuper. The conglomeratic bone-bed—the old boundary—deposited on a water-worn surface, and containing pebbles of the subjacent rock, indicates a break in the succession of the beds.

§ V. *Thickness of the Rhætic Beds and White Lias.*

The following table shows the thickness of the White Lias and the Rhætic formation, both above and below the bone-bed, in Somersetshire.

Locality.	Thickness of Beds.		
	Rhætic.		White Lias.
	Grey marls below bone-bed.	*A. contorta* zone above bone-bed.	
	feet.	feet.	feet.
Watchet	84	20–25	11+
Snake Lane	...	20+	...
Long Sutton	...	......	17
Beer Crowcombe (Moore)	...	$10\frac{3}{4}$	9
High Ham	...	......	12+
Saltford (Wright)	30	25	23

Conybeare and Phillips give the thickness of the White Lias at Bath Easton as 10 feet, at Paulton as 12 feet.

§ VI. *Summary.*

The four points that I have striven to make out in this part of the paper are, first, the true position of the White Lias immediately upon the *Avicula contorta* series, without the intercalation of any Saurian zone, or any other member of the *Ammonites planorbis* group; secondly, its isolation from the Rhætic formation, both lithologically and palæontologically; thirdly, its palæontological distinctness from the *Ammonites planorbis* zone; and lastly, the downward extension of the Rhætic formation below the bone-bed. I have confined myself strictly to Somerset, to which alone my observations apply. Their application to other districts I leave to the greater leisure of some fellow-worker in the field of science.

Part II. *On the* Discovery *of a new* Fossil Mammal *in the* Grey Marls *beneath the* Bone-bed.

§ I. *Introduction.*

So far back as 1847 the existence of a Rhætic Mammal, having closer affinities with the Marsupials than with any other order, was proved by the discovery of *Microlestes* in the bone-bed of Diegerloch*, which yielded also coprolites and Saurians. Eleven years later, in 1858, Mr. Charles Moore, F.G.S., submitted to Professor Owen several small teeth from a Rhætic breccia that filled a fissure in the Mountain Limestone, near Frome, in Somersetshire. These were determined to belong to the genus *Microlestes* of Professor Plieninger, and to be most closely allied to the *Plagiaulax* found, by the energy of Mr. Beckles, F.G.S., at Purbeck, and described by Dr. Falconer, F.R.S., in the Journal of the Society. In the year 1861 I had the good fortune to discover the traces of a Rhætic Mammal on the sea-shore to the west of Watchet, in the rocks that underlie the bone-bed.

§ II. *Position of the Fossil.*

The hard arenaceous marlstones (F of fig. 1 of the preceding Part), which yielded the first traces of life in the passage from the red marls upwards, yielded also the tooth in question. I chiselled it out of the ripple-marked surface of a reef which the sea had freed from the deposits above, and out of which also were obtained teeth of *Acrodus minimus* and *Sargodon Tomicus*, scales of *Gyrolepis Alberti* and *G. tenuistriatus*, a hollow compact Pterodactylian bone, a portion of the pen of *Beloteuthis* or *Geoteuthis*, a small undetermined amphicœlian vertebra, and a few fragments of wood and of *Pecten Valoniensis*. The fissile many-laminated stone did not admit of my separating the layer in which the fossil tooth occurred from the rest of the laminæ that make up the mass of G. Its exact position was 2 feet 6 inches below the lower boundary of H (fig. 1), and 10 feet 6 inches below the bone-bed. Having been found at a lower horizon,

* Jahreshefte Würtemberg, 1847–48, p. 164.

therefore, than the Microlestian teeth of Frome and Diegerloch, it is the earliest-known trace of a fossil Mammal in the Secondary rocks.

§ III. *Description.*

The crown (see fig. 3), oblong in shape, is very long in proportion to its width, being 1·5 inch long to 0·4 wide. The higher side of its obliquely worn summit, imbedded in, or rather adherent to, the stone, exhibits two isolated involutions of enamel on that portion of the tooth that is supported by the posterior fang. Anterior to these are two wider and less prominent folds. The anterior corner, unfortunately broken by the waves, may perhaps have borne an additional fold. The cervix is very well defined. Of the two divergent fangs, the anterior had been broken short off before it was imbedded in the matrix; the posterior or smaller of the two (in length 0·11 inch) is perfect, and has its tip slightly reflected. There is no evidence as to its position in the jaw.

§ IV. *Determination.*

The former discovery of Marsupials in the Secondary rocks naturally inclined me to seek the existing analogue of this bone and mutilated stump in that great order, now, with the exception of the Opossum, confined to the southern hemisphere; and this inference has been verified by a rigid comparison. The small well-marked folds on the higher side of the tooth, coupled with its oblique grinding surface and its great length and narrowness, point, and point only, towards the *Macropoda* of Van der Hoeven (the Kangaroos) and the *Hypsiprymnidæ*, or Kangaroo-rats. Of the former genus, the first trenchant bifanged milk-molar approximates closely to the fossil in the waved outline which it would present if the inner and posterior extension of the trenchant edge were removed by wear; but the section, in that case, would be trihedral, instead of being oblong as in the fossil. The absence of plication on the permanent premolar of *Macropus*, apart from its great transverse extent, puts that genus out of the comparison. The trenchant plicated premolar, on the other hand, of *Hypsiprymnus* is impressed with all the main characteristics of the fossil. The oblique wear of the crown, the great length as compared with the breadth, the plicæ, and the implantation by two fangs are seen alike in both (see figs. 3–5). But, while the general correspondence in form is so marked, the minor differences are by no means unimportant. One section of the *Hypsiprymnidæ* [*H. Gaimardi*, *H. Hunteri*, *Bettongia Grayi*, *B. penicillata*, &c.] presents seven narrow plicæ, a second [*H. minor* (=*H. murinus*, Owen), *Bettongia rufescens*, &c.] four wide plicæ respectively on their premolars. In the small number of folds (four, or perhaps five), and in their width, the fossil points away from the former towards the latter of these; it differs from the latter in the fact that two of the plicæ are supported by the posterior fang, while in the recent four-plicated premolars all the plicæ are supported by the stout anterior fang. Figs. 4 *a* and 4 *b** represent the unworn

* Nos. 1783–84 of Hunterian Catalogue.

and worn lower premolar of *Hypsiprymnus Hunteri*, magnified four times, the latter being a little more advanced in wear than the fossil. The outer and lower side of its crown presents but the faintest traces of the plicæ, while on the inside they are easily recognized. It proves that the absence of plication in the corresponding side (the lower) of the fossil cannot be admitted as evidence against its Hypsiprymnoid character. In a word, the nearest living representative of the fossil appears to me to be *Hypsiprymnus Hunteri*, *Bettongia rufescens*, or some other of the Kangaroo-rats with four-plicated premolars. All the premolars of *Hypsiprymnus* which I have examined are at least twice the size of the fossil.

Figs. 3–5.—*Illustrating the affinities of* Hypsiprymnopsis Rhæticus.

Fig. 3.

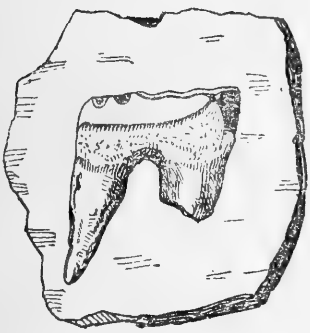


Fig. 5.

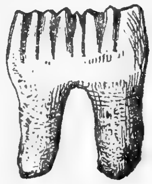


Fig. 4 *a*.

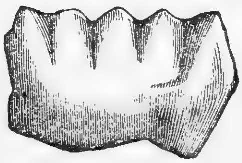


Fig. 4 *b*.

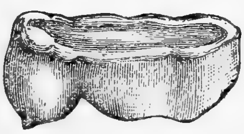


Fig. 3. Premolar of *Hypsiprymnopsis Rhæticus*; × 4.
4 *b*. Right lower premolar of *Hypsiprymnus minor*, very much worn; × 4; = *H. murinus* of Hunt. Cat. 1784.
4 *a*. Unworn left lower premolar of *H. minor*; × 4.
5. Unworn left lower premolar of *H. Hunteri* (Ow.); × 2.

Whether or not the tooth belongs to the Rhætic *Microlestes* cannot be decided, because the tubercular true molars of the latter have alone been found. Nor can its relation to *Plagiaulax* be affirmed, as the worn crown reveals nothing of the verticality or the obliquity of the folds. But, nevertheless, there is a sufficiently characteristic portion of it left to indicate a premolar most closely allied to that of the Kangaroo-rats. Until, therefore, additional remains be found, I have provisionally named it *Hypsiprymnopsis Rhæticus*—a name that represents its position in the geological scale and its zoological affinities.

§ V. *Range of Marsupials in Time.*

It is a very significant fact, that all the Secondary Mammalia that have with any accuracy been determined represent one or other of the families of the most lowly organized Mammalian order*. Of

* The small jaw of *Stereognathus*, from Stonesfield, is *sui generis*, different

the six families into which the eminent Dutch zoologist, Van der Hoeven*, divides the Marsupials now existing, the entomophagous and sarcophagous *Dasyurina* are represented in the "dirt-bed" of Purbeck by the *Spalacotherium* † and *Triconodon* ‡, and in the Stonesfield slate by the *Amphitherium* and *Phascolotherium*, the former the analogue of the insectivorous *Myrmecobius* § of Western Australia, the latter that of the *Thylacinus* ‖ of Van Diemen's Land. The *Pedimana* (Wagn.) can hardly be said to be represented, though both the above fossils from Stonesfield present some of their characteristics, and the latter to such a degree that the scale of evidence inclines but a little in favour of *Thylacinus*. The presence of the *Macropoda* (Van der H.) (= *Poëphaga*, Owen) is proved by the discovery of the Kangaroo-rat allies:—namely, in the Purbeck beds, of the *Plagiaulax*, the true affinities of which have been so amply demonstrated by Dr. Falconer¶; in the Rhætic bone-bed, of the *Microlestes* of Frome and Diegerloch, closely allied, according to Professor Owen, to *Plagiaulax* (Palæont. p. 303); and, lastly, in the strata below the bone-bed, by the discovery of the *Hypsiprymnopsis Rhæticus* of the Watchet shore. Thus, out of Van der Hoeven's six families, two are amply represented, and have an extended range—the entomophagous and sarcophagous *Dasyurina* from the Purbeck to the Inferior Oolite, and the phytophagous *Macropoda* also from the Purbeck downwards into the Lower Rhætic Marls. At the present day, of the Marsupials but a few species of the Opossums linger in the northern hemisphere, in Mexico, California, and the Southern States; and but one genus (*Didelphys*) is found out of Australasia and the islands to the south-east of the Straits of Macassar. But, on reviewing the past, we see their range rapidly extending. Cuvier's memorable discovery in the Paris Basin extends the area of *Didelphys*, or the most cosmopolitan of the existing Marsupials, to Europe in the Eocene period. And still further back, amid the relics of a fauna and flora similar to those which still inhabit the area now occupied by the Marsupials—amid *Zamiæ* and *Cycadeæ*, Cestracionts, and *Trigoniæ*—the few Mammalian scraps that have escaped the waves indicate the presence in England of members of one-third at least of the existing Marsupial families.

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from that of any animal living or extinct. On the faith of *Pliolophus vulpiceps* of the London Clay being less unlike it than any other, I am unwilling to admit its classification among the Placental herbivores. (See Quart. Journ. Geol. Soc. vol. xiii. p. 4; Owen, Palæont. p. 308.)

* Handbook of Zoology, vol. ii. pp. 612–622, 8vo, 1858. Transl. by Dr. Clarke.

† Owen, Palæont. p. 315.

‡ *Ibid.* p. 313.

§ Owen, Brit. Foss. Mam. pp. 29–60; Palæont. p. 303.

‖ Owen, Brit. Foss. Mam. p. 67; Palæont. p. 306.

¶ Quart. Journ. Geol. Soc. vol. xiii. p. 261; vol. xviii. p. 348.

2. *On the* Geological Structure *of the* Malvern Hills *and adjacent* District. By Harvey B. Holl, M.D., F.G.S.

[The publication of this paper is postponed.]

[Abstract.]

The object of this communication was threefold, namely, (1) to discuss the structure and origin of the crystalline rocks of the Malvern Hills; (2) to give the results of an examination of the superposed Palæozoic strata; (3) to state the chronological relationship of the several events in their geological history.

The geological structure of these hills was described in detail, and it was concluded that the rocks hitherto treated of as syenite, and supposed to form the axis of the range, are in reality of metamorphic origin, consisting of gneiss (both micaceous and hornblendic), mica-schist, hornblende-schist, &c., all invaded by veins of granite and trap-rocks. It was then shown that the Hollybush Sandstone is the equivalent of the Middle Lingula-flags, and that the overlying black shales correspond with the Upper Lingula-beds, the whole being overlain, as in Wales, by Dictyonema-shales. These rocks, on the east of the Herefordshire Beacon, are altered by trap-dykes, which were shown to be of later date than those traversing the crystalline rocks before alluded to. Allusion was next made to the Upper Llandovery strata which overlie unconformably the Primordial rocks just noticed; after which the several faults in the district were described in detail.

Dr. Holl concluded with some remarks on the general relations of the rocks of the Malvern Hills with those of the surrounding districts, describing the successive physical changes supposed to have been consequent upon their deposition and their subsequent elevations and depressions.

June 22, 1864.

T. Currie Gregory, Esq., C.E., 149 West George Street, Glasgow; John Hamilton, Esq., Tyne Court; Edward Langdon, Esq., B.A. (Oxon.), New College, Oxford; and George Paddisen, Esq., M.I.C.E., Petersham, Surrey, were elected Fellows.

M. Bosquet, of Maestricht; M. Jules Desnoyers, of Paris; and Dr. Charles Martins, of Montpellier, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* Fossiliferous Rocks *of* Forfarshire *and their* Contents. By J. Powrie, Esq., F.G.S.

[Plate XX.]

As stated in a former paper *, the lower members of the Forfarshire Old Red Sandstone consist of gritty beds and pebbly conglomerates having a highly indurated matrix, passing upwards into conglomerates

* Quart. Journ. Geol. Soc. vol. xvii. p. 534.

formed of the same kind of pebbles as in the lower, but imbedded in a softer matrix, it being of a consistence similar to that of the intercalated and overlying sandstones. Occupying a position intermediate between the more indurated lower and the softer upper strata are found the flaggy beds which yield the well-known Arbroath paving-stones. These flaggy beds, although rather intercalated than interstratified in the conglomerates, are of great extent and very considerable thickness, especially along and on both sides of the anticlinal line of Forfarshire (its position is pointed out in the paper above referred to); they consist of alternating layers of shales and freestones. The freestones are sometimes thick and solid-bedded, affording an excellent building-stone, sometimes raised in layers thin enough to be generally used as roofing-slates, although of very inferior quality, and sometimes of sufficient thickness to form good, but rather soft, paving-stones. The shales are for the most part argillaceous, generally of a light greenish, occasionally of a pink colour, and are locally known as "caulm." These beds are not only of considerable economic value, but are interesting to the geologist as affording almost the only field in Forfarshire for the labours of the fossil-collector. Generally, organic remains in anything approaching to a good state of preservation are rare, and can only be procured by getting the quarrymen to preserve such things as may, from time to time, turn up. It is, however, different in a deposit at Farnell, where, as mentioned in the same paper, the Rev. Hugh Mitchell first discovered remains of Acanthodian Fishes; also in some localities in the Sidlaws, where Mr. Walter M^cNicol very soon after discovered similar organisms: these deposits are highly fossiliferous. I have lately been able to trace their connexion, and find them to consist of one very extensive and highly fossiliferous Fish-bed, holding an intermediate position among the flaggy beds, continuous and apparently equally extensive with them. This bed is composed of a semicalcareous shale, some bands highly calcareous and semicrystalline, and having many imbedded nodules. A peculiar band of a tenacious light-coloured clay, some 5 or 6 inches in thickness, is very persistent in this shale, and from it the Fish-bed may be readily recognized wherever it crops out. The colour of these calcareous shales varies much: sometimes, as at Farnell, it is of a fine cream-colour, changing to a dirty grey; often it is of a dark rusty brown; but the prevailing colour is a bright deep blue, generally mottled. The thickness varies from 3 to 8 feet. Some of the layers are exceedingly fissile, splitting into laminæ not much thicker than writing-paper. I have now found this Fish-bed in Canterland Den in Kincardineshire, near Farnell, at Turin Hill, in some quarries south of Forfar, in many places in the Sidlaws, in Balruddery Den in Forfarshire, and in Rossie Den in Perthshire. It thus extends over a range of more than twenty miles. The above localities are all to the north of the anticlinal; it has, however, been observed by Mr. M^cNicol in one or two places to the south of it. Wherever this deposit has been discovered, it abounds in Ichthyic and Crustacean remains, the former being far the more abundant.

The most prevalent organisms found in the Forfarshire beds are evidently of vegetable (Algoid?) origin. In only one or two instances have I ever been able to detect in them the slightest trace of structure, and in these rare exceptions the traces are exceedingly indistinct. Burrows and tracks which may have been formed by Annelids are not uncommon; but the only animal-remains, properly so called, belong entirely to the classes Crustacea and Pisces.

CRUSTACEA.

Crustacean remains are very widely and very generally distributed through those beds which may be called the Arbroath pavement-beds, and are found in nearly equal abundance in all. Excepting a very few favoured localities, good specimens are only to be got when the rocks have been largely quarried. As Mr. H. Woodward has at present this class in hand (a task for which his acquirements and opportunities so eminently fit him), I shall here merely indicate the various genera and species which have as yet been found in the Forfarshire rocks.

The following four genera have, up to the present time, been found:—

Campicaris, Page.

The only known species of this curious larva-looking creature is the *Campicaris Forfarensis*, Page; it occurs in Canterland Den in Kincardineshire, and Balruddery Den in Forfarshire.

Pterygotus, Agassiz.

This genus appears to be represented by only one species, *Pterygotus Anglicus*. Fragments of it are, however, much more frequently to be met with than of all the other genera which lived in the waters in which the Forfarshire rocks were deposited. This creature varied much in size; plates in my collection indicate the gigantic length of at least 6 feet, by over 18 inches in breadth, while some moderately complete specimens are barely 6 inches long. Mr. Page's restoration, in his 'Advanced Text-Book,' is the best published, embodying nearly all that is known with certainty of this species. Fragments of *Pterygotus punctatus* have also been found, but this species I understand belongs to the genus *Stylonurus* rather than *Pterygotus*.

Eurypterus, Dekay.

Mr. Walter McNicol discovered a solitary specimen seemingly of *Eurypterus pygmæus*, Salter; and the Rev. H. Brewster obtained from the deposit at Farnell what appears, from the position of the eyes and the narrow telson, to be a new species of this genus.

Stylonurus, Page,

Is represented by the *Stylonurus Powriei*, Page, and by at least one other new species, almost rivalling in size the larger specimens of *Pterygotus Anglicus*.

Besides these, several fragments in my collection indicate other distinct species of *Eurypterus* and *Stylonurus*.

It is worthy of remark that while the genus *Pterygotus*, which is so abundant in the Forfarshire rocks, is represented by the single species *P. Anglicus*, almost every recognizable fragment which has been found of the genera *Stylonurus* and *Eurypterus* evidently belongs to distinct species.

PARKA, Fleming.

Amongst the Crustacean remains I would class that very curious organism, *Parka decipiens*. Some high authorities undoubtedly consider it of vegetable origin; but, so far as my observation goes (and I have had opportunities of examining hundreds of specimens), the amount of evidence in favour of its being the fossilized spawn of Crustacea is, in my opinion, very strong indeed. In many specimens the individual ova, in a highly carbonized state, can be easily detached. These I have frequently examined under moderately high powers, but have always failed in detecting structure. As, however, they are always found wherever remains of Crustacea are preserved, and only where these occur, it seems extremely probable that their origin is the same. Vegetable remains are, as above stated, more abundant than any others in the flagstones and shales. They are, however, mostly confined to certain beds, some of which are quite covered by them. In these beds *Parka* is in plenty, also fragments of *Pterygotus* not uncommon. In the more solid-bedded sandstones and some of the flagstones and shales, vegetable remains are seldom, and in a few scarcely ever, to be met with; from these the best specimens of Crustacea have been obtained, and in these *Parka* is by no means uncommon. In the Fish-bed, vegetable markings are remarkably few; Crustacean remains rather rare, though occasionally fine specimens turn up; and *Parka*, if not abundant, is by no means rare. In short, *Parka decipiens* and Crustacean remains are more widely and equably distributed through these formations than any other organism, excepting perhaps *Cephalaspis Lyelli*.

Again, had the *Parka* been of vegetable origin, the parent Plant must have been rather highly organized; and surely, had this been the case in a formation so well suited for preserving marks of structure, and where the most minute markings on the small Acanthodian Fishes are in a state of the finest preservation (even the membranous fins with rows of very small scales being occasionally beautifully shown), vestiges of a Plant showing structure would ere now have turned up. My workings have now been very extensive, and other labourers in the same field have not been idle, yet our united efforts have never been rewarded by the merest fragment of such a Plant. A specimen of *Parka* figured with a stalk in the last edition of Hugh Miller's 'Old Red Sandstone,' and much more correctly drawn in the valuable Monograph of Crustacea by Messrs. Huxley and Salter, has been adduced as a proof of its vegetable origin. This specimen is now in the collection at Rossie Priory, which, through the kind liberality of the noble owners, Lord and Lady Kinnaird, is open to all interested in such pursuits. I have had many opportunities of examining it, and to me the stalk seems to have no connexion with the egg-packets; indeed, it appears to be on a distinct thin overlying film of stone. It is by no means unlikely, as noticed in the Monograph, that the *Parka* in some cases had been pedunculated, and in this way attached to the parent animal, as specimens are not uncommon showing the eggs spread out on a seeming membrane. At the same time it must be allowed that *Parka decipiens* has never yet been found undoubtedly attached to any of these animals, although frequently in close proximity on the same layer of shale.

PISCES.

Adopting the classification of Professor Huxley in his Introductory Essay to the Tenth Decade of Plates of Organic Remains, published in the Memoirs of the Geological Survey, all the Fish-remains sufficiently entire for identification found in the sandstones and shales of Forfarshire belong to the two families Acanthodidæ and Cephalaspidæ.

Family ACANTHODIDÆ.

Our Forfarshire rocks have now yielded five genera belonging to this family, *Acanthodes, Ischnacanthus, Clematius, Parexus,* and *Euthacanthus.* With the exception of *Acanthodes,* which extends upwards even into Permian rocks, these genera are all peculiar to this formation.

My leisure hours having now for some years been in a great measure devoted to searching for and studying the peculiarities of our Forfarshire fishes, I am necessarily much better acquainted with the characteristics of this family, as exhibited in the comparatively little-known genera belonging to these rocks, than with those found in the upper divisions of the Old Red and still more modern formations. I shall, therefore, in the following remarks, confine myself to the peculiarities of the family as exhibited in these genera. Besides, the genera belonging to the newer formations are mostly well known, and have all been already carefully studied and ably wrought out by much more competent observers.

In the essay referred to, Professor Huxley observes, that although the family Acanthodidæ are generally ranked amongst the Ganoids, several considerations there given lead him to suspect that they may be Elasmobranchs. In many respects their characteristics appear to me to be of an intermediate nature.

Of the dorsal spines he remarks that their form and mode of implantation are similar to those of the Elasmobranchs, but that the implanted portion is less different from the rest of the spine than in that order. It is rare to find spines sufficiently preserved to show the difference; but the better the state of preservation, the more marked the difference becomes. The exposed portion appears to have been strongly coated by a very durable substance resembling enamel, which in the implanted portion had been either wanting or of a more perishable quality; hence the spines, when found, have generally the appearance of being cut sharply across at the point of insertion. The spines are, for the most part, deeply grooved with intermediate bold ridges. The implanted portion is seldom in a sufficient state of preservation to exhibit any markings; I have, however, seen one or two casts showing it distinctly striated, the striæ being much more numerous and much shallower than in the exposed part of the spine. The pectoral spines in all seem to have been articulated with the pectoral arches; in some, as in *Climatius*, these appear to have been completely anchylosed.

The scales also appear to have somewhat of an intermediate character. These in all the Forfarshire genera are small, in some very small, and of a rhomboidal form. Their external surface is smooth and shining, without the slightest trace of sculpturing. This seems to have been the case in all the Devonian *Acanthodidæ* I have examined. In most, this surface is much raised towards the centre of the scale, so that patches of them, especially in some rather imperfectly preserved specimens, have the appearance of shagreen. The inner surface in some species, as in *Acanthodes Mitchelli*, is perfectly smooth and quite similar to the exterior; in others, as in *Euthacanthus McNicoli*, it is sculptured; and in others, again, as in *Climatius reticulatus*, it is both sculptured and tuberculated. The internal structure of the scale is sometimes preserved, but always indistinctly. Considerable misconception as to the true nature of the scales of these Fishes has, in my opinion, arisen from sufficient attention not having been paid to whether the exterior or interior surface of the scale is shown in specimens: this is well exemplified in the descriptions of *Diplacanthus longispinus*, a common species, the scales of which are always said to be sculptured. In this Fish it is generally the inner surface of the scale, or its cast, which is exhibited, but in some few cases the exterior surface is shown. It is quite smooth, and so raised in the centre as to present a mammillated appearance. That the sculptured surface is the interior, the two following reasons will, I think, suffice to prove. First, the sculpture in the scales of *Diplacanthus longispinus* consists of well-marked striæ extending from the anterior margin of the scale to nearly its centre, leaving the posterior half smooth; in scales sculptured externally the sculpture is most marked on the posterior half. Second, in *Diplacanthus longispinus* there is little overlap, but sufficient to show that the smooth portion was overlapped by the striated; in other words, that the overlap was towards the head of the Fish, which could only have been from the interior surface being that shown. In other genera the same peculiarities are found: it is very marked in some of the Forfarshire genera, as will be noticed in describing them. I merely instance *Diplacanthus longispinus* as being well known and having comparatively large scales with well-marked striæ. The object of these sculpturings appears to have been to afford means for the firmer adhesion of their scales to the integument covering the body of the Fish.

With the exception of *Acanthodes Mitchelli*, and in a less degree *Ischnacanthus gracilis*, none of the Forfarshire Acanthodians show ossified cranial bones, and in the exceptions mentioned the traces of ossification are very indistinct.

The branchial apparatus seems in all to have consisted of exposed arches; in some these are numerous and well marked, in others obscure.

None show an opercular bone.

They all appear to have possessed sharp conical teeth; in *Ischnacanthus* they are large, long, and curved.

None seem to have possessed oral appendages.

Acanthodes, Agassiz.

The only species yet found in Forfarshire is the *Acanthodes Mitchelli*, described by Sir Philip Egerton in the Tenth Decade of 'Organic Remains.' All the specimens from which this species was described and figured were from Farnell; some of them had the scales not at all well preserved; and, the external layer having been destroyed, they present under the microscope somewhat of a granular appearance; the artist has thus figured them. Specimens from other localities, with the scales beautifully preserved, have since been obtained, which show that both the outer and inner surfaces were perfectly smooth, exhibiting not the slightest vestige of sculpturing of any kind.

This is by far the most abundant of all the Fishes found in Forfarshire. It seems to have swam in considerable swarms or shoals, numbers gathering together wherever food was to be found. On one small slab, less than 8 inches square, in my possession, covered with scales and other remains of the larger *Euthacanthus*, upwards of two dozen may be counted, attracted evidently by the dead Fish, only to be silted up and entombed with the *Euthacanthus* on which they feasted.

Ischnacanthus, Powrie.

Body slender, fusiform; head long, rather depressed; mouth very large, opening slightly under; teeth long, conical, curved backwards; intermediate teeth sharply pointed, small, conical; fins membranous, each preceded by a long, slender, slightly curved, grooved spine; two dorsals, two pectorals, two ventrals, one anal. Anterior dorsal spine about halfway between the pectorals and ventrals; posterior dorsal longest, slightly behind the anal; pectorals long, articulating with the pectoral bones. Ventrals small, halfway between the pectorals and the anal; anal smaller than, and in advance of, the posterior dorsal. Scales smooth, rhomboidal, very small. Tail elongated, heterocercal.

Ischnacanthus gracilis, Powrie.

Ictinocephalus granulatus, Page.
Diplacanthus gracilis, Egerton.

Sir Philip Egerton describes this species (Tenth Decade of 'Organic Remains'), from a single specimen from Farnell, as belonging to the genus *Diplacanthus*. He there states that the "position and other peculiarities of the spines may hereafter prove of generic value." More perfect specimens, since procured, not only fully bear this out, but also show so many other points widely diverging from those of *Diplacanthus*, that I here venture to remove it altogether from that genus, and to suggest the new generic name *Ischnacanthus* (slender-spine). The above generic description will show that neither the position nor comparative size of the spines in any respect corresponds with those of *Diplacanthus*. The form of the head and that of the body are equally different: in *Diplacanthus* these are compressed laterally, the head short, the body short, stout, and elliptical in shape; in *Ischnacanthus* the body is long, slender, and fusiform; the head long, rather rhomboidal in shape, and somewhat depressed. The scales in all species of *Diplacanthus* appear to have been sculptured on the under surface; in *Ischnacanthus* they are quite smooth on both outer and inner surfaces. The head in *Diplacanthus* is covered by scales similar to, but smaller than, those of the body; in *Ischnacanthus* the indistinctly ossified cranial bones have a coarsely granular covering. In *Diplacanthus* the teeth are described as very small; in *Ischnacanthus* they are very large.

In *Ischnacanthus gracilis* the eye-orbits are large, placed widely apart and nearly centrical in the head. The nasal orifice is large and far forward. The branchial apparatus is obscure, but seems to have consisted of a few exposed arches. The fins appear to have been membranous and covered with very minute scales. One solitary specimen shows a pectoral fin apparently having true rays.

Fragments in my possession indicate another species, shorter and stouter in form, and having larger and very strong teeth, longer and more slender spines, and rather larger scales. This, as yet, wants confirmation.

Next to *Acanthodes Mitchelli*, *Ischnacanthus gracilis* is the most abundant of our Fishes. It is found of all sizes, from little more than 1 inch to over 9 inches in length. It seems to have been the Shark of these olden waters; for while much less strongly protected by defensive armour than most of its congeners, its powerful jaws and long sharp curved teeth eminently fitted it for preying on the other Fishes, while its slender form and large tail and fins must have given it amazing swiftness in pursuit.

The name *Ictinocephalus granulatus* was given by Mr. Page to some jaws, scales, and other fragments from Balruddery, evidently belonging to this species; it is by mistake in the Decade assigned as a synonym to *Climatius scutiger*. It has thus every claim to priority. I have, however, Mr. Page's authority for substituting *Ischnacanthus* as more appropriate and more in keeping with the nomenclature of the Acanthodian Fishes.

Climatius, Agassiz.

Body more or less fusiform; head large, rounded anteriorly, somewhat depressed; tail elongated, heterocercal; fins membranous, covered with very minute scales in parallel rows, each preceded by a spine; spines stout, rather short, conical, curved or straight, serrated longitudinally; intermediate ridges crenulated or smooth; two dorsals, two pectorals, two ventrals, and one anal; two rows of subsidiary or dermal spines between the pectorals and ventrals; anterior dorsal halfway between the pectorals and ventrals; scales rather small, rhomboidal; exterior surface smooth; inner carved, tuberculated, or tuberculated and carved.

Climatius reticulatus, Agassiz.

Head very short and broad; anterior dorsal short, very stout; anterior edge curved; posterior edge nearly straight, all the spines having the ridges crenulated; at least four pairs of dermal spines between the pectorals and ventrals; inner surface of scales tuberculated and sculptured.

This genus and species was so named by Agassiz from a Balruddery spine (anterior dorsal), now in the collection at Rossie Priory. Spines and other fragments of this Fish are by no means rare in the Forfarshire Fish-bed; but good and nearly entire specimens are very scarce indeed, while none have yet been found sufficiently complete to elucidate many of the peculiarities of this genus.

Such specimens as I have procured show a length varying from five to eight inches. The head short, stout, rounded anteriorly, and somewhat depressed. The position of the eye-orbits is obscure; the mouth is situated entirely below the head; the teeth are small, conical, and sharp; the body appears to have been fusiform, and to have increased slightly in thickness from the head backwards to the insertion of the anterior dorsal spine, its depth here being about one-fifth the entire length, thence rapidly to have tapered to the commencement of the tail, which is eminently heterocercal and elongated, having the caudal fin placed entirely below: this organ, indeed, appears to have occupied not much less than one-fourth of the entire length. The spines, as described in the Decade, are stout and short, striated longitudinally with bold rounded ridges, all more or less crenulated. Dividing the Fish longitudinally into five equal parts, the head occupies fully the first fifth: the second fifth terminates nearly in the centre of the broad base of the anterior dorsal spine, which is also placed about midway between the pectorals and ventrals; it is short, very stout, and much inclined backwards; the anterior edge is much curved, the posterior departing but little from a straight line; the grooves and crenate ridges, which are converging, run into one another as they approach its apex. The posterior dorsal spine rises from the commencement of the fourth division; it is much more slender and is longer than the anterior; its anterior margin is perfectly straight, its posterior bulging slightly towards its point of insertion; it is sharply pointed, and, as in the anterior dorsal, the crenate ridges approach and run into one another as they near the apex. The anal spine much resembles the posterior dorsal both in size and markings, but is slightly curved, and does not bulge out towards its base; it is situated rather behind the anterior dorsal. The ventrals, short, stout, and curved, with crenate ridges, are situated not much in advance of the anal. The pectorals are much the longest spines of this species, being nearly equal in thickness to the anterior dorsal, and fully one-third longer; their length is nearly equal to one-fifth of that of the entire Fish; they are also more curved than any of the other spines, and, as remarked by Sir Philip Egerton, the crenate flutings run nearly parallel to the posterior margin, terminating, as the spine narrows, in the anterior margin; they are so firmly attached to the pectoral arches that they appear to be anchylosed rather than articulated with those bones, which are strong, curved, and pointed. As in *Climatius scutiger*, the space between the pectoral and ventral spines is occupied by several pairs of very short, stout dermal spines, having, like all the other spines, crenate ridges. I cannot positively state the number of these, but there appear to have been five pairs. Vestiges of the dorsal, pectoral, and anal fins are preserved in one or other of my specimens; they had evidently been membranous, covered with parallel rows of very minute scales. The scales are proportionally larger than in most of the Forfarshire Acanthodians; they are rhomboidal, and, with the exception of a few rows along the dorsal ridge, which run longitudinally, are arranged in oblique rows across the body, and decrease in size from the shoulder towards the tail. Their outer surface is smooth and shining, and but little raised in the centre: the sculpturing of the inner surface is very peculiar; this surface in each scale is covered by minute tubercles, generally five in number, arranged along the diagonals; each tubercle is distinctly striated, having commonly two or three distinct striæ radiating towards the posterior angle. The head in all my specimens is imperfectly preserved, but appears to be covered by thick, closely set, seemingly hexagonal scales, rather larger than those of the body, having the outer surface coarsely granular, and the inner quite covered by minute sculptured tubercles. The branchial apparatus consists of exposed arches extending from the lower side of the head downwards on the thorax; in only one specimen is this shown, and in it very indistinctly.

Climatius uncinatus, Egerton.

Head broad, short, rounded, depressed; spines with smooth or crenate ridges; anterior dorsal stout, straight, ridges crenate; pectorals slender, curved, toothed posteriorly, ridges crenate. At least five pairs of dermal intermediate spines.

This species is so named by Sir Philip Egerton from its peculiar pectoral spine. On comparing this spine with those figured by Agassiz *, and named *Homacanthus arcuatus*, especially figure 2, and that figured and named by Eichwald *Homacanthus gracilis* †, the resemblance is so marked that I cannot doubt that they also are the pectoral spines of Fishes belonging to this genus. They are, however, described both by Agassiz and Eichwald as having the ridges smooth, while in the *Climatius uncinatus* they are crenate, as is very clearly shown by a specimen in Mr. Mitchell's collection.

This is the rarest of such of our Forfarshire Fishes as have

* 'Vieux Grès Rouge,' pl. xxxiii. figs. 1, 2, 3.
† 'Lethæa Rossica,' pl. lv. fig. 9.

been found in a sufficiently complete state for identification; only four specimens have been obtained, and these are all more or less imperfect.

In size it holds an intermediate place between *Climatius reticulatus* and *C. scutiger*, averaging from three to five inches in length. Its general form resembled that of *C. reticulatus*; the number and position of the true spines are the same in both; the number of dermal spines between the pectorals and ventrals seems greater than in *C. reticulatus*, there being at least five pairs, perhaps six or seven. The spines seem all to have possessed longitudinal striæ with intermediate crenate ridges. The pectoral and anterior dorsal spines depart much from the form of these spines in *C. reticulatus*: the pectorals are longer, more slender, and more bent, and have the posterior margin armed with a row of stout sharp teeth pointing inwards; the anterior dorsal is quite straight, moderately stout, and nearly of the same size as the posterior dorsal, which is quite straight, and proportionally longer than in *C. reticulatus*; it is situated rather in advance of the anal. The anal is also quite straight, and somewhat smaller in size than the posterior dorsal. The ventrals are placed far back, being but little in advance of the anal; they are of medium size, and curved. The scales are somewhat similar to those of *C. reticulatus*, but the sculpturing on the inner surface seems different. The eye-orbits are situated well back and rather high in the head. The branchial arches are exposed and rather under the head.

Climatius scutiger, Egerton.

Head large, rounded, anteriorly depressed; spines ridged, smooth or crenate; three pairs of intermediate dermal spines; scales small, striated, not tuberculate on the inner surface, smooth externally *.

Climatius scutiger very much resembles *C. reticulatus* in form; its principal divergence is in its size, character of the scales, and number of dermal spines. It was found in moderate abundance in the Farnell deposit, and has since been detected in another locality by Mr. Walter McNicol. His specimens show the scales much better than those from Farnell. They are very small, rhomboidal, and smooth on their outer surface; the inner is marked by two or three distinct striæ diverging from the anterior angle. The fins are membranous, and covered by very minute scales arranged in parallel rows. It is right to notice that one of my specimens seems to indicate four pairs of dermal spines; but this is indistinct.

Parexus, Agassiz.

Body short, deep, tapering posteriorly, compressed laterally; head medium size, somewhat ovate, compressed; branchial arches small, exposed; tail large, heterocercal; fins membranous, preceded by stout conical spines, striated longitudinally, ridges crenate or smooth; two dorsals, two pectorals, two ventrals, one anal; anterior dorsal stout, very large-toothed anteriorly, situated immediately behind

* See Tenth Decade of 'Fossil Organic Remains,' where this species is figured and described very fully by Sir P. Egerton from Farnell specimens.

the supra-occipital process; several pairs of intermediate dermal spines between the ventrals and anal.

Parexus incurvus, Agassiz.

Head medium size, compressed; body short, compressed, tapering; tail large, very deep; anterior dorsal straight, longitudinal ridges delicately crenate; other spines with crenate ridges; four pairs of intermediate dermal spines; scales medium-sized, smooth externally, interior surface sculptured.

The spine so named by Agassiz, and described and figured from a Balruddery specimen now in the collection at Rossie Priory *, is evidently the anterior dorsal of this Fish. Specimens are rare; but, when found, are generally moderately entire.

In this species the head is medium-sized and compressed laterally. The eye-orbits occupy a nearly centrical position on each side, and are large. The mouth is indistinct, but seems to have been small, opening rather below. The teeth I have never seen. The branchial arches are exposed, small, and placed immediately behind and rather below the eye-orbits; in a specimen where they are well preserved, they seem to be eight in number. The body is laterally compressed, stout, short, and deepest immediately under the anterior dorsal, the depth being about one-fourth of the entire length of the Fish; thence it rapidly tapers to the tail, which is heterocercal, large, and very broad, the outline both above and below curved outwardly; its length is not much less than one-fourth of that of the entire Fish. The spines consist of two dorsals, two pectorals, two ventrals, and one anal. Four pairs of dermal spines are situated between the pectorals and ventrals. The spines are all striated longitudinally, and have crenate ridges. The anterior dorsal is very long and stout, its length being nearly one-half of that of the entire Fish; it is toothed posteriorly, and, as described by Agassiz, the teeth are rather distant, short, stout, sharp, and point upwards, "arquées en haut." It is situated immediately behind the head, and opposite to the pectorals, and is perfectly straight. The posterior dorsal is situated about halfway between the anterior dorsal and the commencement of the caudal fin, and is quite straight, stout, and about two-fifths of the length of the anterior. The pectorals are attached to the coracoids, or pectoral bones; they are large and much bent, resembling in form those of *Climatius reticulatus*. The ventrals, of medium size, stout, and curved backwards, are placed not much, if at all, in advance of the posterior dorsal. The anal is comparatively small, somewhat curved, and not much behind the ventrals. In none of my specimens are the intermediate spines well preserved; they seem to have been short, stout, and rather curved. The fins are membranous, and covered with small scales arranged in wavy lines; the fin immediately behind the enormous anterior dorsal spine is small, while that succeeding the small posterior dorsal is very large, extending above and beyond the spine. The scales are rather large, and, unlike those of the other genera, are arranged in irregular wavy lines both on the body and

* 'Vieux Grès Rouge,' pl. xxxiii. fig. 27.

fins; their outer surface is not preserved in any of my Fishes, but a specimen belonging to Mr. Mitchell clearly shows that this surface, like that of all the other genera, is smooth and slightly raised in the centre; the inner surface is undoubtedly sculptured, but too indistinctly to admit of correct description. The head is protected by very large strong scales; the scales covering the head of this genus and also of *Climatius* seem rather to have been bony plates than true scales; they are somewhat hexagonal in shape, and appear to me to partake a good deal of the character of the dermal scutes of some of our Reptiles.

The spine figured by Agassiz *, the original of which is also in the collection at Rossie Priory, is considerably curved, and has the longitudinal ridges smooth, differing in these respects from the anterior dorsal of the above-described Fish; it appears to be the anterior dorsal of another and, as yet, unknown species of this genus.

Euthacanthus, Powrie.

Head small, rather compressed, ovate; body rather elongated, slightly compressed laterally; branchial arches numerous, exposed; tail heterocercal; fins membranous, preceded by conical spines; two dorsals, two pectorals, two ventrals, one anal; several pairs of intermediate dermal spines; spines straight, ridged longitudinally; scales minute.

Euthacanthus McNicoli, Powrie.

Posterior dorsal spine rather longer than the anterior, both having smooth, bold, rounded, longitudinal ridges, very large at the anterior margin, small at the posterior; dorsal fins very large; scales very small, smooth externally, inner surface having four or five striæ extending from the anterior margin.

This elegantly formed Fish existed in great numbers in these olden waters. Its remains, consisting generally of detached spines and masses of scales, are frequently to be met with. Good specimens are, however, very scarce, only one complete specimen having as yet been found. It had attained a considerable size; the specimen referred to is seven inches in length; fragments, however, indicate a length of at least eighteen inches.

The head has not been found well preserved; it is small, elliptical, and compressed laterally, and appears to have been covered partly with scales similar to but smaller than those of the body, and partly with hexagonal scales or plates. The eye-orbit is obscure, but appears to have been moderately large, and placed rather back. The branchial apparatus consists of many exposed arches, extending backwards and downwards from the eye-orbit. The body, slightly compressed laterally, gradually increases in depth to the insertion of the anterior dorsal spine; here the depth is about equal to two-ninths of the entire length; from this point it gradually tapers backwards to the commencement of the tail, which is heterocercal, exceedingly graceful in form, and occupies not much less than one-fourth of the

* 'Vieux Grès Rouge,' pl. xxxiii. fig. 26.

entire length. The spines are all straight or very nearly so, hence the generic name (εὐθὺς, straight; ἄκανθα, spine); they are striated longitudinally, having prominent rounded ridges, and in most, perhaps in all, these ridges are perfectly smooth. The anterior dorsal is straight, moderately stout, and placed well back, being about halfway between the snout and the commencement of the tail. The posterior dorsal is in every respect similar to the anterior, but considerably larger; it is equal in length to about one-sixth of the entire Fish, and is placed as much behind the anterior dorsal fin as this is behind the supra-occipital process. The anal is of the same size as, and otherwise similar to, the posterior dorsal, and is placed somewhat further back. The ventral spines, about two-thirds the length of the anal, are placed rather more than their own length in advance of the latter, and are very nearly, if not quite, straight. The pectorals are intermediate in size between the anterior and posterior dorsals, and rather stouter; like the ventrals, they seem to have the slightest possible bend backwards, but so slight as to be scarcely perceptible. The pectorals seem to have articulated with, but to have moved independently of, the coracoids, not being anchylosed as in some of the other genera. Four pairs of subordinate spines, having much the character of the ventrals, but shorter and stouter, and having the ridges perhaps somewhat crenate, are placed between the pectorals and ventrals. The fins are membranous and covered with exceedingly minute scales, arranged in very close, straight rows. The dorsal fins are large, the posterior very large, extending much beyond and above its spine. Portions of the pectorals and anal are preserved, but not enough to show their size. The caudal fin is placed entirely below, and is not large. The scales are very small and rhomboidal; two or three rows, arranged longitudinally, and of rather larger size, extend from the first dorsal backwards to the point of the tail; the others are arranged obliquely across the body. The external surface of the scales is perfectly smooth and shining, very considerably rounded and raised in the centre, and, although in well-preserved specimens the character of this surface seems eminently ganoid, imperfectly preserved patches present so much the appearance of shagreen that, judging from my earlier and less perfectly preserved specimens, I had no doubt that this Fish belonged to the Placoid order. The inner surface is very markedly sculptured; well-defined striæ, from five to six in number, extending from the anterior margin, which is somewhat rounded, to about the centre of the scales. Some specimens show indications of internal structure, but in all this is very indistinct indeed.

I have added, as a specific affix for this Fish, the name of Mr. Walter McNicol, one of its original discoverers, whose industry has largely contributed towards elucidating the nature of the organic remains contained in the Forfarshire Old Red, and to whom I am much indebted for pointing out the position and nature of the bed in which these Ichthyolites are found.

Some of my specimens indicate another species of this genus, the principal difference being in the number and character of the intermediate dermal spines, their ridges in some seeming to be smooth, in others crenate, and some appearing to have more than four pairs of them. No specimens sufficiently perfect have hitherto been obtained to prove this.

Fragments belonging to other distinct species, if not genera, of Acanthodian Fishes occasionally turn up, but as yet these are all very imperfect.

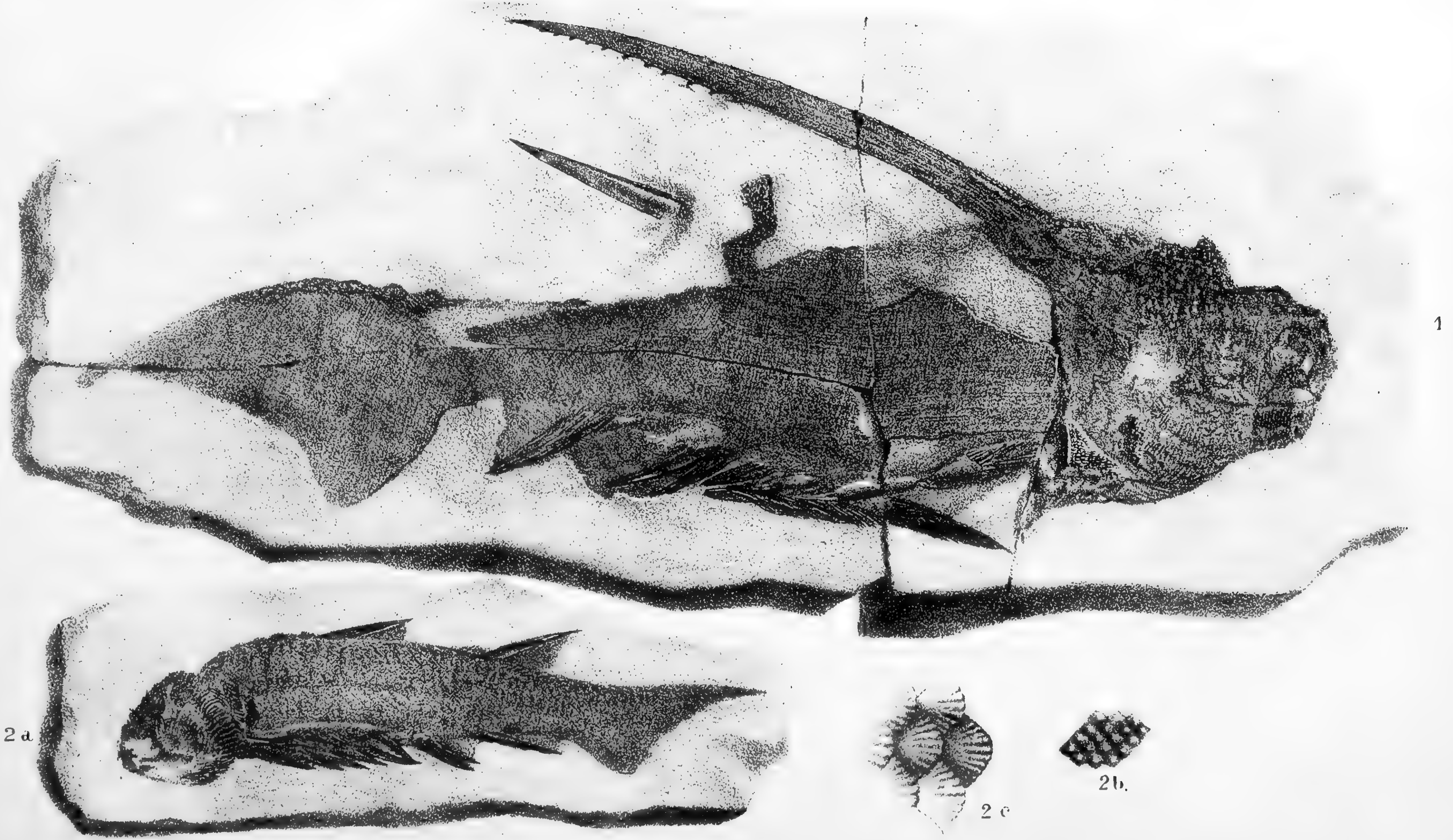
Family CEPHALASPIDÆ.

Of this family the genus *Cephalaspis* is very widely and rather abundantly distributed through all the fossiliferous strata yet examined in Forfarshire. *Pteraspis* has never yet been found in Forfarshire; but, having been detected in sandstones belonging to the same epoch in the neighbouring county of Perth, it may here be classed amongst our Fishes. As, however, I intend, unless some one more competent undertake the task, in a future communication to describe our Forfarshire Cephalaspidæ, I shall here merely remark that the Scottish Old Red Sandstones seem as yet to have yielded only one species of *Cephalaspis*—*C. Lyelli*. Only one species of *Pteraspis* also has as yet been found, which I propose to name *P. Mitchelli*. In the spring of 1861 I procured three tolerably complete heads of this Fish, with several other fragments, from a quarry near Bridge of Allan, in Perthshire. In this quarry the rocks belong to the same geological horizon as the Forfarshire flaggy beds. That this is the case may be readily proved by tracing their stratigraphical connexion, and also from their organic remains. In the same bed in which I discovered *Pteraspis*, I at the same time found a fine head of *Cephalaspis Lyelli*. The Rev. Hugh Mitchell had, considerably prior to this date, procured specimens of this same species also from Perthshire; to him, therefore, belongs the merit of being the first to discover *Pteraspis* in the Scottish Old Red Sandstones; and as it appears to me to be undoubtedly specifically distinct from any known *Pteraspis*, I propose adding the name of its original discoverer as a specific affix.

The intermediate position in the Old Red Sandstone series assigned by the late Hugh Miller to the Forfarshire and other sandstones containing remains of *Cephalaspis*, *Pterygotus Anglicus*, &c., was, until very recently, the classification adopted by our leading geologists; it is that given by Sir Charles Lyell in the last edition of his admirable 'Manual of Geology' (5th edit., 1855). Dr. Slimon's discovery in the Upper Silurian shales of Lanarkshire of Crustacean remains very similar to those of Forfarshire led Mr. Page to adopt the true view of the position of these formations, namely, that they form the lowest members of the Old Red Sandstone series, as exhibited in Scotland (see 'Advanced Text-Book,' chap. xi.; also paper read at the Meeting of the British Association in Glasgow, 1856). This is also the position assigned to the Forfarshire sandstones by Sir R. I. Murchison in 'Siluria' (see 2nd edit. pp. 275–285). The only point in which my observations lead me to differ from the descriptions there so fully and clearly given is that, instead of the Forfarshire beds containing *Cephalaspis Lyelli* immediately succeeding those having *Pterygotus Anglicus* and *Parka decipiens*, these (*Pterygotus, Parka,* and *Cephalaspis*) are always associated in the same beds, and extend through all the fossiliferous rocks of Forfarshire. The Crustacea of the Lanarkshire shales are undoubtedly specifically distinct from those of Forfarshire, but their close affinity clearly indicates near, if not immediate, succession. The same intimate relations of the Ichthyodorulites of the Upper Ludlow bone-bed with those of Forfarshire equally point to the same succession. The *Onchus Murchisoni, O. tenuistriatus,* and similar remains are, in my opinion, undoubtedly spines of Acanthodian Fishes, very similar to, although specifically, if not generically, distinct from, the Acanthodians of Forfarshire.

A connexion similar to that which exists between the Upper Silurian of Lanarkshire, Ludlow, &c., and the lower members of the Old Red Sandstone may be equally distinctly traced between these latter and the overlying beds of Caithness-shire, &c. Indeed, were it not that in no instance has any organism specifically identical yet been found in these beds, one would be inclined to look on them as mere portions of the same continuous series. In their leading features the *Acanthodes, Ischnacanthus, Euthacanthus,* &c. of Forfarshire very much resemble the *Acanthodes, Diplacanthus, Cheiracanthus,* &c. of the newer rocks; but of these the generic characters seem to me so marked as to prove that, with the exception of *Acanthodes,* all the organic remains yet found in these rocks belong to distinct genera. *Acanthodes,* as already noticed, has a very wide range, extending upwards into rocks of the Permian era. The specific distinctions between *A. Mitchelli* of Forfarshire and *A. pusillus, A. Peachii,* &c. have been so clearly pointed out by Sir Philip Egerton that I need only here refer to his descriptions. Wherever the Ichthyolites of Forfarshire are found, *1 terygotus* and its allied genera are also to be found. In none of the Caithness-shire Fish-beds have any of these Crustacea yet been discovered. There is thus a decided blank between the Forfarshire, which may be looked on as the typical lower, and the Caithness-shire or typical middle division of the Old Red Sandstone, making the triple division, in the mean time, at all events, the most convenient, as being the most marked division of this formation. That further research may yet give us the wanting links between these lower divisions I have little doubt; were this accomplished, it might be advisable to restrict these to two great divisions, upper and lower, marked by that want of conformity which has already been traced in most localities where the formation is largely developed and has been carefully wrought out. Each of these divisions, the upper and lower, would again be subdivided; but this is anticipating.

I have little doubt that the overlying unconformable sandstones and conglomerates of Whiteness, near Arbroath, given in Sir Charles Lyell's section (see 'Manual,' 5th edit. p. 48), belong to the upper division of the Old Red Sandstone, of which the Clashbennie red, and Elgin and Dura Den yellow, sandstones may be considered



J.W. Dinkel lith.

M & N Hanhart imp.

typical. As little doubt seems to me to exist that at one time this formation was here largely developed, and extended onwards along the sea-coast continuously, and along the banks of the Tay to where these Upper Red Sandstones are found in the Carse of Gowrie, at Clashbennie, containing characteristic remains; and that the latter have since been removed by denuding agencies. In no case have I detected this unconformable formation *in situ*, except in the localities pointed out by Sir Charles; nor does it appear to exist in any of the inland districts of Forfarshire or Perthshire: along the coast, and especially immediately to the east of Braughty Ferry, large detached boulders, evidently fragments of this upper formation, are, however, abundantly strewed.

The middle or Caithness-shire division has never been found in Forfarshire, nor does it seem ever to have existed in the latter county. Had it ever existed there, and in superposition to the lower rocks, a period of such immensely extended duration would be required for their removal by denudation, before the deposition of the overlying unconformable rocks, as appears to me to be inconsistent with the similarity in character of the Fishes of the middle and upper divisions.

EXPLANATION OF PLATE XX.

Fig. 1. *Parexus incurvus*, Agass.: natural size.
2 *a*. *Euthacanthus McNicoli*, Powrie: one-half the natural size.
2 *b*. —— ——, outer surface of scales: magnified.
2 *c*. —— ——, inner surface of scales: magnified.

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2. *On the* Reptiliferous Rocks *and the* Footprint-bearing Strata *of the* North-east *of* Scotland. By Professor R. Harkness, F.R.S., F.G.S.

Contents.

§ 1. *Introduction.*

Sir Roderick I. Murchison, in his memoir on the Sandstones of Elgin*, has referred to the several geologists whose labours have helped to place these deposits among the Old Red Sandstone series, and he has also described the nature and the arrangement of the strata occurring in the district around Elgin. Since that memoir was published, the discovery of the Crocodilian nature of the *Stagonolepis* found in the sandstones north of Elgin has induced palæontologists, and some geologists, to doubt the Palæozoic age of the

* Quart. Journ. Geol. Soc. vol. xv. p. 421.

beds which yield Reptilian remains in the North-east of Scotland, and to regard them as appertaining to the Trias. This great difference of opinion, involving, to some extent, the value of certain conclusions concerning the general distribution of life in time, and of ideas which have been inculcated with reference to progress in creation, is a matter which the recent discovery of Reptilian footprints in the Tarbetness promontory, Ross-shire, by the Rev. Dr. Campbell and the Rev. J. M. Joass, has again revived, and a careful examination of the Elgin area is naturally called for.

Having on three previous occasions visited this portion of the North-east of Scotland, and knowing many of the localities where exposures of rock occur, and having also, on lithological grounds, formed a somewhat different opinion concerning the arrangement of the strata here, but in matters of detail only, from that held by other geologists, I have been again induced to examine the several areas of the reptiliferous rocks of Elgin, and the strata lying to the south of that district; also the footprint-bearing strata of Tarbetness, and the sedimentary rocks upon which they *conformably* repose.

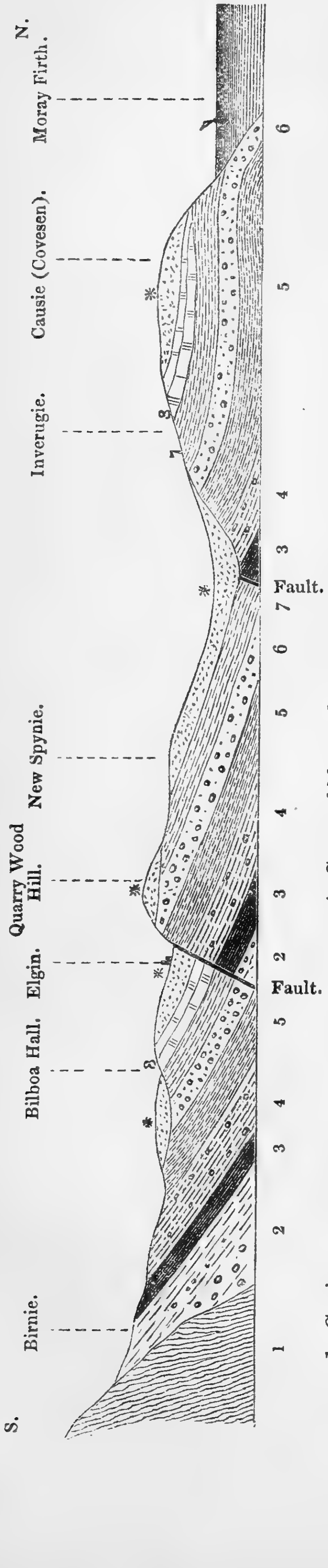
§ 2. *Section south of Elgin.*

To commence with the district south of Elgin, extending from the metamorphic rocks on the south to the Quarry Wood Hill range immediately north of Elgin on the north, a section of which is given by Sir Roderick I. Murchison*. Reposing on the gneissic rocks are conglomerates, having their base made up of subangular fragments of metamorphic rocks, and passing upwards into purplish sandstones, yielding fossils which are similar to the Scat Crag organisms, and which consist principally of scales of *Holoptychius* and the so-called *Bothriolepis.* Grey pebbly beds immediately succeed these strata, and contain the same fossils (see fig. 1.).

In the section of the Shoggle Burn, to the north of the conglomerates, purple sandstones, and pebble-beds, no other rocks are seen, the country being covered by a thick mass of sand and gravel. If, however, we follow the *line of strike* of the exposed strata of Shoggle Burn westward, at the south-east base of Pluscarden Hill occur the rocks which overlie the grey pebble-beds of Shoggle Burn, and which are there masked by débris. On the south-east side of Pluscarden, a little north of the Priory, we see sandstones, cherty in their nature, with pebble-beds which are the equivalents of the higher strata of the Shoggle section. To these succeed light-coloured sandstones, identical with those of Bishops Mill quarries, north of Elgin. The same form of *Holoptychius* occurs also at both localities. About a mile and a half north-east, at Milltown Brae, a conglomerate occurs; and beyond this northwards, until Alves is reached, gravels and sand again cover the rocky strata. Three miles east of Milltown Brae, and about a mile and a half south-west of Elgin, in a wood, a white cherty sandstone, similar to that of Lossiemouth, is seen dipping N.N.W. at 10°, being the direction and angle of dip of the reptili-

* Quart. Journ. Geol. Soc. vol. xv. p. 424.

Fig. 1.—*Section from Birnie to Causie* (10 miles).



1. Gneiss.
2. Red conglomerates and sandstones.
3. Scat Crag Beds.
4. Grey pebbly sandstones.
5. Yellow sandstones with *Holoptychius*.
6. Pebble-beds.
7. Reptiliferous sandstones.
8. Limestone (cornstone).
*. Till.

ferous sandstones of Findrassie, Spynie, and Lossiemouth; it is succeeded conformably by a limestone (cornstone), which is now worked at Bilboa Hall, about half a mile north-east of the quarry in the wood, where the cherty sandstones occur. It continues westwards for a short distance, its western termination being marked by a slight escarpment, beyond which is a flat tract of country from which the limestone has been denuded. Eastwards from Bilboa Hall the limestone forms a low ridge, along which it has been extensively worked at a short distance south of Elgin.

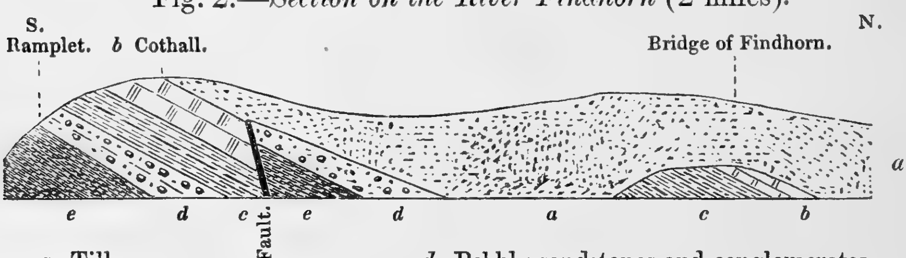
At Glassgreen there is an abandoned quarry, and also at Ashgrove; and the same limestone occurs eastwards at Linkswood, in the cutting of the Elgin and Rothes Railway, resting upon a sandstone like that in the wood just referred to. From Linkswood, as I learn from the Rev. Dr. Gordon, the limestone still continues eastwards to the sea, near the Boar's Head. This band of limestone dips N.N.W. at 10°, and extends under the town of Elgin, where Dr. Gordon informs me it is reached in well-sinking after the sands and gravels are passed through. It was formerly wrought at Pittendricht, a mile and a half west of Elgin, this being the most westerly point where it occurs. Eastwards it is again seen at Sherriff Mill, and also, as is well known, at Linksfield, immediately north-east of Elgin, where the surface of the limestone is beautifully scored by glacial scratchings, and is strewn with sand and striated pebbles, supporting the patch of Lias which occurs here, and which is also covered with sand and transported blocks. At Linkswood, the locality where the cutting in the Elgin and Rothes Railway exposes the sandstone supporting the limestone (cornstone), Dr. Gordon pointed out to me a patch of Lias occurring under precisely identical circumstances with that at Linksfield, which was described many years ago by Captain Brickenden *. The late Mr. Patrick Duff also, in his account of the geology of Moray, points out the contorted forms which the beds of this patch of Lias assume, doubtless the result of pressure from ice-action, while the underlying limestone (cornstone) has a uniform S.S.E. dip at a low angle. These Lias patches, wherever they are seen in the Elgin district, bear no relation to the limestone (cornstone). They have *underneath them glacial drift*, and they owe their present position to Post-tertiary operations.

§ 3. *Section on the Findhorn.*

Westwards from the area just described, in the course of the river Findhorn, good exposures of rock are seen. Portions of the strata on this river are described in detail by Sir R. I. Murchison, from the Metamorphic rocks to the higher limestones which are now worked at Cothall †.

In a matter where the age of certain strata occupying a position superior to sandstones yielding *Holoptychius* is under consideration, it is only necessary to indicate a well-marked horizon, and to trace the sequence from this upwards.

Fig. 2.—*Section on the River Findhorn* (2 miles).



a. Till.
b. Limestone (cornstone).
c. Reptiliferous sandstone.
d. Pebbly sandstones and conglomerates.
e. Yellow sandstones.

South of Cothall, for about a quarter of a mile, a continuous section is exposed either on one or the other side of the river Findhorn, the Ramplet Cliff affording a fine exhibition of some of the strata which underlie the Cothall limestone. The dip is N.N.W. at 10°, being identical with that of the rocks south of Elgin; and here we have an horizon parallel with a well-known position in the section from the Metamorphic rocks northwards to Elgin (see fig. 1).

In the continuous section south of the Cothall limestone, the lowest beds consist of yellow sandstones, yielding the same form of *Holoptychius* as that obtained from the Pluscarden and Bishops

* Quart. Journ. Geol. Soc. vol. vii. p. 289. † *Ibid.* pp. 422, 423.

Mill quarries. To these succeed red sandstones, with pebble-beds and conglomerates, upon which are seen white sandstones with occasional pebbles in them, becoming cherty in their upper layers, and passing conformably under the limestones of Cothall. This sequence of strata agrees perfectly with that already referred to as occurring south of Elgin, and the Cothall limestone is identical in its nature and position with the band which is worked at Bilboa Hall and elsewhere south of Elgin. Between the western limits of these two limestones there has been an immense amount of denudation; but they are on the same line of strike, and are patches of a great band of limestone which once had a very great development west of Elgin. Like the limestone south of Elgin, which extends under the town, the Cothall limestone *has no solid strata succeeding it.*

A short distance below Cothall, on the west side of the Findhorn, a fault is well seen, bringing the limestones against the lower beds of the section. Abutting against the limestones, on their north side, are seen yellowish sandstones containing white quartz pebbles, and greatly false-bedded; and above them are red sandstones. Here the strata are thrown down on their south side by the fault; the sandstone-beds below the limestones occurring on the north side. From this point for some distance down the Findhorn no rocks are exposed; but at the Bridge of the Findhorn the fine white cherty sandstones immediately underlying the limestones (cornstones) become visible, also dipping N.N.W. at 10°, and capped to a slight extent with limestone (cornstone). Evidence of this very distinct fault can be traced E.N.E. It runs along the base of Alves and the Quarry Wood hills, and, stretching onwards to the sea near the Boar's Head, throws the limestones (cornstones) down to the south, and exhibits on its north side the strata below them.

§ 4. *Section north of Elgin.*

Respecting the deposits on the north side of this fault, we have first grey sandstones with pebble-beds, well exposed at Alves, both in the railway-cutting and immediately to the north, on Carden Moor; they have yielded to the labours of Mr. Webster, the station-master at Alves, abundant remains of *Holoptychius* and the so-called *Bothriolepis*. The strata and the fossils here are identical, both in nature and position, with those of Shoggle Burn, which overlie the conglomerates, and they are the representatives of the Scat Crag series. Eastwards from Alves they are succeeded by higher strata. At Newton grey beds with red layers and pebble bands occur, and here *Holoptychius* is the most common fossil. Upon these latter the yellow sandstones of the Quarry Wood range are superimposed, affording also remains of *Holoptychius*; and, as just mentioned, both in lithology and fossils these Quarry Wood sandstones are identical with those at the south-east base of Pluscarden Hill. Here therefore we find ourselves on the same horizon as the yellow sandstones before referred to as forming the base of the section immediately south of Cothall.

About a mile and a half west of Bishops Mill quarries, and on the northern slope of the Quarry Wood Hill, occupying a position immediately above the yellow sandstones, we have, at Laveroch Loch, another quarry of sandstone, which is here somewhat white in colour, and harder in nature than the Bishops Mill rock, having a disposition to assume a cherty condition in its higher beds, while the lower strata have a greater affinity to the soft yellow sandstones of Bishops Mill. Here also fossils occur; *Holoptychius* and *Glyptopomus* having been met with in this quarry, the latter fossil showing an affinity of the deposits here to those of Dura Den in Fifeshire.

About a third of a mile to the west of Laveroch Loch quarry, and nearly on the line of strike of the strata of the last-named locality, but slightly on the rise of them, we have another quarry wrought on the northern slope of the Quarry Wood Hill. This, called the Millstone Quarry, affords white sandstones with conglomerates, the lower beds being red, and the upper strata, as seen on the north side of the quarry, white and cherty. About a mile E.N.E. of the Millstone Quarry, at Mireside, quarries are also seen. The uppermost beds here consist of cherty sandstones, having below them sandstones with pebble-beds, some of which have a reddish hue. The strata are identical with those of the Millstone Quarry, but neither locality, so far as could be ascertained, has as yet furnished fossils.

A quarter of a mile west of Mireside, in Findrassie Wood, there is an old quarry which affords cherty sandstone similar to that of Lossiemouth, and it was from this spot that the remains of the *Stagonolepis* were first obtained. The Hill of Spynie, lying about a mile and a half E.N.E. of Findrassie quarry, also affords a quarry composed of cherty sandstones similar to those of Findrassie and Lossiemouth, and underlain by strata very nearly allied to those seen beneath the cherty sandstones of Mireside quarry. This quarry on Spynie Hill yielded the *Telerpeton Elginense.*

This cherty sandstone, like the sandstone of the same nature south of Elgin, passes conformably under the limestone (cornstone) on the south side of Spynie Loch, and on this limestone (cornstone) the castle, the former residence of the Abbots of Elgin, is placed. Throughout the whole of the strata just described as lying north of the fault before alluded to, there is a continuous N.N.W. dip at 10°, from the grey sandstones with pebble-beds, affording *Holoptychius* and *Bothriolepis*, to the Spynie limestone. The latter rock is only very slightly developed here, having, except the small patch on which Spynie Castle is built, entirely disappeared in consequence of denudation.

The sequence of the strata north of Elgin, through Quarry Wood Hill to Spynie Loch, exhibits a very great affinity to that of the Findhorn section, from the yellow sandstone with scales of *Holoptychius* to the Cothall limestones; and there is every reason for inferring that both these sections are identical in sequence, and also in the position of the strata, the Spynie limestones corresponding with those of Cothall. The beds north of Elgin have yielded a greater variety of fossils than those of the Findhorn; but this is the result of the more extensive quarrying in the former area; for in the latter, with the exception of the limestones, the rocks are almost untouched. The highest bed of the series north of Elgin, like those south of this place, and also those of Cothall, *have no solid rock above them.*

From Spynie Loch, in a W.S.W. direction, no exposures of rock occur, the district being flat; but through it runs a fault, separating the sandstones and limestones (cornstones) of Spynie from those of Lossiemouth, and parallel to that on the south side of the Quarry Wood range above referred to.

As seen in the neighbourhood of Lossiemouth, on the south side of the ridge, the strata (the lowest here exposed) consist of thin-bedded sandstones with interstratified red shales. To these succeed deposits having a great affinity to those which at Spynie quarry underlie the reptiliferous sandstones, and immediately upon these distinctly bedded sandstones is the zone in which the *Stagonolepis Robertsoni* occurs, and upon which there is usually a thin layer of greenish-white clay separating it from the superior white cherty sandstones. Immediately above this clay is found a mass of an arenaceous nature, which is peculiar both in its aspect and composition. The stratification in this arenaceous mass is very imperfectly developed, and it is almost devoid of all traces of lamination. In its mineral nature it consists of a uniform series of cherty sandstones, intersected by well-developed W.N.W. joints, which give to it, when seen from a distance, somewhat the aspect of columnar trap; it forms the valuable building-stone of the district, and, like all compact sandstones devoid of lamination, in Scotland is known to the workmen as "liver-rock." In it concretions of ironstone occur; and although the rocks here attain about a hundred feet in thickness, fossils are extremely rare in them, being confined almost exclusively to the Stagonolepis-zone, beneath which the sandstones are not worked, the lower rocks being valueless.

Besides *Stagonolepis Robertsoni,* which is far from uncommon in the zone below the cherty sandstones, *Hyperodapedon Gordoni,* Huxley, and footprints resembling those from Cummingstone have also been found. Above the cherty sandstones the "hard, thick-bedded cherty and cavernous cornstones" (limestones) alluded to by Sir R. I. Murchison (*op. cit.* p. 428) occur. At Lossiemouth the same dip (N.N.W.), at the same angle as in the country to the south, is seen; here too the limestones (cornstones) *have no solid rock above them.*

§ 5. *Section on the Strike from Burghead to Lossiemouth.*

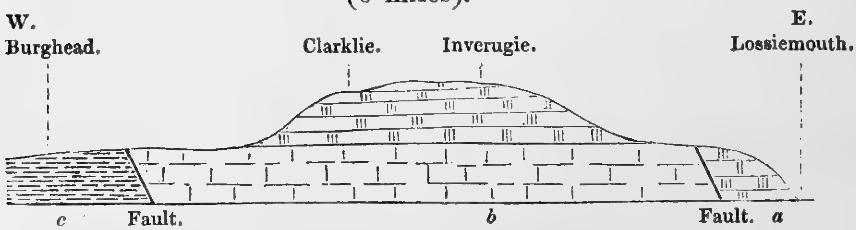
On the shore west of Lossiemouth, at Stoatfield, the limestones (cornstones) are seen abutting against a mass of red sandstone. This arrangement is the result of another fault which has a course nearly north and south. Close to this fault, and on the west side of it, the red sandstones are greatly disturbed; but they soon assume their normal dip, and are seen on the common between Stoatfield and the Greens of Dranie in this position. Still further westwards, from near the Lighthouse at Coosea almost to Burghead, the Lossiemouth sandstones occur, and are extensively worked at Hopetown.

On the coast they form an anticlinal dipping towards the land in a S.S.E. direction, and towards the sea in their usual course *. This dip to the S.S.E., however, soon disappears, and the limestones (cornstones) again make their appearance in the ridge lying south of the coast, extending from Clarklie, near Burghead, eastwards to about half a mile beyond Inverugie, where they are extensively wrought, and have the usual N.N.W. dip. Under them, on their south as well as their north side, the reptiliferous sandstones of Lossiemouth and the footprint-bearing sandstones of Cummingstone occur.

A slight synclinal fold makes its appearance a short distance to the south of the Cummingstone quarries; and on the south side of the Inverugie ridge, in the valley separating this from the Quarry Wood range, runs the fault before alluded to as separating the Spynie rocks from those of Lossiemouth. In the ridge, of which Inverugie forms a part, the limestones are again the highest strata, *no solid rock occurring above them.* (See fig. 1.)

This Inverugie limestone is directly on the line of strike of that of Lossiemouth, and it is, no doubt, a continuation of that band. They are, however, separated by denudation; and it presents, at its eastern end, an escarpment similar to that which marks the western termination of the limestone-area south of Elgin. In its composition the limestone of the Inverugie range is identical with that of Bilboa Hall and Cothall, and is doubtless a continuation of the same stratum. The small patches of limestone (cornstone) at Spynie and Lossiemouth are much less calcareous in their nature than those occurring in the Elgin district. This difference is, however, simply the result of weathering; for the more calcareous limestone has a covering of "Till" upon it, while that of Spynie and Lossiemouth is altogether exposed. At the latter locality the influence of the sea is now exercised upon the limestone, and at a comparatively recent period that of Spynie was also subjected to marine influences.

Fig. 3.—*Section on the Strike from Burghead to Lossiemouth* (9 miles).



a. Limestone (cornstone). *b.* Reptiliferous sandstone. *c.* Pebbly sandstone.

Parallel to the north and south fault alluded to as occurring west of Lossiemouth, and bringing the limestone (cornstone) in contact with the red sandstone, is another fault, seen also on the coast about three-quarters of a mile east of Burghead. Here the cherty sandstones on the east side of the fault come against the pebbly sandstones which are so well developed in the neighbourhood of

* See Sir R. I. Murchison's Memoir, Quart. Journ. Geol. Soc. vol. xv. p. 429.

Burghead. The cherty sandstones on the east side of this latter fault are the Cummingstone and Lossiemouth series, while the pebble-beds on the west side belong to the strata underlying the reptiliferous sandstones, and are, in position, similar to the pebble-beds of Mineside and Millstone Quarries. Of these two faults, the easterly one throws down the strata on its eastern side, and the same effect is caused also by the western fault.

§ 6. *General Conclusions respecting the Strata of the Elgin district.*

The foregoing observations on the several areas where limestones occur in the district around Elgin and in the Findhorn justify the conclusion that, with the exception of the Foths limestone *, which is a local deposit, there is only one limestone in this district. Conformably beneath this limestone there occur cherty sandstones, which are reptiliferous at their base, and which rest *conformably* upon pebble-beds and conglomerates, which pass gradually downwards into whitish sandstones containing *Holoptychius* and *Glyptopomus*. Underneath these whitish sandstones, and agreeing with them in inclination, are the yellow sandstones affording *Holoptychius*, and superposed upon grey and purple sandstones with pebble-beds, which, besides furnishing scales of *Holoptychius*, yield also those of the so-called *Bothriolepis*. These latter strata pass downwards into purplish beds containing the same fossils, and resting upon the coarse conglomerates—the base of the purely sedimentary rocks as they occur in the Elgin district. These circumstances justify a still further conclusion, namely, that all the strata in this locality, from the limestones to the lower conglomerates, are part and parcel of one series of rocks, and that this series is the Old Red Sandstone †.

§ 7. *Section from the Nigg to Cambus-Shandwick, Ross-shire.*

The occurrence of Reptilian footprints in the sandstones of the Tarbetness promontory has recently been made public in a communication to the Geological Society, through Sir R. I. Murchison, by the Rev. Dr. Gordon and the Rev. J. M. Joass ‡.

In this communication the arrangement of the strata occurring along the cliffs between Geanies, about seven miles S.S.W. of Tarbetness, and Portmahomack is described. As this line of coast runs obliquely to the dip of the strata, the thickness of the several deposits is difficult to arrive at; the exposures of rocks along this coast are, however, so abundant that a perfectly correct idea can be obtained of the whole sequence of the strata between these two points. In fact, either in the cliffs or on the shore, from the south of Geanies to Portmahomack, there is one continuous series of rocks exposed, without the least interruption. When examining the line of coast,

* See Sir R. I. Murchison's Memoir, Quart. Journ. Geol. Soc. vol. xv. p. 424.

† In the body of this memoir, allusion has been made to the assistance I have received from the Rev. Dr. Gordon of Birnie. I have still further to add that I am indebted to this gentleman for a knowledge of many of the localities where, in the neighbourhood of Elgin, exposures of rock occur.

‡ Quart. Journ. Geol. Soc. vol. xix. p. 506.

I had the advantage of Mr. Joass's company and knowledge, and was also furnished by him with a copy of the communication to Sir R. I. Murchison on the rocks of this district*.

I have also, since I examined this coast, received from Mr. Joass information concerning the contact between the metamorphic rocks of the Nigg, at the northern entrance into Cromarty Bay, and the sandstones which occur to the north. At their base these sandstones have a conglomeratic nature, being made up, as seen on the beach, of fragments of quartz-rock; and as these sandstones approach the Metamorphic series, they put on an indurated cherty aspect, "passing into a sort of quartzite." This is the appearance of the lower strata as they are seen near Shandwick. These coarse beds are succeeded at Ballintore by yellow thick-bedded sandstones, which, at Hilton of Codboll, are succeeded by grey flaggy sandstones; upon the latter is seen, both on the shore and in the opposite cliff, a band of limestone (cornstone) about nine feet in thickness; to this succeed coarse yellowish sandstones, upon which a thick series of red and yellow sandstones occurs, and passes conformably under the rocks forming the cliffs at Geanies.

The strata, from the Metamorphic rocks immediately south-west of Shandwick, dip continuously, except a small patch on the shore, to the N.W. at 25°; and the series, from the conglomeratic base to the Geanies rocks, must have a vertical thickness of about 1500 feet; and the strata forming this series belong all to the Lower Old Red Sandstone.

The small patch on the shore has an opposite or S.E. inclination; and these reversed dips mark the occurrence near this of an anticlinal axis, which has been alluded to by Sir R. I. Murchison and Professor Sedgwick †.

This anticlinal, which has a north-east and south-west course, runs along the coast nearly parallel to the cliffs from the Nigg to the east of Tarbetness. It rises vertically towards the south-west; and as the area traversed by this axis has been denuded, we have the lower strata of the Old Red formation exposed in a southwesterly direction, while to the north-east the newer portion of that series makes its appearance.

At Geanies, although the rocks are conformable to the beds lying to the south-west, strata of a widely different lithological nature occur. Here, forming bold cliffs, grey flaggy sandstones with intercalated grey strata form the escarpment, and in them fossils are met with. These grey rocks and their organic contents have been alluded to by Sir R. I. Murchison and Professor Sedgwick ‡. Some of the strata here are highly calcareous, as the springs which emanate therefrom abound in carbonate of lime, which appears in the form of Calc-sinter wherever springs are seen in connexion with those grey beds.

The fossils which these strata afford consist of Fish-remains in the

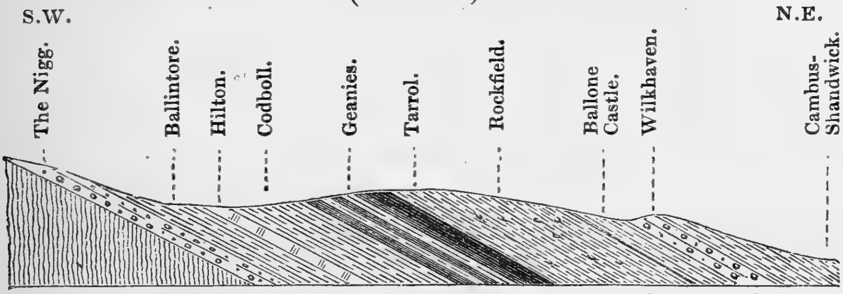
* I also enjoyed the hospitality of W. H. Murray, Esq., of Geanies, whose property is situated in the district, and was thus enabled to examine in detail the rocks of this coast.

† Trans. Geol. Soc. 2nd series, vol. iii. p. 149.

‡ *Ibid.* p. 150.

form of *Osteolepis*, *Coccosteus*, and an Acanthodian. Coprolites and vegetable remains also occur. The grey flaggy sandstones and

Fig. 4.—*Section from the Nigg to Cambus-Shandwick, Ross-shire* (10 miles).



a. Footprint-bearing sandstones.
b. Conglomerates and purple sandstones.
c, f, h. Yellow sandstones.
d. Whitish sandstones with red blotches.
e. Red and yellow sandstones.
g. Thin cornstone.
i. Conglomerates.
k. Gneiss.

shales of Geanies are the equivalents of the Caithness flags, and, like the latter, they contain, in the joints, asphaltum similar to that which has recently been obtained from the Old Red Sandstone at Mount Gerald, near Dingwall*, but not in such great quantities. These equivalents of the Caithness flags, measured from the top of the Lower Old Red series to the point where they disappear under strata referable to the Upper Old Red, have a thickness of about 350 feet, and their dip conforms to the underlying and overlying strata, being towards the N.W. at 25°. At Geanies the anticlinal before alluded to is very distinct, the strata on the cliff having the usual inclination of the land-rocks, while on the shore the beds have a directly opposite dip. Here the rocks forming the anticlinal sink, and consequently newer beds present themselves than those towards the south-west, where, as before stated, the axis rises in vertical position.

About a mile north-north-east of Geanies Hill, at Tarrol, the representatives of the Caithness flags are succeeded by strata appertaining to the higher members of the Old Red formation, and consisting of whitish sandstones with red blotches, which continue along the coast for about a mile and a half, to Rockfield. At Tarrol the anticlinal makes a turn to the east for a short distance, but soon assumes its original course. From Rockfield to Ballone Castle the same rock occurs, and in this interval a slight roll is seen in the rocks on the coast.

A short distance north-north-east of Ballone Castle, the strata on the shore consist of similar sandstones with flexures in them; and about half a mile beyond Ballone Castle, in the cliffs, reddish shales, reposing upon sandstone, and supporting white cherty strata, having the normal north-west dip, are seen. These shales are in some spots greenish white in colour, like those immediately overlying the reptiliferous sandstones of Lossiemouth.

The surfaces of the flags associated with these shales are marked

* Quart. Journ. Geol. Soc. vol. xix. p. 522.

by mud-ripples and tracks, probably those of Crustaceans. Besides these, there are, at regular intervals, a series of linear markings, such as might have been produced by the action of the fins of Fishes striking upon mud; and also the casts of worm-burrows. As these latter occur on the under side of the sandstones resting upon the shale-beds, they are natural casts in relief of the original impressions.

From this point, north-north-east, thick yellow sandstones, similar to those of Bishops Mill quarries, near Elgin, are seen, and they continue until the south-east side of Wilkhaven is reached. These sandstones, I believe, are identical in position with the Bishops Mill strata, and although, so far as I could discover, they have as yet afforded no fossils, I expect that in them the same form of *Holoptychius* as that of Bishops Mill will be found when they have been carefully examined.

The arenaceous strata which succeed the Geanies equivalents of the Caithness flags, as seen in the coast-section, are also oblique to the dip. Allowing for this obliquity, the thickness of this series, from the top of the Geanies grey beds to the strata seen at Wilkhaven, where the sandstones are succeeded by conglomerates, would be about 1800 feet.

The rocks which make their appearance at Wilkhaven consist of purple sandstones and conglomerates, the latter being principally made up of quartz-pebbles. These rocks continue along the coast to Tarbetness, and they have a thickness of about 200 feet. They are the representatives here of the pebble-beds and conglomerates which overlie the Bishops Mill sandstones, and the beds which underlie the white sandstones, beneath the Cothall limestone in the Findhorn section. To these conglomeratic rocks there succeed light-coloured sandstones, with pebbles and occasional red layers, and in them Reptilian footprints have been found. These sandstones continue along the coast south-west of Tarbetness to Cambus-Shandwick, where the highest members of the continuous section from the metamorphic rocks of the Nigg occur. These higher sandstones continue from Cambus-Shandwick to Portmahomack, about a mile southward, the strata affording numerous Reptilian impressions, the beds being usually light in colour and thin-bedded, with occasional red layers. The surfaces of the sandstones are often separated by thin way-bands of red clay, which finds its way into the joints, staining the outside of the arenaceous rocks, while their interior exhibits a light colour.

The impressions which the zeal and energy of the Rev. Mr. Campbell, of Tarbet, have laid bare, consist for the most part of *Ichnolites*, identical with those found in the Cummingstone quarries, the form of the impressions, their size, and also the length of the strides being usually precisely similar.

Besides these footprints, there are others somewhat different; among which is one with a well-marked continuous furrow between the footprints, produced probably by a keel-shaped sternum. The surfaces of the sandstones south-west of Tarbetness, at Cambus-Shandwick and Portmahomack, have other impressions than those produced by the feet of Reptiles. They are marked by such tracks as result from Crustaceans; ripple-marks also are very abundant, likewise shrinkage-cracks, and besides these the imprints of rain-drops are common, all of which circumstances indicate the litoral conditions which prevailed when these sandstones were being deposited. These footprint-bearing sandstones, occupying a position above the purple sandstones and conglomerates of Wilkhaven and Tarbetness, have a thickness of about 400 feet. They represent in Ross-shire the reptiliferous sandstones of the Elgin area; and although there is no direct proof that the footprint-bearing sandstones of Ross-shire are overlain by limestones (cornstones), as in the Elgin district, fragments of such cornstones are seen on the shore both at Wilkhaven and Portmahomack, as alluded to by Dr. Gordon and Mr. Joass *. These fragments of cornstone have in all probability been derived from the north-west, the direction in which the footprint-bearing sandstones uniformly dip in the Tarbetness promontory; and this circumstance justifies the inference that in the Dornoch Firth these sandstones are succeeded by cornstones, as at Lossiemouth, Cummingstone, and elsewhere in the district around Elgin. South-west of Portmahomack sand forms the coast until Inver is reached; and here, on the line of strike of the Portmahomack sandstones, Mr. Joass states that the same arenaceous strata occur.

The continuous section along the Tarbetness promontory, from the Metamorphic rocks of the Nigg to the reptiliferous strata of Portmahomack, exposes throughout the whole line of coast a perfect section of about 3250 feet of deposits without a break or a mask. Here we have the Lower, Middle, and Upper Old Red Sandstones all conformable to each other, and dipping north-west at a uniform angle. In the upper portion of this series of rocks abundant evidence of the existence of reptilian life is seen in the form of footprints, and every circumstance that we find in connexion with these sandstones of Ross-shire and Moray justifies the inference that the Reptilian remains of the North-east of Scotland appertain to the age of the Old Red Sandstone.

My practical knowledge of the rocks on the north side of Dornoch Firth, in the south-east of Sutherland, does not justify me in expressing any definite conclusions concerning that area.

Sir R. I. Murchison, in the memoir previously referred to †, observes that in the neighbourhood of Dornoch there are, well exposed in quarries, light-coloured sandstones with occasional pebble-beds, gently inclining S.S.E.; they have an opposite dip from the strata on the south-east side of Dornoch Firth, which trough under this arm of the sea, and form part of the series exposed in the Tarbetness promontory. The position of these sandstones on the north-west side of the Dornoch Firth has been ascertained by their organic remains; for from them Mr. Peach has obtained scales of *Holoptychius* similar to those from the yellow sandstones of the Elgin district. In the Tarbetness promontory the light-coloured rocks

* Quart. Journ. Geol. Soc. vol. xix. p. 509. † *Ibid.* vol. xv. p. 398.

of Dornoch are doubtless represented by the yellow sandstones which underlie the conglomerates and purple rocks of Wilkhaven.

With reference to the reputed Triassic age of the reptiliferous and footprint-bearing strata of the North-east of Scotland, it has been urged that Liassic rocks are found in close connexion with them. The relation which the Lias of the Elgin area bears to the reptiliferous beds has been previously alluded to. Patches of Lias occur also on the Cromarty and Ross-shire coasts; they have, however, no relation in their arrangement, and have a dip often at right angles to that of the footprint-bearing beds, showing a total discordance between the two series of strata. This discordance in the inclination has been pointed out by Dr. Gordon *. While there is this great difference between the Liassic strata and those of the reptiliferous series, the latter are *constantly and uniformly conformable* to recognized Old Red Sandstone deposits.

§ 8. *Palæontological Evidence of the Reptiliferous Sandstones.*

It must be in the memory of many geologists that, at a period not very far back in the history of the science, it was the received axiom that no air-breathing animal existed anterior to or during the epoch of the deposition of the Carboniferous formation. It was urged that, prior to the growth of the Plants which form the coal-seams, the atmosphere abounded to such an extent in carbonic-acid gas as to render it unfit for the respiration of even Reptiles, and consequently no remains of creatures of this class would be discovered in rocks older than the Magnesian Limestone (Permian) series. The terms *Palæosaurus* and *Protorosaurus* applied to the fossil Reptiles of the Permian rocks are indicative of these remains having been looked upon as evidences of the commencement of Reptilian life on the globe. The discovery, in 1844, of footprints on the surfaces of sandstones belonging to the Carboniferous formation, in America, first militated against this conclusion; and in the same year the discovery of the genus *Archegosaurus* among the ironstone nodules of the Bavarian coal-field entirely upset the conclusions which had been arrived at from purely *negative* evidence. Since the discovery of these Reptilian remains, others have been added, both from the Coal-measures of America and of Great Britain, most of which are referable to the order Labyrinthodontia. Of these Reptilian remains, those from America have been principally discovered by Dr. Dawson, and have been described by him. Of one of these genera of the coal-reptiles of America, namely *Hylonomus*, Dr. Dawson remarks, "the smooth cranial bones, the simple teeth, the long curved ribs, the well-developed limbs, and the cutaneous appendages must absolutely prevent this genus from entering either the order Ganocephala or the order Labyrinthodontia, as defined by Owen †."

Concerning the Reptiles from the British Carboniferous strata, Professor Huxley, in a recent memoir, sums up the evidence which they afford ‡. In this memoir he regards the order Labyrinthodontia as

* Quart. Journ. Geol. Soc. vol. xix. p. 510. † *Ibid.* vol. xix. p. 473.
‡ *Ibid.* vol. xix. p. 473.

made up of "two apparently very distinct types—that of the *Archegosauria* (*Archegosaurus*), at present known to occur only in the Carboniferous rocks, and that of the *Mastodonsauria* (*Mastodonsaurus*, *Labyrinthodon*, *Capitosaurus*, *Trematosaurus*), which seem to have flourished in remarkable abundance during the Triassic epoch." To this latter type Professor Huxley refers the *Anthracosaurus Russelli*, a Reptile recently discovered in the Ardrie coal-field. In this case we have a form of a group of Reptiles highly characteristic of the base of the Mesozoic series passing downwards into the Palæozoic division, and making its appearance in the Coal.

With reference to the Reptiles of the Elgin area, evidence of them was first obtained in the footprints of Cummingstone, by Capt. Brickenden, in 1850; and subsequently Mr. P. Duff, in 1851, was so fortunate as to procure the *Telerpeton Elginense*. The discovery of Footprints and this Reptile, the affinities of which are doubtful, seems in no way to have affected the conclusion that the strata containing them were of the age of the Old Red Sandstone.

In the year 1858 the remains of the *Stagonolepis* came under the notice of Professor Huxley*, who at once perceived their Crocodilian affinities; and then the question arose as to the true age of the beds in which these remains were found, palæontologists referring them to the Trias, while geologists maintained, on stratigraphical grounds, their higher antiquity. It has been assumed that, as the *Stagonolepis* is decidedly Teleosaurian in its affinities, it must consequently mark a Mesozoic group of rocks. But we have already seen that *Mastodonsauria*, which abound in the Trias, occur in the Coal-measures; and stratigraphical evidence shows us that Teleosaurian Crocodiles have a wider geological range, since we meet with them in the Old Red Sandstone.

The principle involved in both cases, namely, in that of the *Anthracosaurus* and in that of the *Stagonolepis*, is the same, the difference being only in degree.

It may be urged that the discovery of the *Hyperodapedon Gordoni* in the reptiliferous sandstones is another proof of the Triassic age of these deposits. This Reptile is referred to the Cryptodont family by Owen; but of this Cryptodont family only one form has been met with in Europe, namely, *Rhynchosaurus articeps* of the Grimsill quarries, near Shrewsbury; the other forms appertaining to South Africa, and occurring in strata the age of which is very uncertain. Until we know more of the diffusion of this family than can be obtained from a single specimen, it requires great caution in assigning to this group a purely Triassic age.

Like many other conclusions which have been drawn from negative evidence, the inference concerning the non-existence of Crocodilian life during the latter portion of the Palæozoic period is very probably one of those which a more perfect examination of strata and a more extensive collection of fossils will ultimately overthrow.

* Quart. Journ. Geol. Soc. vol. xv. p. 440 *et seq.*

3. *On some* Bone- *and* Cave-deposits *of the* Reindeer-period *in the* South *of* France. By John Evans, Esq., F.R.S., F.G.S.

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

[Abstract.]

The deposits to which the author particularly called attention in this paper are those which have been and are still being explored under the direction of MM. Lartet and Christy, and which were visited by him under the guidance of the latter gentleman, and accompanied by Mr. Hamilton, Prof. Rupert Jones, Capt. Galton, Mr. Lubbock, and Mr. Franks.

Mr. Evans first gave a detailed description of the physical features of the valley of the Vézère, and of the contents of the caverns of Badegoule, Le Moustier, La Madeleine, Laugerie-Haute, Laugerie-Basse, the Gorge d'Enfer, and Les Eyzies, with a list of the animal-remains discovered, which are for the most part of the same species from all the caverns.

The author then discussed the antiquity of the deposits according to four methods of inquiry, namely, from geological considerations with regard to the character and position of the caves; from the palæontological evidence of the remains found in them; from the archæological character of the objects of human workmanship; and from a comparison with similar deposits in neighbouring districts in France; and he came to the conclusion that they belonged to a period subsequent to that of the *Elephas primigenius* and *Rhinoceros tichorhinus,* but characterized by the presence of the Reindeer and some other animals now extinct in that part of Europe.

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4. *On the* Carboniferous Rocks *of the* Donetz, *and on the* Granite *and* Granitic Detritus *of the Neighbourhood of* St. Petersburg. By Professor J. Helmersen.

[In a letter to Sir R. I. Murchison, K.C.B., F.R.S., F.G.S., &c.]

[Abstract.]

The Carboniferous Rocks of the Donetz were stated by Professor Helmersen to be much richer than is generally supposed, nearly four hundred beds of coal being known to occur in them, as well as many seams of iron-ore. The true succession of the beds is difficult to determine, as they have been so much disturbed; but it appears almost certain that the limestone containing *Productus giganteus* forms the base of the formation, while that containing *Spirifer Mosquensis* forms the roof, in which case the rocks of the Donetz would be perfectly comparable with those of the western slope of the Oural, where, as Professor Pander has lately discovered, the beds of coal, accompanied by grits, are always found between those two calcareous formations.

The boring for the Artesian well at St. Petersburg, which has been in progress for more than two years, has been perfectly successful. For fourteen days a copious stream of water (more than a cubic

foot per second) rose about 1 foot above the surface, coming from a depth of 525 English feet; its temperature was 52° Fahr.

The following beds were passed through:—

	feet.
1. Alluvium and diluvium (at the depth of 80 feet excellent water rose 2 feet above the surface)	88
2. Greenish clay (Silurian), with *Fucus*	300
3. Fine-grained sandstone, very hard, with some alternations of clay	137
	525

At the depth of 414 feet a second issue of water was met with; it was slightly salt, and more abundant than the first. The third discharge of water, which rose with great force, was reached at the depth of 517 feet. Its quantity and height were augmented when they bored 6 feet deeper. This water proceeds from a bed of gravel, which is the result of degradation of Finland Granite. It was proposed to bore down to the Granite *in situ*, which, as Professor Helmersen believed, would very soon be reached. This would be an interesting geological fact.

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5. *On a* Supposed Deposit *of* Boulder-Clay *in* North Devon.

By George Maw, Esq., F.G.S., F.S.A., F.L.S.

[Abridged.]

A deposit of brown potter's clay, of rather a peculiar character, has for many years been worked near Fremington, a village three miles to the south-west of Barnstaple; and lately, by the sinking of a well to the east of Fremington, a much greater thickness and extent of the deposit have been ascertained than was evident when I first measured and inspected the sections that were exposed, in 1852, in the open clay-pits.

To the south-west of Barnstaple, on the south side of the valley of the Taw, extends a low range of rounded hills of Carboniferous and Devonian shales, beyond which, connecting the valley of the Taw (which here forms a loop to the northward) in a more direct line from the river above to the river below Barnstaple, is another valley at a higher level, the site of the deposit about to be described.

Its base, as far as I have been able to ascertain, consists throughout of a bed of shingly gravel, the top of which is about 35 feet above high-water mark. In appearance it closely resembles the coarser beds of the Severn Valley Drifts, excepting that it is for the most part composed of water-worn fragments of the Carboniferous grits and shales of Devon. It is evidently identical and corresponds in height with the raised beaches of the neighbourhood mentioned by De la Beche in his 'Geology of Cornwall, Devon, and West Somerset,' though he makes no mention of their extension inland for several miles, nor of the great mass of clay that partly overlies them.

Fig. 1.—*Section through the Fremington Clay-deposit, from Mullinger to the River Taw, above Barnstaple.*

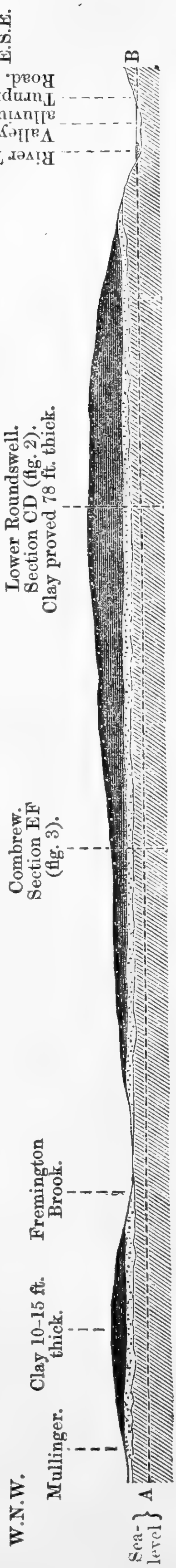


Fig. 2.—*Section through Hele and Lower Roundswell.*

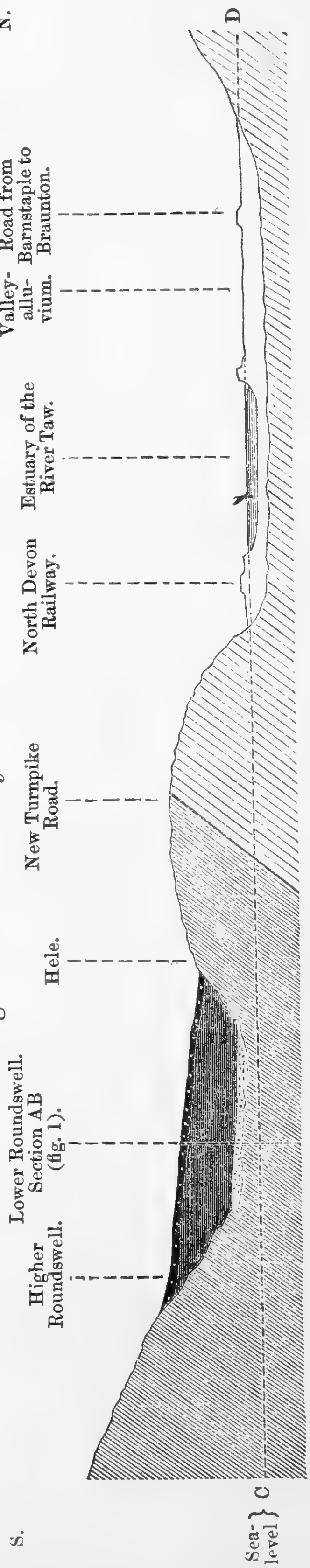
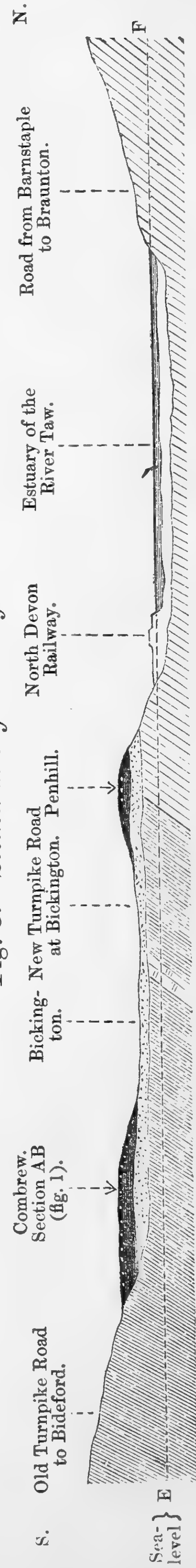
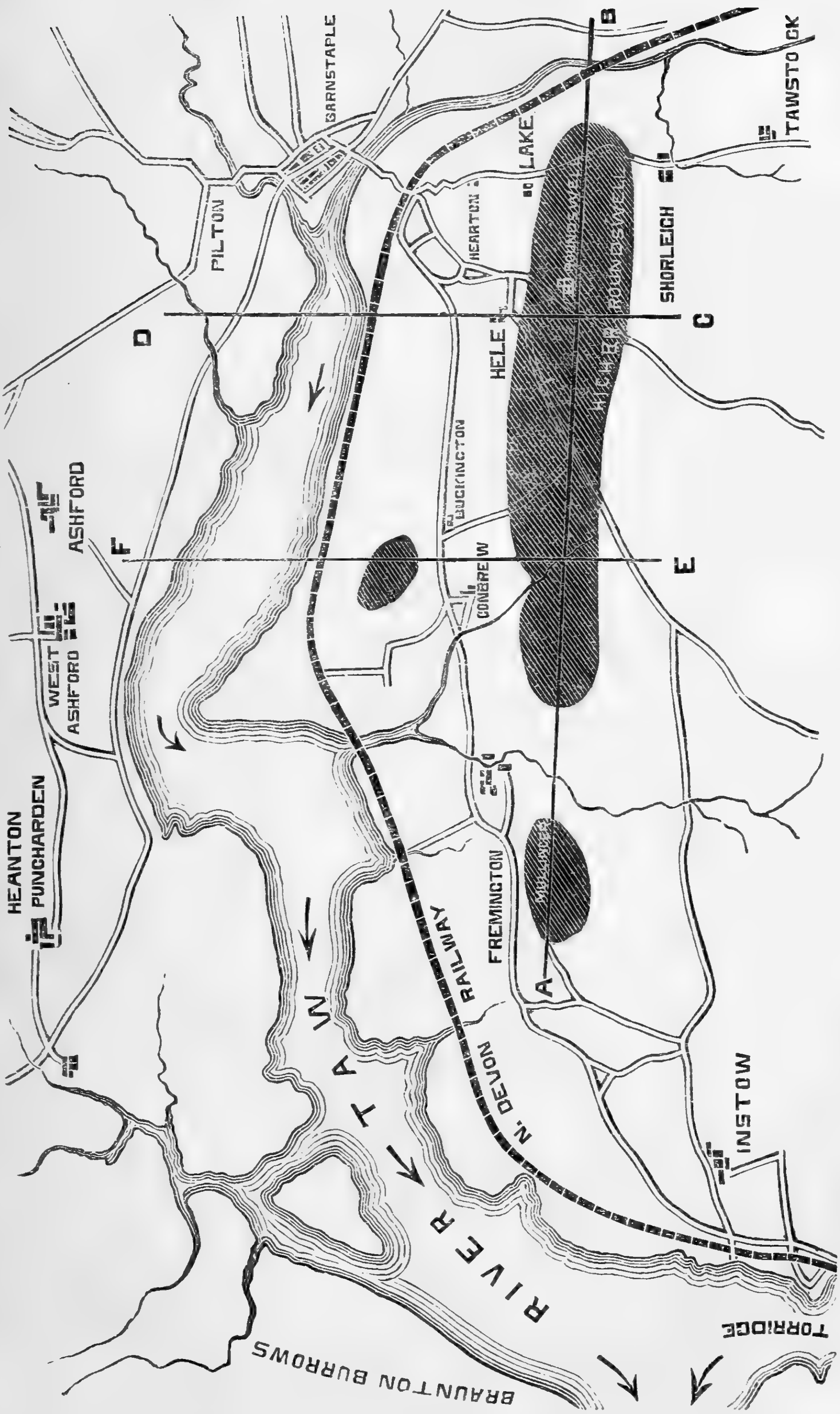


Fig. 3.—*Section through Bickington.*



The capital letters attached to the lines of Sea-level refer to those on the Map (fig. 4) showing the position of the sections. Vertical Scale twice the Horizontal.

Fig. 4.—*Map showing the distribution of the Deposit of Boulder-clay near Barnstaple.*



Boulder-clay. Scale 1 inch to a mile. → Course of the stream.

The gravel-bed is exposed on the banks of the Taw at Fremington, where it forms a low cliff, in the railway-cutting to the west of Fremington Pill and station, by the roadside in the village of Bickington, and in the limestone-quarry at Lake, near Tawstock. From a comparison of these several points, the upper surface of the gravel-bed appears to have a very level disposition; its thickness is from 15 to 20 feet, and it rests on the Devonian and Carboniferous shales. A raised beach on the coast to the south-west of Northam Burrows, on the south side of Barnstaple Bay, appears also identical with it in character. But all these shingle-beaches differ, in aspect and apparent age, from the curious raised beach of concreted sand near Croyd, on the north side of the bay, which appears to be a more recent formation. The Fremington gravel-bed underlying the clay rests on a fundamental rock from 15 to 20 feet above high-water mark, which would be from 40 to 50 feet higher than the fundamental rock of the present Taw-valley alluvium.

The clay-bed composing the bulk of the formation extends as an oblong patch, three and a half miles in length by about half a mile wide, from the village of Lake on the east, nearly to Mullinger on the west, and is severed in two, a little to the south of Fremington, by a small stream which appears to have assisted in its denudation. A small outlier, which was some time ago worked for pottery purposes, also occurs between Penhill and Bickington, to the north of the Barnstaple and Bideford new turnpike-road.

At the western extremity of the deposit, where the clay has been extensively worked, it is from 16 to 22 feet thick, from which it gradually thickens to Roundswell, where it appears to attain its greatest thickness of 80 to 90 feet; and from this place towards the eastern extremity of the deposit, north of the village of Lake, the ground gradually falls, and the clay therefore declines to a thickness of from 25 to 30 feet.

The surface of the clay, in addition to sloping up from the eastern and western extremities of the deposit, towards Roundswell, also has a very regular slope upwards of about 1 in 45, from north to south, gradually increasing in thickness until it terminates against the higher ground of Carboniferous shales below Shorleigh, Rookbeer, and Lydcot. The regular slope of the deposit upwards from south to north can be well observed on the Forrington turnpike-road at Roundswell, and also on the Bideford old turnpike-road, near Brinsworthy, about a mile and a half from Barnstaple.

At Roundswell, between Fremington and Tawstock, at a height of about 100 feet above the sea, a well was sunk in 1862 by Mr. J. Bowden through a thickness of 78 feet of the clay, at which depth he came to a gravelly beach, similar to that observed at Fremington, with which it would about correspond in level. To the southward of Mr. Bowden's house the ground rises considerably, which would imply a thickness of clay near Higher Roundswell of at least 90 feet; and here the ground is from 115 feet to 120 feet above the sea-level.

The whole of the 78 feet penetrated by Mr. Bowden (excepting the upper 10 or 12 feet) was through a bed of perfectly homogeneous brown clay, exceedingly tough, free from the slightest grit, and as smooth and soft as butter. The upper 12 feet was somewhat intermixed with stones, the number of which decreased from the surface; and in the remaining 66 feet, I was assured by Mr. Bowden that not the least particle of stone, pebble, or sand was observed, the whole mass consisting of an uninterrupted bed of perfectly homogeneous clay, excepting that at a depth of about 40 feet some blackened pieces of driftwood were found imbedded in it.

A few months ago Sir Boucher Wrey, of Tawstock Park, caused two pits to be sunk further to the east, above the village of Lake, and ascertained the existence of similar clay to a thickness of 25 or 30 feet, resting on shingly gravel. The form of the ground and depth of the gravel-bed at this spot would imply a correspondence of its level with that at Fremington and the other points where it has been observed.

The clay that has been dug for many years at Fremington for the manufacture of pottery is similar in character to that at Roundswell and Lake. In its extreme smoothness and fineness of texture it notably differs from the Boulder-clay of Shropshire, which is mixed up confusedly with beds of sand and silt.

In the hamlet of Combrew (marked "Combworthy" on the Ordnance Map) is a large boulder of basaltic Trap, $3\frac{1}{2} \times 2\frac{1}{2}$ feet, weighing many hundredweights, which Mr. E. B. Fishley, of the Fremington Pottery, informed me was found in the middle of the adjacent clay-bed, ten feet from the surface, and unaccompanied by any smaller masses. The whole surface of the clay is covered over with clayey gravel, from 5 to 7 feet thick, containing stones and occasionally large masses of amygdaloid Trap-ash (one of which is to be seen in the yard of Mr. Fishley's pottery). This superficial gravel is, I believe, independent of the clay, and coeval with its erosion. The boulders of Trap-ash, and other large stones, in the superposed gravel may, however, have been derived from the eroded clay, and left after its denudation on the surface of what remained. The stones found in the upper 12 feet of Mr. Bowden's sinking probably belonged to it, and got commingled with the top of the clay at the time of its denudation, so that the large mass of Trap at Combrew is the only authenticated example of a boulder occurring *in the clay*.

As the valley forming the site of the deposit is in a rather more direct line between the river Taw above and below Barnstaple than the present river-bed, I have thought that the deposit may represent the ancient course of the river; but the great height to which it extends above the river- and sea-level (110 to 120 feet), and the superior height of the fundamental rock (from 40 to 50 feet) to that of the present river-bed, would represent a great extension of the sea for miles inland, unless the present contour and system of valleys had been entirely remodelled since the formation of the deposit. The alluvial mud of the present Taw valley is, moreover, of a very different character from the Fremington clay. It contains a large proportion of sand, also *Hydrobia ulvæ* and *H. ventrosa*, brackish-water Shells which do not occur in the clay.

I am therefore of opinion that the existing bed of clay is merely the remnant of a once more extensive deposit, not limited to the present, or formerly existing, river-valley, its irregular thickness having been produced by denudation,—a supposition which appears supported by the fact of the superficial gravel following its varying outline.

I failed to detect any Shells or other organic remains in the gravel-bed at the Fremington railway-cutting or elsewhere, and the men who have been in the habit of digging and working the clay assured me that they had never noticed any Shells in it.

The neighbouring raised beach at Croyd, at the north side of Barnstaple Bay, described in papers read before the Society in 1836 by Messrs. Sedgwick and Murchison, and the Rev. D. Williams, is distinct in character from the Fremington raised shingle-beds, and would, from the following facts, appear to be of more recent formation.

1. Both it and the Raised Beach at Hope's Nose, near Torquay, which it somewhat resembles, are composed of hard laminated beds of concreted sand, interstratified with layers of pebbles and Shells, including *Ostrea, Cardium, Balanus, Patella*, &c., none of which have a more northern character than those of the neighbouring seas.

2. Similar sandy concretion is still going on in several places on Braunton Burrows, where I have found isolated slabs, *in situ* amongst the loose sand, quite as hard and compact as the layers of the neighbouring Croyd Beach.

3. The Fremington Raised Beaches described by Sir Henry De la Beche, and the corresponding bed of loose shingle, forming the base of the clay-deposit, are entirely different in aspect from the Croyd beach, and also contrast with it and the Hope's Nose beach in being devoid of Shells, a feature which, although of a negative character, is common to much of the glacial drift.

4. In Mr. Williams's paper "On the Croyd Raised Beach" he describes the occurrence of a large block of supposed Cumberland granite imbedded in the beach at its very base, resting directly on the fundamental slate-rock. As its exposed portion is 6 feet long and 3 feet deep, it must weigh several tons, and would appear to be a true erratic block.

The position of the erratic blocks in relation to the two deposits would favour the probability of a distinct period of deposition, and of the Fremington beds being the more ancient.

At Fremington the blocks occur either within a few feet of the top of the clay-bed or in the superficial gravel, whereas the Croyd Bay boulder had been evidently resting on the slate-rock before the raised beach of concreted sand had begun to be deposited over it, with which it would have no necessary connexion.

If the boulders of the two localities were of contemporary deposition, the Croyd Beach must have been formed subsequently to the Fremington shingle-beds, and separated by at least the interval in which most, if not all, of the Fremington clay-bed was deposited.

In Messrs. Pengelly and Heer's paper on the Bovey Tracey Lignite deposit, read before the Royal Society in 1862, *Betula nana*, *Salix cinerea*, and other Alpine *Salices* indigenous to a much colder temperature than the present climate of Devonshire, are stated to have been found at the bottom of the drift covering Bovey Chase, implying the probability of its deposition during some part of the Glacial epoch. I notice the fact as suggesting the possibility of the shell-less shingle of Fremington, and its overlying clay, being alike referable to it. If the Fremington clay is a representative of the boulder-clay formation, the scarcity of boulders in it becomes an interesting fact, as being correlative with the comparative absence of erratic blocks throughout Devonshire, and would lessen its importance as implying the non-submergence of this part of the country during the Glacial period.

In connexion with this subject, I would notice the occurrence at Petroclistow, near the centre of the county, of an isolated bed of gravel, composed almost entirely of the detritus of Dartmoor Granite, twelve miles from the nearest granite *in situ*.

From its situation, it is impossible that it can be a mere alluvial deposit brought down from Dartmoor by any existing or ancient river-valley. I have carefully examined the country between Dartmoor and Petroclistow, and could not find a trace of the deposit in any of the intervening valleys, the alluvium of which is of a different character, being composed of the detritus of the adjacent Carboniferous beds.

The Oakment is the only river that runs from south to north, or that could have brought detritus from the direction of Dartmoor; but the form of the ground denies the possibility of its ever having flowed over the site of the Petroclistow gravel-bed, situated in an independent close valley, the drainage of which falls into the valley of the Torridge; and it is also separated from Dartmoor by unconnected valleys and several high parallel ridges of early formations, running at right angles to it. It therefore seems probable that the deposit of gravel can only be accounted for by an amount of submergence covering the whole of these ridges, and that since its deposition a great amount of denudation must have taken place to remove all trace of the trail or connecting link between it and Dartmoor, the evident source of its derivation. The granite-gravel of the Petroclistow valley closely resembles that covering the Bovey Tracy deposit, which, as before noticed, is possibly assignable to the Glacial epoch.

I refer to these facts in connexion with the Fremington deposit, from the probability of their all bearing on the question of the submergence of Devonshire during the Glacial period, and as being worthy of fuller investigation by those who may have opportunities of comparing them with glacial deposits in other parts of the country.

6. *On the* Former Existence *of* Glaciers *in the* High Grounds *of the* South *of* Scotland. By John Young, M.D., F.R.S.E., of the Geological Survey of Great Britain.

[Communicated by Archibald Geikie, Esq., F.G.S.]

The heights bordering the counties of Peebles and Dumfries contain the well-preserved remains of a group of Glaciers, to one of which Mr. Chambers published, in 1855, a brief allusion*. In the autumn of 1862 Mr. Geikie and myself found moraines in several of the valleys of this district, and the description of them given by my colleague in his paper on "The Phenomena of the Glacial Drift in Scotland" is the first published account of Glaciers occurring south of the Clyde †. Last summer the investigation of this district by the Geological Survey began: I had the advantage for a short time of Mr. Geikie's advice and assistance, and am further indebted to him for the Sketch in Talla Valley (fig. 3), as well as for much of the details regarding Loch Skene and Mid Law Den, of which he prepared, in 1862, the Map accompanying this paper (fig. 2).

The Tweed and Yarrow flowing northwards, and the Annan and Moffat waters flowing south, rise on opposite sides of a watershed, of which Hartfell and Whitecoomb are the highest points. The two former rivers meet near Selkirk, the two latter converge below the town of Moffat, 8 and 12 miles respectively from their sources. The country included between these river-valleys forms the highest range in the Silurian tract of the South of Scotland. The Broad Law, 2754 ft., is the centre of a ridge, of which Dollar Law, 2680, Cramalt Craig, 2723, Dun Law, 2584, are the chief minor summits. A valley curves across the chain from Tweed to Yarrow, its highest point at the watershed between Talla and Megget being about 1440 ft.: the Broad Law is thus separated from another mass of hills whose heights are, Whitecoomb 2695, Loch Craig 2625, Frithy Brig Head 2616, Moll's Cleuch Dod 2571, and Great Hill 2540. A second depression between the tributaries of Tweed and Moffat water separates this group from a mass culminating in Hartfell, 2650 ft. The extent of country, over 2500 ft. above the sea, represented by these heights is very considerable, for the hills are mostly broad low-backed ridges with long gentle slopes: none are peaked. Hence, as seen from the top of the Broad Law, they appear to form an elevated table-land from which the bosses just named project like roches moutonnées. Armstrong justly remarks that a race-course of more than two miles could be easily made on the summit of the Broad Law.

This wide plateau and these long slopes would under other climatal conditions form an extensive snow-field whence glaciers might descend into the valleys beneath. The presence of moraines in twelve valleys demonstrates the former existence of these conditions; while the occurrence of boulder-clay in every respect comparable with that of the low country, either filling up valleys

* Edin. New Phil. Journal, New Series, vol. ii. p. 184.

† Transactions of Geological Society of Glasgow, vol. i. part 2. Glasgow, 1863.

parallel to, or entering those once the seats of glaciers, or lying high up on the sides of these latter, speaks of an earlier glaciation whose resulting deposits have in places been partially removed by the later ice-streams.

The above grouping of the hill-masses, though now somewhat artificial, is for the distributions of the ice-streams perfectly natural. Thus:—

1. From the Broad Law Range glaciers descended into the valleys of—On the north side, Manor and Polmood.
   On the south side, Cramalt, Linghope, and Wylie's Cleuch.
2. From the White Coomb Range glaciers descended into—
   Northwards, Talla.
   Westwards, Gameshope and Donald's Cleuch.
   North-east, Loch Skene, Mid Law Den, and Garlie Burn.
3. From Hartfell a glacier descended into—
   Westwards, Fruid.

They may be further classified as social and solitary, to borrow terms from zoology, thus:—

Social—

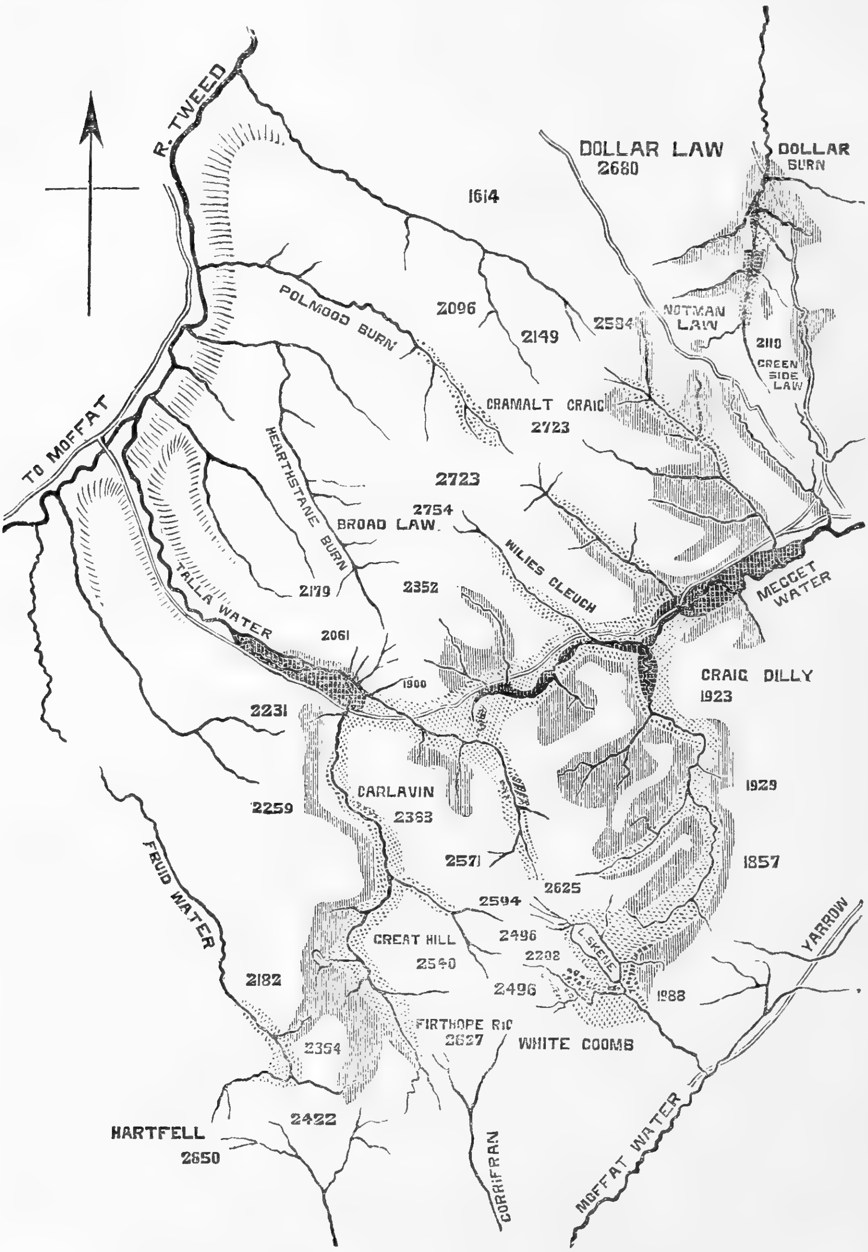
1. Gameshope glacier	united in Gameshope	join in lower Talla Valley.	
2. Donald's Cleuch glacier			
3. Talla bifurcates	left branch		
	right branch	join in Upper Megget	join in Lower Megget.
4. Wylie's Cleuch glacier			
5. Garlie glacier		join in Winterhope	
6. Skene glacier bifurcates	left branch		
	right branch	join at Tail Burn.	
7. Mid Law			
8. Linghope	from common watershed.		
9. Polmood			

Solitary—

10. Manor.
11. Cramalt.
12. Fruid.

The ridge whose terminal heights are Firthy Brig Head and Firthope Rig overlooks a shelf or terrace of grit, which is closed to the south by White Coomb, passes northwards between Loch Craig and Firthy Brig Head into Talla Valley, and to the east dips into Mid Law Den and Loch Skene by a steep rocky face, divided by, and prolonged on either side of, Mid Craig—a spur running eastwards from the centre of the terrace. At the head of Mid Law Den, the declivity, whose smoothed rock-surfaces show at one place striations running down-hill, ends in a swampy plain stretching from the grassy slopes of Mid Craig to the black cliffs of White Coomb. The plain is closed in front by a semicircular ridge of rubbish about 40 ft. in height, pierced near its centre by the burn, one extremity resting on White Coomb, the other lost among mounds covering the flank of Mid Craig. It is a beautifully perfect terminal moraine consisting of the usual materials, namely, angular gravel, drab clay-sand, and loose blocks, the latter mostly resting on the surface. The heaps into which it passes are limited above by a ridge de-

Fig. 1.—*Sketch-map of the Glacier-valleys of Peeblesshire.*

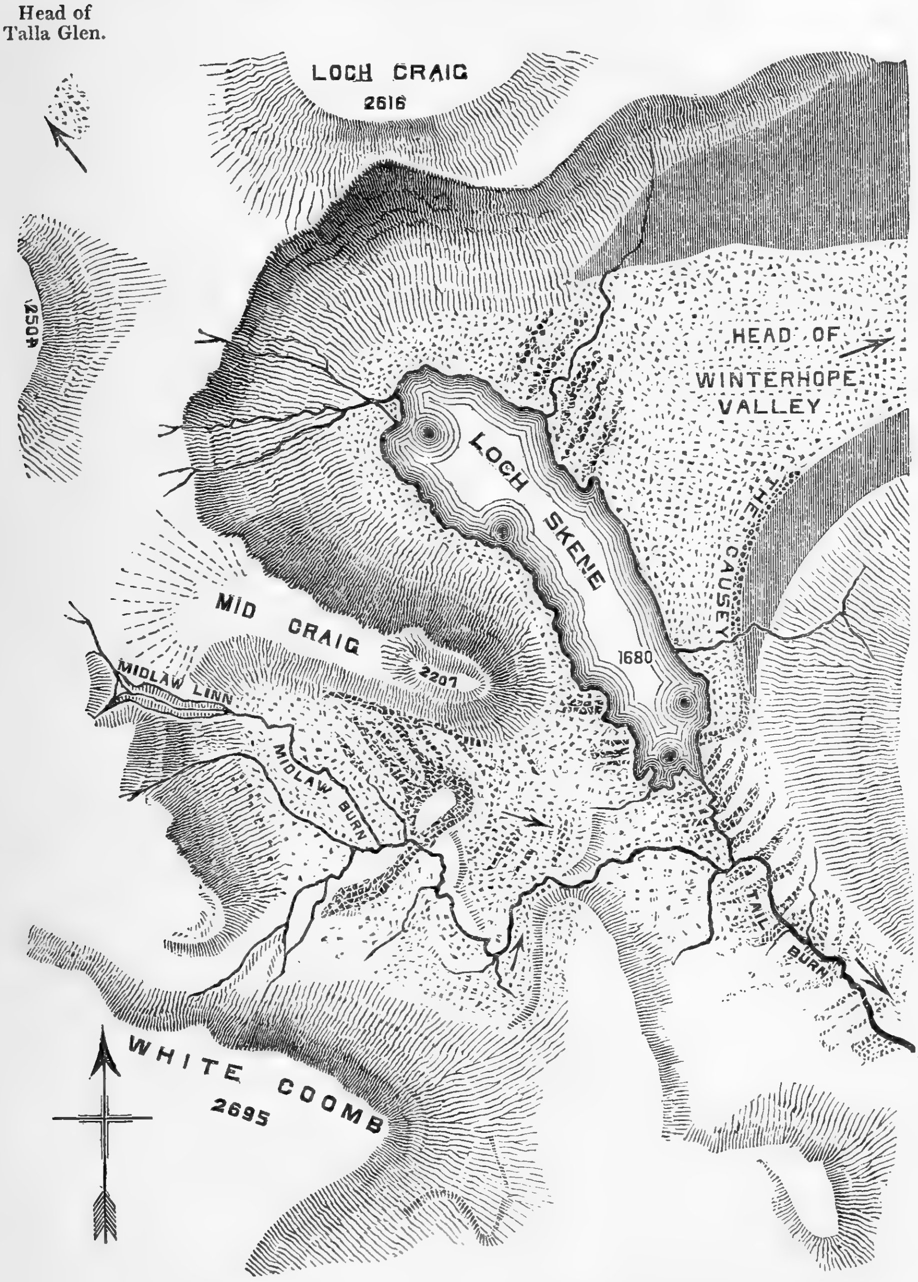


Boulder-clay.

Moraines and Detritus.

Alluvium.

Fig. 2.—*Map of the Glacier-moraines of Loch Skene**.



Moraine-matter: the darker bands show the position of the ridges of the moraines.

Boulder-clay.

The arrows indicate the direction in which the Glaciers moved; the figures the heights above the sea.

* By Archibald Geikie, Esq., F.G.S.

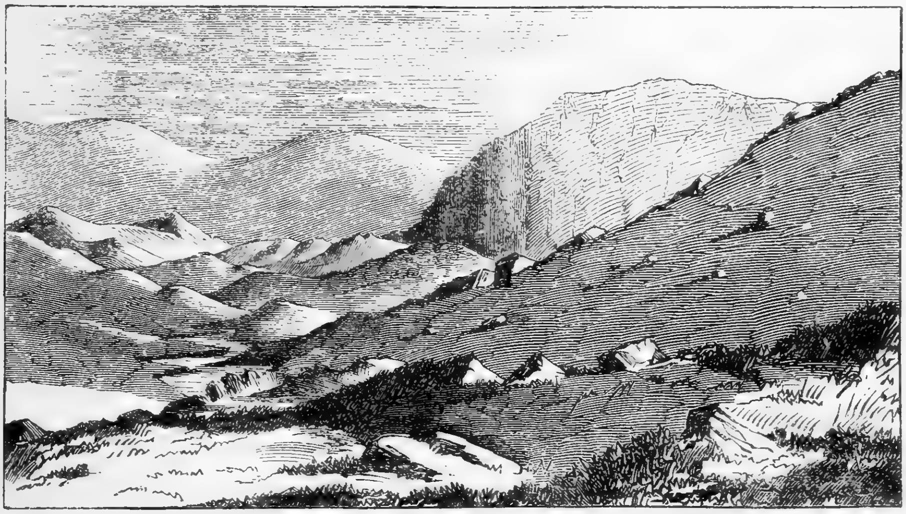
scending slightly towards the mouth of the Glen, and separated from the hill by a hollow gradually deepening eastwards. This, the lateral moraine of the glacier, terminates at the end of the hill. Beneath it, across the valley external to the terminal moraine, and away eastwards towards Loch Skene, is a sea of mounds, showing no trace of order, their surface strewn with large blocks, one of which contains over 1200 cubic feet: the depth from the grits exposed in the burn to the summit of the mound is nearly 90 feet.

Loch Skene lies about 200 feet lower than the plain of Mid Law. It is open to the east and south-east. Mounds of detritus lie below the smoothed but nowhere striated declivity at its head, and skirt the loch on either side, while beneath the water, whose depth is unknown, appear the ruins of heaps which near the outflow project their tops above the surface. The stream cuts through a series of mounds arranged in concentric curves pointing down in the axis of the lower half of the loch. Their extremities are lost among the heaps descending from Mid Law, and those on the hill-side to the left. Nearly a dozen may be counted; after that, the heaps are irregularly disposed, and descend towards the waterfall of the Grey Mare's Tail. The loch has two axes: that of the lower half is S.S.E.; that of the upper is S.E., pointing towards the top of Watch Knowe. On the foot of this slope, 70 feet above the level of the loch, is a long ridge called the Causey, which follows the curve of the hill, one end being lost among the mounds of the Tail Burn, the other sinking under the peat-moss at the head of Winterhope, on the east side of the loch. This ridge is at once a frontal and lateral moraine. The glacier seems to have divided against the slope, one branch passing south to the waterfall, the other east towards Winterhope. Between this and Loch Craig the hollow is filled with moraine-matter buried under a deep peat-moss: but, whereas the Causey is 70 feet above the water's edge, detritus is found to a height of nearly 200 feet on the slope east of the cliffs of Loch Craig. Thus the loch is dammed in on the south and east by moraine-matter, probably entirely so, the first exposure of rock in either burn being at some distance below the level of outflow. I cannot say precisely how far to the south-west moraine-matter extends, as the ground lying in the county of Dumfries has not yet been mapped in detail; probably, however, it does not extend far beyond the limits assigned to it on the present Map (fig. 2).

Following the course of Winterhope Burn, the floor of the glen is covered with detritus of varying depth and irregular surface, which dies off on either side upon slopes of Boulder-clay. The Garlie Burn joins it at the commencement of a wider portion of the valley, and here, the right bank being steep and surmounted by nearly vertical grit-faces, a few mounds of the characteristic detritus appear. The Garlie seems to have lodged a small glacier, the stream flowing through a thin sheet of detritus, which at the foot on the left side forms an obscure lateral moraine. In the main valley the detritus is now confined to the right side of the stream, a few mounds appearing here and there; the left bank is a long slope of thick Boulder-clay. About a quarter of a mile below the house, the detritus again crosses the stream, and throughout the rest of its course, until it joins Megget, covers both banks, shrinking very much, however, at the base of Dead-for-Cauld, whose coomb-like crags form a recess in which lies a thick mass of Boulder-clay. Here the moraine-matter contains an unusual number of scratched stones, derived doubtless from the older glacier deposit. Craigdilly, the hill on the east side of this, the lowest portion of Winterhope, presents towards the burn a bare rocky slope, along whose base the detritus is limited by a very distinct line, and by a series of moutonnée surfaces indicating the passage of ice at a higher level than that of the detritus, whose interlacing mounds enclosing small pools or peat-pots are disposed without any order.

Between Firthy Brig Head and Loch Craig the rock-terrace formerly mentioned passes northwards, and dips, first gently, afterwards rapidly, into Upper Talla Valley. The irregular surface of the terrace, the col, and the slope to the valley are covered with loose grit-fragments and sandy débris; the glaciated aspect of projecting rocks is marked, but the crumbling nature of the coarse pebbly grits is unfavourable for the preservation of striations. They are seen only in one place, namely, on the west slope a little north of the March-dyke, on a smooth surface among the loose blocks which strew the hill-side. The striæ run down the valley at a low angle, but their position, about 50 feet above the watershed, renders it possible that they may belong to the earlier glaciation.

Fig. 3.—*Sketch of Moraines in Upper Talla Valley, seen from the North*.*



The more rapid slope terminates in a marsh, beneath which the detritus is spread evenly. The marsh lies in an expansion oblique to the valley, in fact in the N.E. strike of the rocks, since it is hollowed out of a mass of softer shales, on either side of which are massive grits, namely, above at the slope, and below at Talla Craig, which pro-

* By Archibald Geikie, Esq., F.G.S.

jects into the hollow, its base lapped by mounds increasing in coarseness until it is difficult to distinguish them from rock in place.

From the Craigs the valley for a mile contains a fine series of moraine mounds and ridges, the latter on the west side parallel to the stream; while on the east side, though the mounds are for the most part irregularly disposed, enclosing hollows lodging pools of water or small peat-pots into which have rolled a few of the loose blocks which abundantly strew the surface, there may be traced a few curved lines of heaps stopping short of the burn, as if only half of several frontal moraines had been formed.

The east wall of the valley is formed by the heights descending from Loch Craig, whose steep faces run straight north, and at Wood Brae turn abruptly east into Upper Megget. The west wall slopes down from Talla Craigs, and some distance above Wood Brae turns west towards Carlavin Hill. The open space left by the divergence of these slopes is bounded by the wide base of Fan's Law (the southern extremity of Broad Law range), which eastward forms with Wood Brae the throat of Megget, and westward with Carlavin the pass leading to Lower Talla. This space is filled with a peat-covered mass of detritus which, directly opposite the mouth of Upper Talla, reaches to the 1500-ft. line, sloping from thence east, west, and south. Descending Talla, the natural course of the stream seems to be along the foot of Wood Brae into Megget: it follows, however, the curve of its western wall, and passes towards Carlavin, while the Megget has a separate origin 200 yards to the north, a narrow neck of peat-moss and detritus little elevated above either stream dividing them. The spit of moraine-matter resting on Fan's Law, and pointing up Talla, is a repetition of what was described at Loch Skene, namely, it indicates the point of bifurcation of the ice-stream, when, arrested by the opposing hill, one branch passed down Megget, the other westwards towards Lower Talla. In the concavity of the bend, on Wood Brae, are several lateral moraines rising above the level of the detritus on the opposite side; the lowest of these ridges, of great beauty and perfection, is about 1000 feet in length. From this point the detritus thins out, lying between slopes of Boulder-clay, which on the north side is of great thickness. At Wylie's Brae it again swells out and forms a confused series of mounds which, joined at Megget Head by the detritus descending from a valley to the north, extend below the junction of Winterhope and Megget waters. The common stream soon enters a broad alluvial plain, where the moraines are lost, the sides of the valley being lined by Boulder-clay.

Westwards, the detritus passes to the head of Talla Linns, showing one or two obscure mounds, which seem to have crossed the stream. The declivity is covered by detritus, limited above on Carlavin by a line of rocky moutonnées. At the foot of the hill the common alluvium of Talla and Gameshope occupies the floor of the valley, and a short way below the Shepherd's House Boulder-clay is thick on the right bank. The characteristics of glacier-débris are well marked throughout these valleys, and are admirably seen in several sections, contrasting strongly with the Boulder-clay, also well exposed in adjoining burns. At one point west of the bend in Talla Water, there is seen, beneath the loose sandy clay and angular gravel of the mounds, a hard stony drab clay. Its density, diagonal jointing (resembling the pseudo-stratifications of the Till), the comminution of its materials, and the presence of scratched stones suggest that it has been subjected to pressure, and recall the description of the Moraine Profonde given by Hogard in his Terrain Erratique des Vosges. The scratched stones have not the uniform rounding, fine polish, and parallel longitudinal striation characteristic of Till; on the contrary, they are mostly angular, and smoothed only on one surface, on which the striæ are short, imperfect, and often decussating. Where stratified nests of sand occur, they are invariably overlain by gravel, and seem therefore due to percolation, which has removed the finer materials to a lower level, leaving the larger fragments.

The top of Wood Brae is traversed by a series of rock-mouldings curving from Talla parallel to Megget Valley, and ending in the recess from which Nitties Burn flows. The section in that burn is through rudely stratified Boulder-clay, and exposes the moraine-matter resting against the clay near the foot of the hill. Huge blocks from this clay strew the burn-course; they are all rounded on the margin, polished and scored on all sides, the striæ running parallel from end to end of a surface more than 3 feet in length. This is the end of the deposit which, varying in thickness and extent, lies on both sides of the valley up to Loch Skene, being evidently the wreck of the mass which probably filled the valley until the last glacier wore a passage through it down to the present level. The recess between Fan's Law and Wylie's Brae is similarly filled with Boulder-clay, which also clothes the slope and fills the small burn between Upper Talla and Carlavin, and on the face of that hill there are also straggling patches in nooks above the moraine-detritus.

In a depression south of Firthoperig lies the source of Gameshope Burn. A low lip of rock separates the peat-moss whence it flows from the craggy head of Corrifran. The first part of its course is through a straight valley covered with a thin layer of detritus, extending a short way up the slopes on either side, which show roches moutonnées wherever the grits are exposed. About a mile down stream the detritus spreads out to the left, and may be traced up to a small loch which, surrounded on the south and west by Boulder-clay, and on the north by grits, is closed to the east by moraine-matter. Lying high above the stream, it seems a lake formed in a lateral valley by the passage of a glacier which has shed a lateral moraine across its mouth. Below the loch the stream bends to the east. The glacier has ground this part of its course through Boulder-clay, which lies thick on the left bank, the scarps and rills giving cross sections of moraine-matter resting against the clay; on the right side the detritus lies on the grits of Great Hill. Between this hill and Firthy Brig Head lies a wide funnel-shaped valley. In the gorge to which it contracts there are a few mounds of detritus, and on the north side lateral moraines; while, in Gameshope Valley, at the mouth of the Cleuch there is a high pile of moraine-matter. In the main valley the detritus now reaches on the east to 250 feet above the stream, partly from the additional transported matter of Donald's Cleuch, partly because a ridge of grit crosses the valley alongside of the tributary burn. From this point downwards the Boulder-clay has been completely worn out of the valley by the ice-flow, and is now confined to patches, among the crags, 500 feet above the stream. The moraine-detritus no longer forms a continuous covering, but is scattered in nooks of rocks, gathered in mounds among the roches moutonnées which stud the sides and floor of the valley, or perched on bare tables of grit too decomposing to retain striations. Patches of alluvium and peat lie surrounded by smoothed bosses of rock, or retained by heaps of rubbish; piles of large blocks alternate with mounds of the finer and more characteristic moraine-matter; bosses rise to a height of 40 feet in the centre of the glen, under whose lee lie long ridges of débris. In short, the valley presents every variety of ice-action; it is as it were the dissection of a glacier. This glen, interesting geologically and remarkable as a scene of savage gloom and desolation in strong contrast with the soft pastoral beauty of the surrounding country, ends at the head of the lower Talla Valley. The alluvium of the latter comes a little way up stream, and skirts the base of a lateral moraine prominent upon the detritus clothing the flanks of Carlavin and continuous with that descending over the Linnhead.

The absence of striations in these valleys allows no other guide in estimating the depth of the ice-stream than the height of the detritus above the bottom of the valley. The uncertainty of inference drawn from this alone is well illustrated at Loch Skene, where moraine-matter is found on Loch Craig about 100 feet higher than the termino-lateral moraine opposite. This may be accounted for, on the one hand, by the close proximity of a cliff along whose base rubbish would be piled up in large quantities, on the other, by the spreading of a glacier in crossing the open ground, and the wider distribution over its surface, and diversion into either of its branches, of the rubbish derived from the loch-head. Keeping in view the possible recurrence of similar circumstances in the curves and expansions of the valleys, it must also be remembered that much of the detritus on the hill-sides may have been washed down into the hollows, and, in places, has even been wholly removed. The average height, however, to which moraine-matter extends in those glens, whose similarity in shape and dimensions renders this comparison possible, is 200 feet towards the lower part of their course. In Upper Talla, below the craigs, the horizontal distance at that level, from side to side, is over 1000 feet. In Gameshope, above the Shepherd's House, it approaches 1500 feet, but a little lower contracts to 1000 feet. At Megget Head the elevation is about 100 feet, with a horizontal distance of about 1100 feet. At a corresponding point above Talla Linnfoots the measurements give nearly the same result. If the striæ alluded to at Firthy Brig Head belong to the later glaciation, they would indicate at least 60 feet of ice above the watershed.

These, the largest glaciers of the district, are dwarfs in comparison with those which have left their traces in other parts of the country, but the set next to be described are very much smaller.

The watershed between Fruid and Black Hope is covered with Boulder-clay on its south-eastern side as far up as the central peat-moss. Towards Fruid the irregular ground is thickly strewed with detritus, which passes over the waterfall, lodged among the recesses of roches moutonnées, and appears in definite mounds at the foot. The glacier seems to have come down the shallow depression on the north flank of Hartfell in the course of the Back Burn, and to have turned abruptly northwards, wearing its course through the Boulder-clay, against which on the right side its detritus rests, down to the rock beneath.

Close below the summit of Broad Law, on the south-west side commences a wide valley, soon contracting into a narrow, along whose sides, but especially towards the mouth, smoothed surfaces and roches moutonnées are seen. Few definite mounds appear, and the upper limit of the detritus is very irregular, the result probably of denudation. While, therefore, the character of the débris is identical and continuous with that in Megget, the valley seems to contain a moraine in a stage of decay only less advanced than in that to the east. The Broad Law and Cramalt Craig are connected by a ridge of grit, 2200 feet high, whose base on either side is covered with detritus. The narrow glen, Linghope, to the south-east retains little signs of a glacier; indeed it is only by careful comparison of the débris covering its floor with that of other valleys, and with the Boulder-clay lining its sides, that it can be proved to have contained a glacier, which, however, did not reach Megget, a high bank of Boulder-clay crossing the stream, and separating it from the main valley. On the north-west side of the col the evidence is clearer. Definite mounds occur a little below the roches moutonnées at the base of Polmood Craig, and the characteristic moraine-matter is easily recognized as far as the second ravine on the left side, where an alluvial plain occupies the floor of the valley. Beyond it Boulder-clay lines both sides down to the stream.

Between Cramalt Craig and Dun Law, at the base of the former, is an elevated piece of ground covered with Boulder-clay; it is overlapped at its edge by detritus which, descending from the foot of the declivity between the two heights, shows a few definite mounds above the first ravine to the left, and gradually thins out about a mile and a half from its commencement. It lies in a groove worn through Boulder-clay, which lines the ravines and covers the slopes on either side, and fills the valley below the lowest point to which characteristic moraine-matter can be traced.

The shape and contents of the valleys to the east forbid the supposition that they have been occupied by ice since the period of the Boulder-clay which fills them.

The east side of Dollar Law is, however, skirted by a deep narrow valley, in which the traces of a glacier are distinct. Manor Water is formed by the confluence of two burns, of which that to the east descends from a very narrow watershed over bare slopes of grit débris: that to the west flows from a patch of Boulder-clay on the shoulder of Notman Law. Opposite the *cone de déjection* formed by this latter, which contains a large quantity of rounded, polished, and striated stones, there is on the hill-flank a ridge resembling a lateral moraine, consisting of sandy gravel made up of angular fragments. Midway down the glen there are a few mounds close to the stream, the steep slopes being thinly covered with surface-waste. At the mouth of the glen lateral ridges rise on the right side, turning eastwards along the flank of the hill, and dipping towards the south-east corner of the broad alluvial plain which the stream now enters. This plain is bounded on the west by the long bare slopes of Dollar Law, and on the east by a precipice, or rather succession of cliffs rising one above the other, their summits moulded in long smooth ridges and dome-shaped bosses, while to the north it is closed in by a semicircular ridge pointing down stream, and succeeded by a close-set group of mounds whose proper form is much obscured by moss. Their upper limit is lost on the left in the *cone de déjection* from a boulder-clay-filled ravine; and on the right they merge into the grass-covered ridges and mouldings probably of the same period, namely the earlier glaciation, as those of the Bitch Craig with which they are continuous, and whose counterpart is seen at a height of 600 feet, above and behind the Shepherd's House. The mounds cannot be traced beyond the *cone de déjection*. A short way down Boulder-clay occurs in the bed of the stream.

The line of 1000 feet elevation above the sea-level may be taken as the lower limit of the glaciers of this district—at least it is the lowest point to which moraine-matter now reaches. Nor is it probable that it ever extended much lower, as Boulder-clay speedily replaces it along the sides of the alluvium in Talla and Megget; while in Manor it appears at Dollar Burn, about 1020 feet, the glacier-detritus probably not coming so low as 1050 feet.

In a country whose hills are covered with peat, which, though still thick, is evidently only a fragment of the former more extensive covering, it is a matter of surprise that any traces whatever of the loose incoherent deposit from a glacier should have survived the joint action of weather and streams, still more that they should have survived in the perfection and beauty seen in some of the above-described glens. If therefore we find valleys (and there are a few such) whose form and position suggest the possibility that they too were once the seats of glaciers, while their contents furnish no evidence on which to rest a decision either way, we may perhaps be allowed hypothetically to regard them as illustrating the last stage of decay of which, commencing with Mid Law, whence the ice might seem to have but recently retreated, this district furnishes so many interesting studies.

7. *On the* Formation *and* Preservation *of* Lakes *by* Ice Action.

By Thomas Belt, Esq.

[Communicated by Prof. Ramsay, F.R.S., F.G.S.]

[Abstract.]

The author remarks on the number of lakes, great and small, that occur in Nova Scotia, either in connected chains or isolated on the tops and sides of the hills. It is a common feature in British America, increasing as we proceed northwards.

The lakes constituting the Shubenacadian chain, stretching almost across the province of Nova Scotia, are found by the author to be in true rock-basins of hard quartzites and metamorphosed schists, of Lower Silurian age, covered irregularly with unstratified Boulder-clay. The surfaces are scratched, grooved, polished, and moutonnée, and bear huge transported boulders.

The direction of the main line of scratches varies from N.N.E. to N.N.W., and is coincident with the major axes of the lakes. The Shubenacadian lakes commence near Dartmouth, on Halifax Harbour, and stretch in an irregular northerly direction to the source of the Shubenacadie river, a distance of twenty-two miles, and, with the river, they occupy one basin of a great depression extending from Cobequid Bay to Halifax Harbour, a distance of fifty miles. The largest lake, "The Grand," is eight miles long; the greatest depth is 74 feet below the sea-level. The sea-coast is indented by long and narrow fiords, also having a northerly direction, like that of the scratchings and of the chain of lakes.

The glaciation of the rocks and the carriage of boulders might be ascribed to the agency of icebergs, *but not so* the scooping-out of the continuous deep channels and gorges in these hard rocks. All Nova Scotia is grooved and furrowed and covered by masses of gravel. The configuration of the country is explained by Agassiz as owing to a vast accumulation of continental ice, during the glacial epoch, moving southwards from the Arctic regions, and scooping out the larger valleys and deep fiords. During its retrogression, the ice wasted into separate glaciers in the principal valleys, and there left terminal *moraines* in their courses, and heaps of gravel, &c., on their flanks.

It may be admitted that such lakes as are formed by damming up channels by heaps of gravel and clay may have been caused by glaciers leaving terminal moraines in their retreat, but the production of deep rock-basins is not thus to be accounted for.

Prof. Ramsay, in 1859, showed that there was an intimate connexion between mountain lakes and glaciers, and that the rock-basins have been ground or scooped out by ice; and in 1862 he applied his theory to the production of the lakes of Switzerland and North America, contending that there is such a gradation of size from the least to the greatest that the theory is applicable to all.

Sir C. Lyell urges that though the passage of ice over the surface for ages would doubtless produce depression where the hardness of the rocks beneath was not uniform, yet a depth would soon be

reached when the movement there would cease, and the glacier would be discharged over, and not through, the ice-filled hollow. In the Lago Maggiore the ice, according to Prof. Ramsay's theory, would have at its exit to ascend a slope of five degrees from its deepest part; it is therefore contended that in such a case the depression would be simply filled up, the glacier passing over it.

Sir C. Lyell* considers that the great lake-basins of Switzerland have not been scooped out, but that they are all due to unequal movements of upheaval and subsidence during the great oscillations of level since the commencement of the glacial epoch. But whether or not this theory is applicable to the Swiss and Italian lake-basins, it does not apply to those of British North America and of Northern Europe, where there are lakes of all sizes, increasing in number northwards, and in association with, and evidently forming part of, the evidences of glaciation. Further, it does not explain the palpable connexion of rock-basins with glacial action; and if it cannot be admitted that there have been unequal movements of upheaval and subsidence for the innumerable rock-basins of glaciated countries, no other solution remains than that they have been eroded, and we naturally look to ice as the agent of erosion.

The author accepts Prof. Ramsay's theory as being sufficient to solve the main difficulty, (1) because of the immense depth of some of the basins; (2) because the grinding power augments by increased depth, even should the ice be dammed up, as is shown by the issue of streams of water, mud, and gravel from the bottom of glaciers, excepting those of the higher parts of the Alps, which result from the melting of the ice at the upper surface of the glacier, and especially a not inconsiderable portion from that of the lower surface next the earth, in consequence of abrasion.

He applies these facts to the consideration of the question of a depression in the pathway of a glacier which has reached such a depth that the ice is not bodily discharged, but simply fills it. The ice of the bottom and sides of the hollow would be slowly melted by the earth's heat, and as the ice at the *lower end* of the basin melted, the whole mass would be pushed along by the thrust of the moving glacier above it. The water coming down the bottom of the glacier from above would pour into the crevices at the upper end; it would pass underneath and be forced out at the lower end, carrying with it the mud produced by the crushing of the rock, through the grinding along the floor of the glacier by the ice as it melted at the lower end of the basin. The water coming from above would assist in melting the ice, especially in summer; but its most important effect would be the scouring out of the bottom of the basin, so that an ever clean face of rock would be presented to the huge tool operating upon it. This action would resemble the production of pot-holes on our coasts, and in the hard beds of many rivers, by the moving water turning a stone in a hollow, and so gradually deepening it. A lake-basin is an immense pot-hole, in which the mass of ice that filled it

* Antiquity of Man, p. 316.

took the place of the moving stone, its grinding power vastly increased, and in great part due to the moving glacier above it.

The rock-basins of Nova Scotia are shallower than those of Italy, because in the one case the rocks operated upon are harder, being metamorphosed schists, than those in the other case.

Many of the lakes, especially the smaller, have been obliterated since the glacial epoch by the formation of a freer passage for the waters, or by the growth of vegetation, or by sedimentary deposits. But in North America and North Europe they are still very numerous: the preservation of these lakes is accounted for by the length and severity of their winters. The preservative action of the ice is twofold: it encloses and carries off mud, gravel, and stones from the beaches, and deposits the same towards the outlets of the lakes, and thus the accumulation of material there counteracts the erosive action of the streams issuing through these outlets. It is therefore directly antagonistic to the obliterating power of running water, and it is even probable that some of the lakes may be enlarged and deepened by the tearing away of their banks and the raising of their outlets.

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8. A Sketch *of the* Principal Geological Features *of* Hobart, Tasmania. By S. H. Wintle, Esq.

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

[Abridged.]

1. *Trap-rocks.*—The hills upon which Hobart is built*, as well as those for the most part immediately surrounding it, are composed of New Red Sandstone, capped, in nearly every instance, with trap or greenstone, which varies considerably in mineral composition, from a felspathic subcrystalline rock to a compact hornblendic greenstone which is used for metalling the roads†. This trap seldom exhibits that step-like appearance said to be characteristic of the English trappean rocks; but this may be ascribed to two causes, namely, its invariably exhibiting numerous joints, which cross each other at different angles, and also to its having been shattered by eruptive forces at some subsequent period. The thickness of this trap in certain localities is very considerable. A quarry near the High School, in this rock, is at the present time upwards of 100 feet in depth, and, from the dip and strike of the underlying sandstone, I estimate that it will attain a depth of 200 feet more before the sandstone is reached.

From Professor Selwyn's Report on the Coal-measures of this part of the island, it would seem that a capping of trap is the prevailing feature of sandstone-hills throughout the district. At Knocklofty

* These hills are as follows:—

Knocklofty	1700 feet.
Proctors Hill	1100 ,,
Mount Nelson	1200 ,,
Surveyors Hill	1080 ,,

† See specimen No. 2, in Coll. Geol. Soc.

this trap is not met with until two-thirds of the ascent is gained. After walking over New Red Sandstone, which is quite bare for several hundred yards, we come to where the soil is sufficiently deep for the growth of scrub. Crossing a steep valley of dislocation, which is densely overgrown with underwood, we have before us the abrupt acclivity of this hill; and at every fifty paces or so immense blocks of sandstone are met with, having been removed from the parent mass by landslips; while a little higher up there are several quarries in the sandstone, most of which are being worked. As yet, not a vestige of trap is seen; but when about two-thirds of the way to the top, it is seen in small fragments, intermingled with sandstone-rubble. A few yards nearer the summit, and the sandstone is no longer visible, but in its stead large masses of half-decomposed trap are found, with which the top of the hill is covered, amid the densest vegetation imaginable.

There are no less than forty-eight of these trappean outbursts within a circuit of ten miles, plainly showing that at a comparatively recent period (say, the Tertiary) the area contained within these limits must have been the seat of intense volcanic action, though for the most part at a considerable depth beneath the surface of the sea, for I have not been able to detect any volcanic ashes or scoriæ.

A dyke of trap has lately been exposed in a road-cutting about 100 yards from a coal-shaft at New Town. It is about twenty yards wide, and has burst through the Carboniferous Sandstone, which immediately overlies the coal, or rather slaty anthracite, to the depth of 80 feet. On either side of this dyke there is a soft pulverulent soil of a dull lead-colour, like that of the sandstone, about a foot and a half wide, and traversed by veins of what I am inclined to think is a sulphate of lime*. Whether this loose incoherent mass is the effect of the molten trap on the sandstone, or not, I cannot say. The sandstone, however, must necessarily have been subjected to an intense degree of heat at the time of the intrusion, and therefore one would be led to expect that that portion of the sandstone in contact with the igneous matter would present more of a vitrified appearance than otherwise; but the reverse is the fact.

There is one singular description of trap-rock which is seen on the banks of the Derwent, two or three miles below the city, and which constitutes a formation of a quarter of a mile in width, and 100 feet in depth. Where the action of the water has eaten it away, thereby forming a cliff, it is seen reposing upon a reef of very beautiful hæmatite, which extends several miles in a north-easterly direction†. In some parts this rock bears the appearance of very vesicular lava, rather than a modified ordinary trap, and is found entirely devoid of the white mineral which in many places composes its chief constituent, and which I think is a crystallized carbonate of lime. I have traced it for a distance of four and a half miles, the river apparently flowing through its centre, when it is cut off at either end by

* See specimen No. 4, Coll. Geol. Soc.
† See specimens Nos. 5 & 6, Coll. Geol. Soc.

greenstone eruptions. To me it appears to have been an overflow of a volcano prior to the deposition of the trap and the greenstone.

2. *New Red Sandstone* (?).—If we imagine a vast sheet of sandstone, about fifteen miles in length and having a diameter of from eight to ten miles in its widest part, enclosed by lofty hills on the eastern and western sides, with the river Derwent winding through the centre, we shall have a tolerably correct idea of the *plateau* of sandstone on part of which the city of Hobart is built. This extensive formation has been shattered in every conceivable direction by subsequent eruptions, which have lifted it to a considerable altitude. This sandstone is remarkable for the great quantity of iron it contains, immense veins being frequently met with of almost pure oxide. I have not succeeded in discovering any fossils in this formation. On the opposite side of the river there is a quarry of white sandstone of very beautiful quality, which is exported to Victoria and the other colonies for architectural purposes, and some of which was sent to the late International Exhibition. As far as I can judge, I believe it to be the lowest member of the New Red series. Here and there, on the banks of the Derwent, the New Red Sandstone forms rather lofty cliffs, which add greatly to the beauty of the scenery of the river.

3. *Carboniferous System.*—This formation is very extensively developed throughout the island, but the coal for the most part consists of anthracite, of a hard slaty nature. There are some very fine beds of bituminous coal, but at the present time they are of little value, owing to their situation rendering the means of transit difficult and expensive.

At New Town there are six shafts being worked on two seams of anthracite, one 4 feet thick, and the other, the lower one, 3 feet 8 inches. These seams are situated in an extensive flat, bounded by Mount Wellington on the west, and the New Town Hills on the south-east, and are three miles by the road from the city. This is the only known coal within many miles. The first seam is 120 feet from the surface, in the centre of the flat, and the second seam 50 feet below that. Carboniferous shale, with two thin bands of earthy anthracite, and the dark brown associated sandstone, are found cropping out at the side of the road which forms the main line through the island. The spot at which these strata make their appearance is about a mile from the city, and two miles from the shafts. In the 120-feet shaft, 80 feet of Carboniferous Sandstone, containing impressions of carbonized stems of *Coniferæ* scantily diffused, was passed through, then a stratum of shale with fern-impressions, 2 feet thick, then sandstone 30 feet, and lastly, 8 feet made up of thin bands of shaly sandstone with streaks of coal—the shale containing a great quantity of nodular ironstone. These beds are exceedingly faulted—a disadvantage which is characteristic of the Coal-measures throughout the island. The whole of this coal-field is surrounded by trap-dykes; one of which cuts it off from the main line of road where the outcrop is seen. In this coal-field we meet with nothing but Carboniferous strata: the New Red Sandstone, so characteristic of Hobart, is entirely wanting. Beneath the alluvial soil the true Coal-measure sandstone is found, in which trunks and roots of trees have been met with, principally *Stigmariæ*.

I may mention, *en passant*, that while on a visit in the country a week since, I had the satisfaction to discover a very extensive coal-field of about 15 miles in length by about 5 in breadth; but unfortunately it is forty miles from Hobart, and far from water-communication. This coal, like that at New Town, is anthracitic, and although I have directed the attention of the authorities to its existence, it can never be of any economic value until we have railway communication with the interior.

At Hamilton, an agricultural district, seventy miles from the city, there is a seam of bituminous coal of magnificent quality, 12 feet in depth, and extending over a very large area, which, for the same reason as that above mentioned, is entirely useless.

4. *Carboniferous Limestone* (?).—This formation is very extensively developed in the neighbourhood of Hobart, and affords a fine field to the palæontologist on account of the vast quantity of fossils it contains. In the gully called The Cascades this limestone is seen exposed for several hundred yards, the water in the rivulet having denuded it of all superincumbent deposits. At this spot the sandstone is seen reposing immediately upon it. This formation is almost entirely composed of *Producti*, *Spiriferæ*, and *Pectinidæ*, with an immense number of Corals. The uppermost stratum consists of a coarse gritty kind of sandstone, interspersed with fragments of quartz, and, like the underlying limestone, is highly fossiliferous. This fact alone has led some, I believe, to consider this formation as being a member of the Devonian system; and it is quite probable that such may be the case, although the New Red Sandstone is directly superimposed,—the Coal-measure series having been removed by denudation before the New Red Sandstone was deposited. But, in the absence of other members of the Devonian system in association, and having failed to discover the principal palæontological characteristics of that system in the coarse arenaceous superstratum, I am inclined to accept it only as a true member of the Carboniferous series. This limestone is seen to dip towards the east at 40°, with a south-easterly strike; but it is not again seen after passing under the sandstone.

The Cascades, the site of this formation, are situated at the base of the first ascent proper of Mount Wellington, and it is only after this first "pinch" has been gained that true indications of the Old Red Sandstone are met with; these are at an elevation of upwards of a thousand feet above the Cascades, and consist of a sandstone-grit reposing upon the representative of the pudding-stone of England. This fact, then, argues in favour, I believe, of the formation in question being a member of the Carboniferous series.

Having passed over the first hill in the ascent of Mount Wellington, we come upon the true Devonian ground. This, however, affords but little interest to the geologist, consisting as it does of a few thin beds of coarse sandstone interspersed with dark-coloured shaly bands, the sandstone being, as I take it, the equivalent of the English "cornstone," the whole of which up to the present time has proved to be unfossiliferous. About a quarter of a mile higher up we meet with the uppermost members of the Silurian system.

5. *Silurian System* (?).—The Silurian strata consist of a dark-coloured inferior slate, in which, as yet, no fossils have been found. This slate rests upon a thin bedding of tilestone, and this again reposes upon mica-schist, and from this point to the basaltic columns of the mountain all is a *terra incognita.*

Mr. Gould has lately shown me a *Calymene Blumenbachii* which he obtained from the Silurian slate of the interior, corresponding to that above mentioned, and therefore I have reason to hope that I may yet find the Mount Wellington slates fossiliferous. The strike of these beds is nearly due north and south, with a dip of about 43° east. They are again forced up by the greenstone which rests upon them on the Huon Track, and dipping again very precipitously are then entirely lost sight of. The Silurian system appears to be very feebly developed in Tasmania, according to the reports of Mr. Gould.

6. *Boulder Drift (?) and Post-Pliocene Deposits.*—There is one other very interesting formation in this city, which for want of a better name I will call the Boulder Drift, although in many respects it differs from the formation of the same name in Great Britain. This consists of immense boulders, principally of felspathic trap and greenstone; imbedded in stiff clay in some parts, and in others in loam. In many instances these boulders are associated with fragments of New Red Sandstone and nodular masses of dolomite. At other times we find the boulders, which very frequently are globiform, with exfoliating surfaces where exposed to the air, cemented together by oxide of iron, which appears to enter largely into their composition; and in many places there are veins of a mineral with needle-shaped crystals distributed among the boulders*. This mineral I am inclined to think is a kind of sulphate of lime. However, it appears to rapidly deliquesce upon exposure to the air into a marl. In some places this formation constitutes hills of considerable size, some of which have been worked for the nodules of dolomite they contain.

The next, and last, important feature in the geology of Hobart to which I must briefly refer, is that of the Post-Tertiary marine deposits (?). In a paper which I read before the Tasmanian Royal Society a few weeks since, I pointed out that, until a very recent period in the geological annals of this island, a great portion of what now constitutes the site of this city had been under water. This is proved by the extensive deposits of comminuted Shells, all of recent species, which are met with, for miles, indeed, along the banks of the Derwent. Some of these deposits are at an elevation of upwards of one hundred feet above high-water mark, and from fifty to one hundred yards from the water's edge, plainly showing thereby that a very recent elevation of the land has taken place. Judging from the condition of the Shells, I think this formation may be assigned to the Post-pliocene period.

* See specimen No. 7, Coll. Geol. Soc.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On the Fossil Echinidæ *of* Malta. By Thomas Wright, M.D., F.R.S., F.G.S. *With additional Notes on the* Miocene Beds *of the* Island, *and the* Stratigraphical Distribution *of the Species therein*; by A. Leith Adams, A.M., M.B., 22nd Regiment, Malta.

[Read February 4, 1863 *.]

[Plates XXI. & XXII.]

Contents.

I. *Description of the* Miocene Beds *of* Malta. By A. Leith Adams, A.M., M.B., Surgeon 22nd Regiment.

The following classification of the Maltese rocks is a modification of that originally proposed by Capt. Spratt, R.N.†, and followed by Earl Ducie in constructing his Geological Map of the Maltese Islands, and with some differences by Dr. Wright in his 'Monograph on the Fossil Echinoderms of the Island of Malta.'

1. *The Upper Limestone.*—This bed was originally called Coral-limestone by Capt. Spratt, for reasons not apparent unless it be that he mistook the *Corallines* in its lower stratum for *Corals*. The latter are not common, at least not more so in this than in the Lower Limestone. It is the Coralline limestone of Dr. Wright, from the abundance of species of these Plants, which however affect the lowermost portion of the bed only. Seeing therefore that a large extent of the deposit is without a trace of Corallines, I prefer the above simple denomination as least likely to embarrass the student or lead to confusion.

* For the other communications read at this Evening-meeting, see Quart. Journ. Geol. Soc. vol. xix. p. 260.

† On the Geology of Malta, reprinted from his paper "On the Geology of the Maltese Islands," Proc. Geol. Soc. vol. iv. p, 225, 1854.

The Upper Limestone is divisible into three well-marked strata or varieties. 1st. *a*. The upper stratum presents a rubbly broken-up appearance of diverse density, open more or less with fissures and cavities lined with calcareous incrustations. Fossils are abundant in this stratum, consisting chiefly of *Lithodomi*, casts of *Voluta*, *Trochus*, *Haliotis*, *Cidaris Melitensis*, Forbes, *Psammechinus Duciei*, Wr., and other *Echinidæ*, which will be described in the sequel. In the faults and dislocations, as well as in the highest parts of the Island, this stratum bears all the marks of having been much disturbed during the upheavals and depressions to which the Island was subject; in fact, its mashed and fractured appearance may be said to be owing entirely to these causes, inasmuch as in the downcast portions of the Island it is so broken up as to have lost all appearance of compactness, presenting a crumbling and disordered mass, which the earlier writers described as shale. The more durable and variegated portions of this bed and No. 5, such as are met with in the quarries of Ras il Kala, Gozo, pass under the name of Gozo marble, and continue to be in repute for monuments and architectural purposes.

2nd. *b*. This variety is a yellowish-white calcareous sandstone, more or less indurated; it is seen to perfection in the cliffs N.W. of Citta Vecchia, where it abounds with casts of Shells and is burnt for lime. Its characteristic fossils are *Schizaster eurynotus* and *S. Parkinsoni*; these are often met with in fragments strewn in long lines across the faces of cliff-sections, resembling the washings of a sea-coast. The softer parts of this variety give off carbonic acid when immersed in water. Although most commonly occupying an intermediate position between the last and next stratum, this variety may be wanting.

3rd. *c*, or Coralline stratum, is usually a reddish-white rock, which becomes soft and dark-coloured in its lower portion; it abounds with organic remains, chiefly fragments of Crustacea and various species of Mollusca and Echinodermata, with button-shaped teeth of Pycnodont fishes. The Coralline stratum is a durable rock, except towards its transition into the Sand-bed. In that situation it is very fossiliferous, containing abundance of teeth of *Squalidæ*, fragments of Cetacean bones, beds of *Astrææ*, and several species of *Terebratulæ*. From the abundance of Sharks' teeth, especially those of the gigantic *Carcharodon megalodon*, it would appear that these monsters began to die out then, as none of their teeth, to the best of my knowledge, have been found in the strata 1 and 2 of the Upper Limestone.

The above strata are not invariably met with in every section; sometimes one or both of the upper strata may be wanting and are often denuded. The measurements of the various beds differ individually to such an extent as to lead me to consider that any statement as to the average thickness of a bed must be received as being only a faint approximation to the truth. This assertion was fully borne out by a late expedition, made on purpose to test the correctness of Capt. Spratt's observations on that head.

2. *The Sand-bed.*—This division presents the following varieties: sometimes it is a rather compact red or yellowish-red sandstone, at others soft and loose; green and black grains are more or less intermixed, and one or both often predominate, giving a complex and almost variegated appearance to the deposit; or the red and yellow sand may be replaced by the brown- and black-grained sand, which passes imperceptibly into the Marl, and as gradually into the Coralline stratum of the Upper Limestone.

The red or yellowish-red variety is the most regular, and abounds with fossils, which are usually found in a high state of preservation. *Lenticulites complanatus*, Defr., in certain situations, enters largely into its composition. Beautiful specimens of *Clypeaster altus* and *C. marginatus*, also the magnificent Urchin *Conoclypus plagiosomus*, are by no means rare. Remains of *Delphinus* and *Manatus* have been found; also teeth of eight or ten distinct species of *Squalidæ*, palate-teeth and spines of gigantic Rays, &c., with Cetacean bones, the flat fragments of the latter having been mistaken for fossil wood. The thickness of this formation is very variable. I have seen cliff-sections not exceeding 4 feet in thickness, whilst in other situations upwards of 50 feet of perpendicular cliff appears above ground.

3. *The Marl.*—This bed does not merit the name of clay, inasmuch as it is never met with free from carbonate of lime. It is a mistake to suppose that fewer organic remains are met with in the Marl than in other Maltese deposits. The only difference is that in the latter they are found in an imperfect state of preservation, and crumble to pieces on exposure to the atmosphere. The fossils are incrusted, and the original substance is replaced by peroxide of iron (not iron pyrites, as stated by Capt. Spratt in his Notes).

In this way several perishable substances have been preserved, such as the bone of a small *Cuttle-fish*, and fragments of a *Nautilus*. Nodules of sulphur are rare.

Beautiful specimens of crystalline and lamellar gypsum abound. The rents and cracks of the Upper Limestone give ready access to rain, which, with the weight of the limestone-strata, causes the Marl to fall and become piled up in great heaps, which appear to best advantage in cliff-exposures, where they look as if they had been carted over the cliffs. The extensive denudations seen all over this Island are evidently the result of the perishable nature of this bed, which has been completely washed away in the east and north-east of Malta; perhaps during the gradual upheaval, or by the wear and tear of the elements during the long unreckoned ages which have since elapsed.

4. *The Calcareous Sandstone.*—According to Capt. Spratt (*op. cit.*) there are five varieties of this bed, but, from a close study of its characters and appearances, I do not find this classification hold good, inasmuch as the different sorts blend so much into one another, and are so variable as to positive conformity, &c., that any attempt at defining the appearance or distribution of one or the other, far less their thickness, must be considered fallacious in a great degree. It

will be found that what appears to be a pale bluish-white sandstone externally is a dark drab-coloured rock when broken up. This is the only variety I can safely say occupies a certain position; it invariably occupies a central position in the group—at least it never forms the uppermost or lowermost stratum. It is very liable to exfoliate on exposure, breaking up with a cleavage. The great indent in the east coast at Marsa Scirocco has been formed in this perishable variety.

Hard lumps of limestone and nodules of chert are often interspersed thoughout the Calcareous Sandstone; the latter are not affected by strong acids. The reddish-yellow varieties of this bed owe their colour, more or less, to the presence of oxide of iron, which exists in much less quantity in the *drab*-coloured variety. The nodular beds are the chief objects of attention in this group; they traverse the rock at variable depths, and differ as to extent, thickness, &c. There is one bed in particular which, for its constancy and abundance of organic remains, deserves especial notice; I refer to that overlying the Lower Limestone. The nodules are of irregular shape and consistence, and are usually found cemented together or dispersed throughout the sandstone. They are various as to consistence, being often crystalline, or merely a liver-coloured porous substance, showing a whitish surface when fractured. As to their being of organic origin, there does not appear to me any proof at present: several nodules contained casts of Shells, chiefly small univalves; the Sharks' teeth and Cetacean bones which are common in the nodular beds, are often very much worn, as if they had been rolled; Retepores and marine parasitic Plants are often found in the nodules. According to Capt. Spratt's description, it would appear that there is only one bed of nodules; but this is incorrect, as in cliff-sections two or more bands may often be observed. As to the position of these nodular seams in the group, they occupy diverse levels, sometimes near its upper limits, and often lower down. It does not appear that all are uniformly distributed throughout the sandstone; the one stated as being generally present at the junction of the Calcareous Sandstone with the Lower Limestone is most regular and uniform.

5. *The Lower Limestone* is often compact, hard, and semicrystalline; oftener a coarse-grained gritty mass composed of small particles of Shells, Corals, and Corallines. A curious variety shows spheroidal structures like travertine, presenting globular-shaped nodules interspersed in an irregular and varied manner throughout a soft rock. This variety is remarkable in being apparently devoid of fossils. It forms large portions of the upper strata; all these vary in colour from yellowish white to white. The harder varieties form excellent building-stone, but do not take so fine a polish as the "Gozo marble." The transition between this rock and the Calcareous Sandstone is often marked by the nodular bed already mentioned and an abundance of interesting fossils. The *Scutella subrotunda* may be said to be characteristic of the Lower Limestone and the transition between it and the group above; there

is also a new species of *Thecidium*, a *Lenticulites*, a small *Terebratula*, and one or more *Cidarites* which I have not observed elsewhere.

I have found a few teeth of the great Shark, *Carcharodon megalodon*, and a smaller species, besides teeth of *Pycnodonts*, and the pavement-shaped teeth of *Ptychodonts*, also Cetacean bones in fragments. In a large quarry in this rock at Ras il Kala, Gozo, is seen a regular nodular bed traversing the face of a cliff of semicrystalline limestone. The nodules are exactly similar to those of No. 4, but more rounded and water-worn, and are firmly cemented by a hard light-brown cement (in fact a vein of conglomerate). The *Fungia*, so characteristic of the beds of No. 4, is also common in this bed. This is the only locality in which I have observed the nodular bed in No. 5; it is situated about 12 feet below the level of the bed. *Scutella striatula* (if distinct from *S. subrotunda*) must be very rare in the Maltese beds, as I have not met with one specimen of a full-grown Urchin to agree with the description of Marcel de Serres.

II. Descriptions *of the* Species *of* Echinoderms.
By Thomas Wright, M.D., F.R.S., F.G.S.

1. Cidaris Melitensis, Forbes.

Stratigraphical position.—The small and perfect specimens are found in No. 1 bed—the Upper Limestone; many fragments of larger individuals of the same species are found in bed No. 5.

Collections.—Earl of Ducie; Mus. Royal School of Mines; Geol. Soc.

2. Cidaris Scillæ, Wright.

Echinus, Scilla, Corp. Mar. tab. xxiii. xxiv. 1747.

Form of the test unknown; ambulacral areas sinuous, narrow, with four rows of small granules; poriferous zones narrow, holes small, interambulacral areas wide, plates large; areolas wide, flat, and superficial; mammary summit smooth, and without crenulations; tubercle large, with a small perforation; median intertubercular space wide, filled with fine small tubercles.

This *Cidaris* appears to be the species figured by Scilla. Dr. Adams has collected only a fragment of the test, consisting merely of portions of the areas and zones, and the median intertubercular space. It must have attained a large size, was very distinct from *Cidaris Melitensis*, and equally remote from *Cidaris Adamsii*, Wr.

Stratigraphical position.—Found in bed No. 4 at Malta. I have no notes of the distribution of this species beyond the figures on the fragment.

3. Cidaris Adamsi, Wright, spec. nov. Pl. XXI. fig. 5.

Test large, form unknown; ambulacral areas narrow, with two marginal rows of small tubercles and four minor rows of small granules; poriferous zones narrow and depressed in a groove; fifteen pairs of holes opposite one of the large interambulacral plates; a fine ridge divides each pair of holes; interambulacral areas wide; each column of plates forms a convex prominence, occasioned by the plate bulging out in the middle and being depressed at the suture; each plate is oblong, and has its mammillary eminence nearer the poriferous zones than the median suture; a circle of small tubercles surrounds the areola, and forms a moniliform boundary; the rest of the surface of the plate is thickly studded with regular rows of very fine prominent granules; median suture much depressed, forming a marked concavity entirely filled with regular rows of fine granules. The summit of the boss is smooth, and without any trace of crenulations; the tubercle is large with a wide hole.

The only fragment found is the one under description. It consists of a portion only of two columns of interambulacral plates, four in each row, with the half of the adjoining ambulacral area and poriferous zone *in situ*.

I am not acquainted with any allied form of *Cidaris*. The prominence of the columns of interambulacral plates, and the regularity of the tuberculation on the other parts of the same, well characterize the species, which I dedicate to Dr. Leith Adams.

Stratigraphical position.—Collected from bed No. 5 at Malta.

4. Psammechinus Duciei, Wright.

Stratigraphical position.—Should the specimens in this collection prove to belong to this species only, it will be seen that *P. Duciei* extends throughout the Maltese beds, excepting Nos. 2 and 3, where I have not hitherto found it. The finest and largest specimens are from No. 1, and chiefly from the *white calcareous sandstone,* and the *coralline strata* of that bed, where it is plentiful, and associated with *Cidaris Melitensis,* &c. Sometimes fragments of this and *Schizaster Scillæ* strew great portions of the white calcareous sandstone strata in lines, like the washings on a shore or the deposits from currents. It is difficult to find the larger specimens entire; the largest in this collection may be considered one of the best in that respect. There is one small specimen from No. 4 bed, and the only one I have hitherto seen or heard of from that formation. In the upper stratum of No. 5, at the transition between it and No 4, small specimens are very common, and usually seen associated with *Cidaris* and the Nummulite-like or Foraminiferous-looking body sent along with the collection of *Cidaris.* A specimen showing this distribution is sent, also a fragment showing two teeth. I have not examined the deeper portions of No. 5; I cannot in consequence be certain that the Urchin extends downwards in that formation. It may be that its rarity in No. 4 is owing to that bed not having preserved it so well as the Limestones. All the specimens I have as yet found in No. 5 were very small compared with the largest from No. 1. (A. L. A.)

5. Psammechinus Scillæ, Wright.

Echinus, Scilla, Corp. Mar. tab. xiii. fig. 1 and tab. xix. fig. 3.

Test globular, flattened at the base; ambulacral areas moderately wide, with two rows of marginal tubercles closely set together, and a few smaller tubercles disposed without much regularity in the middle of the areas; interambulacra with two rows of primary tubercles on the centre of the plates, and one short irregular row of secondary tubercles on each side of the primaries; base convex, peristome small.

Dimensions.—Height 1 inch and 1 line; transverse diameter $1\frac{1}{2}$ inch.

Description.—The globular form of this Urchin, with the few rows of primary tubercles on the interambulacra, seem to indicate that it was a large individual of this species which Scilla figured in the plates already referred to. The ambulacral tubercles are uniform in size and placed on the margin of the areas; within these only a very few small tubercles are irregularly scattered; there are in reality only two rows of primary tubercles in the interambulacra, for all the others are of secondary size and limited to a portion of the area; of these, the rows between the primary tubercles and the poriferous zones contain the smallest, and the two rows near the median suture the largest secondary tubercles.

Affinities and differences.—The globular form of the test and the sparseness of its tubercles readily distinguish it from *P. Duciei*, Wr.

Stratigraphical position.—It was collected from bed No. 1, the Upper Limestone at Malta, where it appears to be rare.

Genus Clypeaster, Lamarck, 1801.

Form oval, inclining to pentagonal, rostrated before, truncated behind; upper surface more or less inflated, sometimes campanulate, conical or subconical; inferior surface flat, always concave around the mouth, with fine straight simple ambulacral furrows proceeding from the angles of the mouth to the border. Dorsal ambulacra largely petaloidal, greatly exceeding the interambulacra in size, and forming elegant leaf-like expansions, in general convex, arched, and prominent, bounded on each side by wide poriferous zones, the holes of which are set far apart and united by transverse sulci. Apical disk small, formed of five genital and five ocular plates. Madreporiform body central, and covering over the other elements of the disc with its spongy tissue. Tubercles small, numerous, uniform in size, and equally distributed over the test, those on the upper being smaller than those on the under surface; summits perforated, and surrounded by deep areolas. Mouth symmetrical, central, pentagonal, lodged in a concave depression in the middle of the base. Auricles composed of ten distinct processes set in pairs: the jaws resemble a pentagonal pyramid composed of ten separate pieces united in pairs to form the five jaws; they contain five large teeth enamelled on the outer surface and lodged in a groove formed between the two halves of each jaw. Anus small, round, and inframarginal. Interior of the test with a number of pillar-like processes towards the border.

All the great divisions of the globe contain a certain number of Clypeasters. In Europe they are found only in a fossil state, while in Asia, Africa, America, and Oceania both living and fossil species are found. The fossil European species characterize the Miocene deposits of the great Mediterranean basin, especially those of the

South of France, Spain, Portugal, and Italy, the Islands of Corsica, Sardinia, Sicily, Malta, the Ionian Isles, and in Austria, Hungary, and Greece.

6. Clypeaster altus, Leske.

Stratigraphical position.—This is an abundant Urchin in the Sand-bed No. 2, where some very fine specimens are obtained. It is likewise found in the Miocene beds of Port-de-Bouc, Saint-Miniato, Tuscany, Nice, Turin, Ile de Crête, Isle of Capri, Bonifacio, Corsica, and Oran.

Collections.—Common in all collections of Miocene fossils.

7. Clypeaster tauricus, Desor.

Clypeaster tauricus, Desor; Agassiz and Desor, Cat. Raisonné, 1846, p. 73.

Clypeaster tauricus, Desor, Synopsis des Echinides Foss., 1858, p. 240.

Clypeaster tauricus, Michelin, Monographe des Clypéastres Foss., 1861, pls. 10 & 11, p. 118.

Test large, pentagonal, elongated, and sinuous, with five rounded angles; lateral and anterior border inflated, posterior flat; upper surface very much elevated under the ambulacra, especially the posterior pair; under surface flat, concave towards the mouth-opening, the five valleys deep and narrow, disappearing at the border. Ambulacral summit under the posterior ambulacra. Madreporiform body pentagonal, granular, placed beneath the commencement of the ambulacra; ovarian and ocular pores disposed around the circumference of the body. Ambulacral areas largely open at the lower part, much inflated and prominent; petaloid ambulacra very long, extending nearly to the border; poriferous zones wide, reposing in concave depressions; interporiferous zones elevated slightly above the border; interambulacra narrow, and concave at the border; tubercles small, numerous, and regularly arranged on the upper surface, but closer together and larger at the base, often forming straight lines on the interporiferous spaces; miliary granulations small, numerous, and visible near the border; mouth-opening small; peristome pentagonal, with deep narrow valleys radiating from the angles; vent small, circular, situated near the border.

Dimensions.—Antero-posterior diameter $6\frac{1}{2}$ inches; transverse diameter $5\frac{7}{10}$ inches; height $2\frac{1}{4}$ inches.

Affinities and differences.—This is one of the largest Clypeasters, remarkable for the elevation of the ambulacral above the interambulacral areas, the size and depression of the poriferous zones, and the wide terminal expansion of the interporiferous spaces.

Localities and Stratigraphical position.—Collected from bed No. 1, Malta, where it is rare. It is found likewise in the Miocene of Mount Taurus, Asia Minor, and in the Isle of Crete.

Collections.—The Earl of Ducie, and my cabinet.

8. Clypeaster marginatus, Lamarck.

Stratigraphical position.—Collected at Malta from the Sand-bed No. 2. It is found likewise in the Miocene beds of Touraine, Landes, Narosse, Dax, Bonifacio, Santa Maura, and Corsica.

Collections.—British Museum; Royal School of Mines; Geological Society; Bristol Museum; Earl of Ducie's collection; my cabinet.

9. Clypeaster Reidii, Wright.

Locality and Stratigraphical position.—This species is from bed No. 1, the Upper Limestone. Fine specimens are in the Museum of the Royal School of Mines and in the collection of the Geological Society of London. The type-specimen in my collection has been figured by M. Michelin in his beautiful monograph of Fossil Clypeasters.

10. Clypeaster portentosus, Desmoulins.

Clypeaster portentosus, Desm. Etudes des Echinides, 1835, p. 218.
C. Agassizi, Sismonda, Suppl. Echin. Foss. di Nizza, 1842, p. 48.
C. altus, var. *turrita*, Ag. & Desor, Cat. Echinides, 1846, p. 72.
C. turritus et *altus*, Desor, Synopsis des Echinides Foss., 1858, p. 240.
C. portentosus, Michelin, Monogr. des Clypéastres Foss. 1861, pl. 48.

Form in general nearly regularly pentagonal, very much elevated in the centre; border thick and round, about one-third of the total height; upper surface forming an elevated pyramid, sometimes inclined to one side; the length of the sides nearly equal to the height of the pyramid; under surface flat, mouth-opening deeply sunk; the ambulacral grooves disappear near the border; summit irregular, sometimes one of the ambulacra rises higher than the others. Madreporiform body small, pentagonal, surrounded by the elevated ambulacra which rise above its surface; genital plates small, ocular plates nearly concealed; ambulacral areas elongated, large and prominent throughout, petaloid, and widely open below; poriferous zones wide, composed of sulci terminating in pores; septa large, with from 6 to 10 tubercles; interporiferous zones semicylindrical; interambulacral areas narrow, less prominent than the ambulacral; peristome in a deep concavity, pentagonal, with narrow ambulacral sulci radiating from the five angles; vent inframarginal.

Dimensions.—Length $5\frac{4}{10}$ inches; transverse diameter $4\frac{3}{4}$ inches; height $3\frac{3}{4}$ inches.

Affinities and differences.—It resembles *C. pyramidalis*, Mich., but differs, according to M. Michelin, by the pyramidal elevation of the ambulacral zones and the smallness of the summit.

Stratigraphical position.—Collected at Malta from the Sand-bed No. 2, where it is not uncommon. It is likewise found in the Miocene of Dax, Landes, Eisenstadt, and Isle of Capri.

Collections.—British Museum; Royal School of Mines; Geological Society; my cabinet.

11. Clypeaster latirostris, Agass.

Echinus, sp., Scilla, Corp. Mar. Lapid. tab. 10. fig. 2.

Clypeaster latirostris, Agassiz, Cat. Syst. Echin., 1840, p. 6.

Clypeaster Scillæ, Agassiz & Desor (pars), Cat. Raisonné des Echinides, 1846, p. 73.

Clypeaster scutellatus, Desor, Synopsis des Echinides Foss. 1858, p. 242.

Clypeaster latirostris, Michelin, Monogr. des Clypéastres Foss., 1861, pl. 15, p. 137.

Form in general subcircular, compressed, pentagonal, with rounded angles; border very thin, especially posteriorly; upper surface a little elevated under the petaloid ambulacra, with a flat margin beyond; under surface flat, deeply concave towards the peristome, with deep ambulacral sulci radiating from the angles to the border; median summit often compressed; apical disk small. Madreporiform body forming a convex prominence, which nearly conceals all the other elements of the disk; petaloid ambulacra convex, and undulated towards the middle, extending more than halfway between the summit and the border; poriferous zones slightly depressed; inner series of pores small and round, external series elongated; septa carrying from 8 to 10 tubercles; interporiferous zones elevated, and covered with close-set tubercles; interambulacral areas likewise elevated and covered with tubercles set wide apart; surface of the test between the areolas of the tubercles covered with a fine granulation, which is best seen near the border; base flat, concave towards the mouth-opening; peristome round, at the bottom of a deep cavity; vent submarginal, cordiform, with the angle towards the mouth; test composed of thick plates.

Dimensions.—Length 4 inches; breadth $3\frac{3}{4}$ inches; height $\frac{3}{4}$ inch.

Affinities and differences.—This species resembles *C. marginatus*, but it is much smaller and less elevated in the centre; the petaloid ambulacra are not so prominent, the border is rounder, and the test thicker than in that species. It very much resembles *C. laganoides*, Ag., from the Miocene of Corsica.

Stratigraphical position.—"Collected from bed No. 5: I find this Urchin often associated with *Scutella subrotunda*, Leske, and by no means rare. These two, as far as I have yet observed, are characteristic of the Lower Limestone." (A. L. A.)

12. Scutella subrotunda, Leske.

Stratigraphical position.—"This species is plentiful in the Lower Limestone No. 5, and in the transition between it and No. 4. It is usually associated with the Echinolampades of No. 5." (A. L. A.)

13. Pygorhynchus Vassali, Wright. Pl. XXII. figs. 6 *a*—6 *c*.

Stratigraphical position.—Collected from one of the nodular beds of No. 4, at Malta, where it is very rare.

Collections.—Mus. Royal School of Mines; Geological Society cabinet of the Earl of Ducie.

14. Echinolampas Hayesianus, Desor.

Stratigraphical position.—This species was collected from the Sand-bed No. 2, at Malta. It has likewise been found in the Miocene at Oran, Algeria, Carthagena, Catalonia, and Balistro (Corsica).

Collections.—The Maltese specimen is unique, and is in the cabinet of the Earl of Ducie.

15. Echinolampas Laurillardi, Agassiz.

Stratigraphical position.—Collected from the Marl No. 3, and the nodular beds of No. 4, at Malta, where it is not well preserved. It is found in the Miocene deposits of Bordeaux, and of Dego and Cassinelle, Piedmont.

Collections.—Mus. Royal School of Mines; Earl of Ducie's cabinet.

16. Echinolampas hemisphæricus, Lamarck.

Clypeaster hemisphæricus, Lamarck, Anim. sans Vert., 1816, vol. iii. p. 293.

Clypeaster hemisphæricus, Grateloup, Oursins Foss., 1836, tab. 1. fig. 7.

Echinolampas hemisphæricus, Agassiz, Prodrome Mém. Soc. de Neufchâtel, 1835, vol. i. p. 187.

Echinolampas hemisphæricus, Desor, Synopsis des Echinides Foss., 1858, p. 307.

Test large, discoidal, slightly rostrated behind, subconical; ambulacral summit excentral; petaloid ambulacra unequal, moderately wide, extending over two-thirds of the upper surface; single ambulacrum much narrower than the others; poriferous zones narrow, less than one-third the width of the interporiferous area; under surface concave; peristome large, excentral, transversely oval opposite the disk, surrounded by five lobes, between which are five alternating narrow phylloidal expansions with numerous pairs of pores; vent small, inframarginal; tubercles small, closely set.

Dimensions.—Antero-posterior diameter $4\frac{3}{4}$ inches; transverse diameter $4\frac{3}{4}$ inches; height $1\frac{4}{10}$ inch.

Description.—This large Echinolampas seems very characteristic of the Miocene formation. All our specimens are more or less compressed; the upper surface is convex or subconical, and the posterior border slightly produced; the single ambulacrum is much narrower than the pairs; the petaloid ambulacra extend over more than two-thirds of the dorsum, and are slightly raised above its general surface; the poriferous zones are narrow and composed of oblique pairs of pores,—the zones are scarcely one-third the width of the interporiferous area, and the outer row consists of oblong, the inner of round holes with faintly marked connecting sulci. The apical disk, small and slightly excentral, occupies the ambulacral summit; the spongy madreporiform body envelopes all the discal elements, so that the genital plates are only visible in weathered specimens. The base is concave in the Maltese specimens, but rather convex towards the border in a specimen from the Molasse of St. Jean de Royan (Drôme).

The peristome is large, transversely oval, and surrounded by small lobes, between which are narrow phylloidal expansions. The tubercles are small, and closely set together on the entire upper surface; those on the base are wider and further apart. The small vent is quite inframarginal, and situated in the prolonged portion of the interambulacrum.

Affinities and differences.—This species differs from *E. scutiformis* in having a larger and more discoidal test, as wide as it is long, in having its surface covered with small tubercles very closely set together on the entire upper surface (those on the base are wider and further apart) and in the concave base. The small vent is quite inframarginal, and situated in the prolonged portion of the interambulacrum.

Stratigraphical position.—This Urchin has been collected from all the strata of No. 1, although entire specimens such as those sent are rare. It is found likewise in the Molasse (Miocene), St. Jean de Royan (Drôme), St. Paul-Trois-Châteaux, Cape Couronne, and Martigues, and in the Faluns bleus de Narosse.

Collections.—Museum of the Geological Society; my cabinet.

17. ECHINOLAMPAS SCUTIFORMIS, Leske. Pl. XXI. fig. 4 *a*, 4 *b*.

Echinus, Scilla, Corp. Mar. tab. 11., upper figure showing the dorsum.

Echinoneus scutiformis, Leske apud Klein, 1778, p. 174.

Galerites scutiformis, Lamarck, Anim. sans Vert., 1816, vol. iii. p. 22.

Echinolampas scutiformis, Desmoulins, Etudes sur les Echinides, 1835, p. 348.

Echinolampas Francii, Desmoulins, Etudes sur les Echinides, p. 350.

Echinolampas scutiformis, Desor, Synopsis des Echinides Foss., 1858, p. 308.

Test large, oval, wider behind than before; upper surface convex, subconical; ambulacral summit excentral; petaloid ambulacra equal in width, extending over more than half of the dorsum; sides inflated; border rounded; base convex at the sides, concave towards the mouth-opening.

Dimensions.—Length $3\frac{4}{10}$ inches; width $3\frac{1}{10}$ inches; height $1\frac{6}{10}$ inch.

Description.—This is a rare Urchin at Malta, and is found only in the lower bed No. 5, associated with *Scutella subrotunda*. The test is oblong, rather wider behind, and slightly produced anteriorly and posteriorly. The petaloid ambulacra are nearly uniform in width, and extend over more than one-half of the upper surface; the poriferous zones are narrow and unequal in length in the same ambulacra; the pairs of pores are oblique; the outer series are round, slit like the inner, and the connecting sulci are very distinct. The apical disk is small and a little excentral; the genital plates are small, and concealed by the spongy madreporiform body which covers them; the sides are tumid, the margin is much rounded, and the outer side of the base convex, becoming concave towards the mouth. The vent is wide, transversely oblong, and closely inframarginal. The peristome lies in a depression opposite the disk, but is unfortunately concealed by hard matrix.

Affinities and differences.—The oblong form, tumid sides, and shorter ambulacra distinguish this species from *E. hemisphæricus.* The convexity of the base, and equality in the width of the ambulacra, afford likewise good characters by which these two allied species may be distinguished from each other.

Stratigraphical position.—("This species is not at all uncommon in bed No. 5, but, from the hardness of the rock, is by no means easily extracted. I have often seen it, associated with *Scutella subrotunda.*" A. L. A.) It is found in the Molasse (Miocene) of several departments in France, and in the Canton of Neufchâtel, Switzerland.

Collections.—Museum of the Geological Society; my cabinet.

Genus Amblypygus, Agassiz, 1840.

Urchins in general large, with a depressed ovoid test and a rounded border; ambulacral areas unequal in width and length; poriferous zones very narrow, extending from the disk to the peristome; base concave and arched; mouth-opening near the middle; peristome oblique, angular, without any poriferous petals. Vent large, pyriform, situated at the base, between the mouth and the border. Apical disk small, nearly central, with four ovarian pores.

This genus resembles *Pygaulus* in the general form of the test, but is distinguished by the position of the vent, which always occupies the base between the peristome and the border; the poriferous zones are simple throughout, and are not petaloid around the peristome. The narrowness of the poriferous zones and the absence of oral lobes and petals serve to distinguish *Amblypygus* from *Conoclypus.* All the species are extinct, and found in the Tertiary rocks.

18. Amblypygus Melitensis, Wright, sp. nov. Pl. XXI. figs. 3*a*—3*c*.

Test elongated, depressed, border inflated; ambulacral areas narrow, unequal in width, the single ambulacrum narrowest; poriferous zones very narrow; pores a little more apart on the upper surface than at the border; base concave, arched in the antero-posterior direction; mouth-opening nearly central, oblique, and angular; vent oblong, occupying the space between the peristome and the border.

Dimensions.—Length $1\frac{1}{2}$ inch; breadth $1\frac{1}{5}$ inch; height $\frac{8}{10}$ inch.

Description.—This beautiful little Urchin might be mistaken for a *Pygaulus*, if the position of the vent were overlooked; it has a regular ovoid form, convex and depressed above, concave and arched below; the ambulacral areas are narrowly lanceolate and of unequal width, the ambulacrum being the smallest, and the anterior pair the widest. The poriferous zones are very narrow, and the pores appear to be a shade more apart on the upper surface than they are at the border or base. The interambulacra are likewise unequal in width, the sides are tumid, and the border is rounded. The base is convex at the sides, and concave towards the centre, where the two openings of the test are situated; it is likewise slightly arched from front to back. The peristome is nearer the anterior border; its form is indistinct from adherent matrix; it appears to be oblique and angular. The poriferous zones descend to the margin without doubling. The vent is large and oblong, one extremity approaching the peristome, the other reaching nearly to the border, and occupying much of the basal portion of the interambulacrum. The apical disk is small and excentral, with four ovarian pores; the tubercles are small, equal, and closely set.

Affinities and differences.—It resembles *A. apheles*, Ag., from the ferruginous Nummulitic bed at Verona; but it differs from that species in having the test a regular ovoid, not tapering behind, and in possessing a larger vent.

Stratigraphical position.—Collected from bed No. 1, the Upper Limestone, at Malta, where it is extremely rare.

19. Conoclypus plagiosomus, Agassiz.

Stratigraphical position.—"I have met with this Urchin pretty often in the red and yellow Sand-bed No. 2, chiefly in the redder portions. The specimen from No. 4 I am disposed to consider specifically identical with those from No. 2. It is rare, and when met with is usually seen in fragments. All I have found have been in the nodule-beds of No. 4. The difference in shape of the specimens in the collection is evidently the result of pressure." (A. L. A.)

Collections and localities.—Bristol Museum; Royal School of Mines; Earl of Ducie's Coll.; my cabinet. Balistro, Corsica; Molasse du Cap Couronne, près Martigues (Michelin); d'Alicante (Deluc); Faredjah and Santarieh, west of Egypt (Desor).

20. Hemiaster Cotteaui, Wright.

Stratigraphical position.—"Collected from bed No. 4, the Calcareous Sandstone, at Malta. I have not found it in any collection of Miocene fossils. What appears to me a specimen of this Urchin from No. 1 bed is, however, a very imperfect example. The specimens from beds Nos. 4 and 5 certainly belong to this species; should there be any doubt as to that from No. 1, we had better discard it and wait for more authentic information. *H. Cotteaui* is a common Urchin in No. 4, and is nearly always associated with *H. Scillæ*, especially in the weather- and surf-worn rocks around the harbour of Valetta, where it may be seen in groups on the shelving parts, with the ambulacral surfaces lying uppermost, as if the animals had died where they are now found. I may remark that this is generally the case with all Echinoderms of No. 4, excepting those in the nodule-beds, where the fossils are all jumbled together. It is met with in the nodule-beds, also in the upper portions of No. 5, where it is common." (A. L. A.)

21. Hemiaster Scillæ, Wright.

Stratigraphical position.—"This Urchin is common in No. 4 with the other species of the genus just named. It is also plentiful in the transition and upper portions of No. 5; but all the specimens I have met with hitherto from the latter bed have been very small. It is also common in the nodule-beds of No. 4." (A. L. A.)

22. Brissopsis Duciei, Wright.

Stratigraphical position.—"All the specimens have been collected from the Upper Limestone No. 1, and its white sandstone-stratum, where the Urchin is very uncommon." (A. L. A.)

Collections.—Earl of Ducie's Coll.; Museum of the Geological Society; my cabinet.

23. Brissopsis Grateloupi, Sismonda.

Stratigraphical position.—"This Urchin is common in bed No. 4, and its nodule-beds immediately overlying No. 5, associated with *Hemiaster Scillæ*, Wright, and *H. Cotteaui*, Wright. It is likewise found in the upper portion of No. 5." (A. L. A.)

Collections.—Museum of the Geological Society; my cabinet.

24. Schizaster Scillæ, Desmoulins.

Stratigraphical position.—If I am correct as to the determination of the specimens I have thus named, there are in Dr. Leith Adams's collection representatives from beds Nos. 1, 2, 4, and 5. The large specimens from No. 1 abound in the white calcareous sandstone-stratum of that bed, and are most usually associated with Oysters, Pectens, &c., to be noticed hereafter.

I have furnished a series of No. 1 specimens to show their gradation. The apical disk in several is much nearer the centre of the test than in others.

"This Urchin appears occasionally in the black and yellow sand at its passage into the subjacent clay (No. 3); the specimens are similar to those from No. 4, both in size and configuration, excepting one description, of which I have sent several specimens; in these the single ambulacrum is not nearly so broad; and I have not seen any from the calcareous sandstone or the overlying bed which equal in size those from No. 1. There are likewise several from the nodular bed of No. 4, all small or young specimens. The single individual from No. 5 is the only one I have seen. I procured it from the *Lower Limestone* at the fault or gorge of Air Selina, Gozo. Like the others it differs in some particulars from the type-specimens of the upper rock, and possibly I may be incorrect in my diagnosis, and have been confounding different species with each other." (A. L. A.)

Collections.—In almost all collections of Maltese Echinoderms.

25. Schizaster Parkinsoni, Defrance.

Stratigraphical position.—"Of this I have sent a series. There are specimens from No. 1, where it is rare. It is the most common Urchin in No. 4, where it will be seen there is some variety. I have found it not easy to distinguish at all times between specimens of *S. Desori* and this species. There are ten broken specimens from No. 5 bed, which I take to be this species; but in case of error I will attempt to procure more perfect individuals from that bed." (A.L.A.)

Collections.—Royal School of Mines; British Museum; Bristol Museum; Museum of the Geological Society; Earl of Ducie's cabinet.

26. Schizaster Desori, Wright.

Stratigraphical position.—"All my specimens are from No. 4 bed, where this Urchin is not uncommon, and is usually associated with *Hemiaster Scillæ*, *H. Cotteaui*, and *Brissopsis Grateloupi*, also *Schizaster Parkinsonii* and *Prenaster excentricus*." (A. L. A.)

Collections.—Common in all collections of Maltese Urchins.

Genus Brissus, Aristotle, Klein.

Large Urchins with an ovoid or elongated test; ambulacral summit very excentral, and ambulacrum rudimentary; anterior pair of ambulacra deeply sunk and nearly transverse; posterior pair forming an acute angle with the anterior pair and directed backwards, they are sinuous and concave; the peripetalous fasciole closely embraces the ambulacral pairs, and forms an arch on the anterior border; the subanal fasciole describes a cordate figure below the vent, which is large, oblong, and vertical. Apical disk small, four genital pores. Madreporiform body elongated between the plates. Mouth near the anterior border; peristome labiate on the posterior border. This genus comprises living and fossil species; the latter are found only in the Tertiary formations, and are chiefly of Miocene and Pliocene age.

27. Brissus latus, Wright.

Distinctive characters.—The breadth of the test; the depression of the upper surface; the depth of the ambulacra, the anterior pair being less transverse, and the posterior pair more expanded than in the other species; the ambulacral summit is more central, and the anteal sulcus deeper than in its congeners.

Stratigraphical position.—I have only found this Urchin in No. 1, and chiefly in the lower or coralline stratum, where in certain localities it is not uncommon, and usually met with in a fragmentary condition. Several good specimens have been found in the above stratum at the fault in Forn-i-riale Bay, where the accompanying specimens were discovered. What appear to be the spines of this Urchin are seen on the under surface of the broadest of the specimens.

Collections.—Museum of the Royal School of Mines; Earl of Ducie's cabinet; Museum of the Geological Society; and my cabinet.

28. Brissus cylindricus, Agassiz.

Stratigraphical position.—"Allowing for the effects of pressure, there is evidently some diversity in the configuration of the specimens, chiefly in the dorsal surfaces, which appear flatter in some than in others. This Urchin is common in the coralline stratum of No. 1, especially on certain cliff-exposures on the south coast. It is often associated with *Brissus imbricatus* (so named and sent). There does not appear to be any difference between the specimens from Nos. 1 and 5 in the collection.

"This Urchin is not uncommon in the upper portion of No. 5. The different colouring of the tests is the result of the colour of the rock. The white specimens were from the white stratum; the reddish from the red coralline limestone above the red sand, where the two blend almost imperceptibly; the darker, from the soft drab-coloured rock, often found overlying the clay, where No. 2 is seemingly wanting. The bed No. 2 is not apparently uniformly distributed over the Island.

"I have not hitherto met with this Urchin in any of the other beds." (A. L. A.)

Collections.—Museum of the Royal School of Mines and of the Geological Society; Marquis of Northampton's, the Earl of Ducie's, and my cabinet.

29. Brissus imbricatus, Wright. Pl. XXII. fig. 2.

Affinities and differences.—It differs from all the preceding species in having the anterior pair of petaloid ambulacra directed obliquely forwards and outwards, and with the posterior pair forming a St. Andrew's cross on the dorsum or upper surface. It differs from *Brissus Scillæ* in having a depressed test, with the base much more highly ornamented, and likewise in the direction of the anterior ambulacra.

Stratigraphical position.—Both specimens were collected from bed No. 1, the Upper Limestone, at Malta.

Collections.—The Bristol Museum contains the type, and the Museum of the Geological Society of London the most perfect specimen.

30. Brissus tuberculatus, Wright, sp. nov. Pl. XXII. fig. 1.

Test ovoid, depressed, tapering behind; the two pairs of petaloid ambulacra long, narrow, lanceolate, and extending over two-thirds of the dorsum; anterior pair curved forwards, posterior pair directed outwards and backwards; poriferous zones wide, depressed; interporiferous zone convex; peripetalous fasciole narrow; anterior border, sides, and upper surface, within and without the peripetalous fasciole, covered with large crenulated and perforated tubercles, among which smaller ones are scattered; no anteal sulcus; posterior border slightly truncated; vent large, oblong; subanal fasciole having a cordate figure beneath the opening.

Dimensions.—Length 5 inches; breadth $4\frac{1}{2}$ inches.

These measurements are only approximate, as the two specimens I have are both much distorted.

Affinities and differences.—This species differs from all the other Miocene species of *Brissus* in having much larger tubercles on its upper surface: from *B. latus*, Wright, in having the ambulacra level with the surface, and no anteal sulcus; the same characters distinguish it from *B. cylindricus*, Ag.; and it differs from *B. imbricatus*, Wright, in having large tubercles *without* as well as within the peripetalous fasciole. The tuberculated character of the upper surface is a good diagnostic character. The imperfection of the only two fragments I possess prevents a more extended comparison with other forms.

Stratigraphical position.—Collected from bed No. 1, in a marly stratum of the Upper Limestone, at Malta.

Collections.—My cabinet.

31. Pericosmus latus, Agassiz.

Stratigraphical position.—Collected at Malta from bed No. 4, both from the calcareous sandstone and its nodule-beds; the specimens from the sandstone have their fascioles well preserved. I have one specimen from the Miocene of Corsica.

Collections.—Museum of the Geological Society; my cabinet.

32. Toxobrissus crescenticus, Wright.

Stratigraphical position.—Collected at Malta, from the calcareous sandstone of bed No. 4. I know only the specimen I figured in the Ann. and Mag. Nat. Hist. 2nd series, vol. xv. pl. 6. fig. 1, and which is in my cabinet.

Genus Prenaster, Desor, 1853.

Urchins with an ovoid inflated test, and the ambulacral summit very excentral. Petaloid ambulacra very little depressed, nearly level with the surface, very divergent, and often even perpendicular; anteal sulcus nearly obliterated. Peripetalous fasciole incomplete, absent from the anterior border. Lateral fasciole entirely encircling the lower border of the test. The species are all extinct, and found in the Upper Cretaceous rocks and in the Eocene Tertiaries. Our species from Malta is the only one yet catalogued from the Miocene deposits.

33. Prenaster excentricus, Wright. Pl. XXII. fig. 3.

Stratigraphical position.—The specimens, which are all much compressed, were collected from bed No. 1 at Malta.

Collections.—Museum of the Geological Society; Royal School of Mines; the Earl of Ducie.

34. Eupatagus Konincki, Wright. Pl. XXII. figs. 5 *a*—5 *c*.

Affinities and differences.—This species is distinguished from *E. ornatus*, Defr., in being smaller, having fewer large tubercles within the peripetalous fasciole, and being more elevated behind; the basal tubercles and the pairs of interambulacra are likewise smaller and more numerous.

Stratigraphical position.—"This Urchin is common in bed No. 4, and in its nodule-bed also in the upper portions of No. 5." (A. L. A.)

35. Spatangus ocellatus, Defrance. Pl. XXI. figs. 1 *a*, 1 *b*.

Affinities and differences.—This Urchin was described in my memoir on the Maltese Echinoderms as *S. Hoffmanni*, Goldf., in consequence of *S. ocellatus*, Defr., having been sent to me from Belgium as *S. Hoffmanni*; this occasioned the error in my determination. *S. Nicoleti*, Agass., from the Molasse of Chaux-de-fonds, is stated by M. Desor to be identical with *S. ocellatus*, Defr. This species is so remarkable for the size and depth of the areolas of the large tubercles on the upper surface of the test, from the centre of which the tubercles are elevated on pillars, that it is readily distinguished from its congeners by this character. One other species, *S. Pareti*, Ag., has similar deep areolas, but the petaloid areas are relatively narrower, and the poriferous zones are very nearly as wide as the interporiferous spaces.

Stratigraphical position.—Collected by the Earl of Ducie from the calcareous sandstone of bed No. 4, where it is not abundant.

Collections.—Earl of Ducie's collection; my cabinet.

36. Spatangus delphinus, Defrance. Pl. XXII. figs. 4 *a*, 4 *b*.

Spatangus delphinus, Defrance, Dict. Sc. Nat. 1827, tom. l. p. 96.
Spatangus Corsicus, Desor, Cat. Raisonné, 1846, p. 113.
Spatangus Desmaresti, Wright, Ann. and Mag. Nat. Hist. 1855, vol. xv. p. 18.
Spatangus delphinus, Desor, Synopsis des Echinides Foss., 1858, p. 421.

Test large, inflated, short, cordate, and carinated; petaloid ambulacra long and narrow, the external poriferous zone of the anterior pair much arched, narrow at the upper half, and nearly obsolete at the summit; test much inflated before, with a wide anteal sulcus; a broad ridge extends from the disk to the posterior border, which is broadly and sharply truncated; ambulacral summit very excentral; disk small, with four ovarian holes; a few large tubercles in rows in all the interambulacra, the small tubercles very closely set together; vent large, transversely oval, in the upper part of the truncated section; base plano-convex; peristome, in the anterior third, large, labiate, and transversely oblong.

Dimensions.—Antero-posterior diameter $4\frac{1}{5}$ inches; transverse diameter $4\frac{1}{4}$ inches; height $2\frac{1}{5}$ inches.

Description.—This large Urchin was so imperfectly described by Defrance, who gave no figure of it, that it was long overlooked. Many examples resemble so much *S. Desmaresti*, Goldf., that they were considered to be identical with it; under this impression it was described by that name in my memoir on the Maltese Echinoderms. The test is broader than long, elevated, flattened, and inflated before, and broadly truncated behind; a blunt ridge runs from the disk to the posterior border. The petaloid areas forming the ambulacral star are long, narrow, and biflexed; the external poriferous zone of the anterior pair is much arched forwards and flexed outwards; the pores are small in the upper half of the zone, and near the summit they form a simple row of minute holes. In the external zone of the posterior pair the holes are likewise small. The dorsal surface of the interambulacra between the petaloid areas supports two or three irregular rows of larger tubercles, which are proportionately greater in small specimens. The other parts of the upper surface are studded with small close-set tubercles, and the general surface of the intertubercular spaces is covered with a fine granulation. The anterior border is very flat, the anteal sulcus broad and deep, and the pores of the ambulacrum invisible. Behind the small apical disk, with its four ovarian holes, a blunt arched ridge extends to the posterior border, which is broadly and sharply truncated; in the upper half of this space the large transversely oval vent is found. The base is flat; the plastron has a raised ridge in the middle line, and the basal portion of all the interambulacra are covered with large tubercles; the naked spaces on each side of the plastron correspond with the posterior ambulacra.

Affinities and differences.—*S. delphinus* resembles *S. Desmaresti*, but is proportionately shorter and broader; the petaloid ambulacra are longer and narrower, and the external rows of the poriferous zones have smaller pores near the summit; the dorsal ridge is much more arched and prominent, and the truncation of the posterior border much greater.

Locality and Stratigraphical position.—A large specimen has been obtained from the No. 1 (the Upper Limestone), and a smaller form from No. 2 (the yellow sand) at Malta.

M. Defrance's specimen came from the Molasse of St.-Paul-Trois-Châteaux.

Collections.—Museum of the Geological Society; my cabinet.

37. SPATANGUS PUSTULOSUS, Wright, sp. nov. Pl. XXI. fig. 2.

Test cordate; anterior border widely grooved; anteal sulcus deep; petaloid ambulacra long, nearly equal, and concave; the five upper plates of all the interambulacra with groups of large tubercles on each; apical disk small, excentral; four genital pores; posterior border truncated; base rounded before, with a prominent convex plastron.

Dimensions.—Antero-posterior diameter $1\frac{7}{10}$ inch; transverse diameter $1\frac{6}{10}$ inch; height $\frac{9}{10}$ inch.

Description.—The wide groove in the front border, and the groups of large pustular-looking tubercles on the five uppermost plates of all the interambulacra, form the diagnostic characters of this species. The petaloid ambulacra are nearly equal in size; they are long, straight, and concave, the anterior pair being gently flexed forwards and outwards, whilst the posterior pair are directed backwards. The poriferous zones are half as wide as the internal spaces; the small apical disk is excentral, with four ovarian holes, the spongy madreporiform body occupying the middle; the surface of the plates is covered with very small tubercles set closely together, which contrast strongly with the large dorsal tubercles of the interambulacra; the posterior border is slightly truncated, and the vent occupies the upper half of the section; the base is slightly convex anteriorly, but largely so posteriorly; from the prominence and convexity of the plastron, the true position of the peristome cannot be ascertained in consequence of the fracture in the base of the most perfect specimen.

Affinities and differences.—The diagnosis of this species has been already pointed out; it differs from all its known congeners in the width of the groove, in its anterior border, and the regular grouping of its large tubercles.

Locality and Stratigraphical position.—Collected from bed No. 4. The only specimens I know are those belonging to the Museum of the Geological Society.

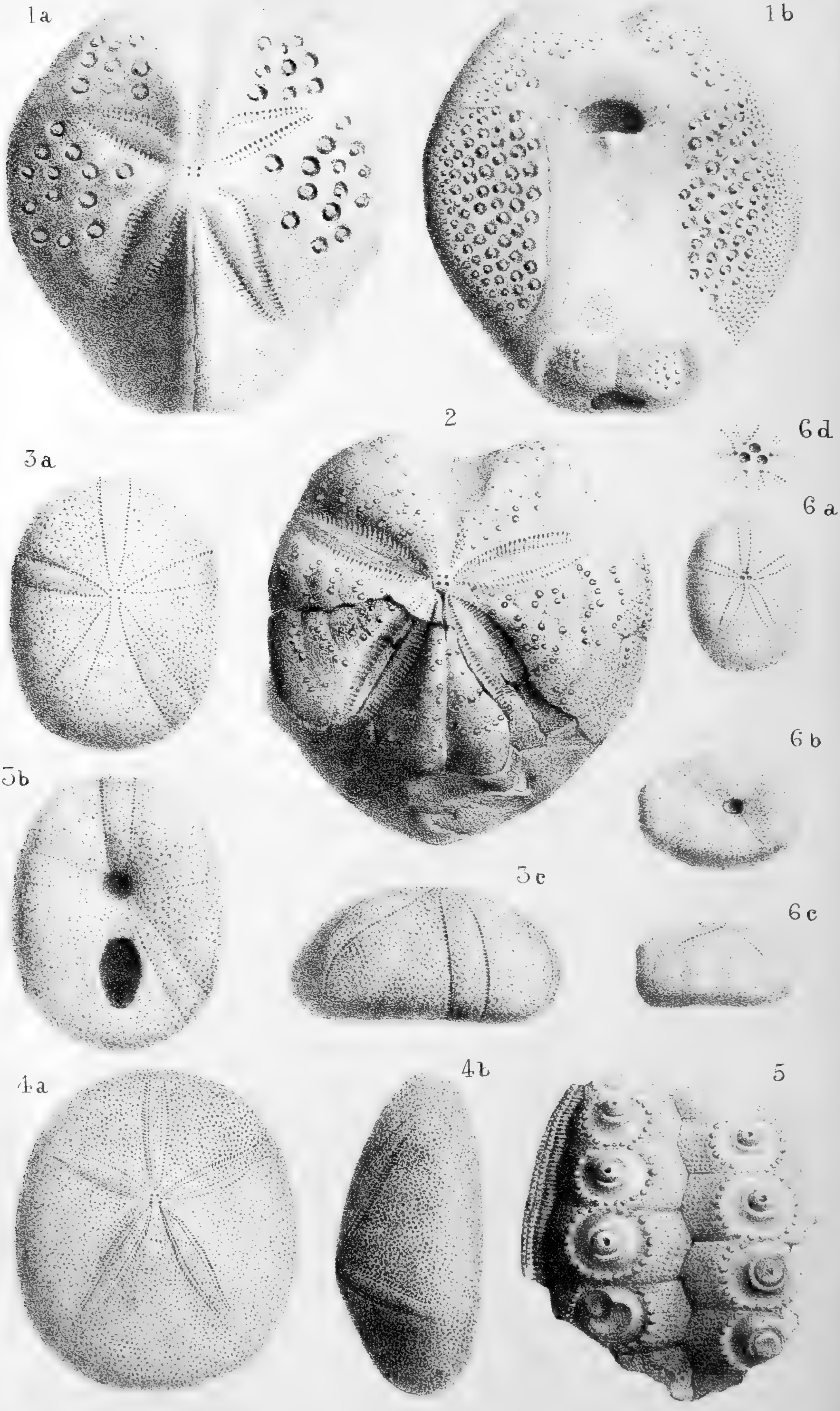
III. *Table of the* Stratigraphical Distribution *of the* Echinoderms. By Dr. Wright, F.R.S., F.G.S.

Genera and Species.	No. 1. Upper Limestone.	No. 2. Sand-bed.	No. 3. Marl.	No. 4. Calc. Sandstone.	No. 5. Lower Limestone.
Cidaris Melitensis, *Forbes*	*				*
—— Scillæ, *Wright*				*	
—— Adamsi, *Wright*					*
Psammechinus Duciei, *Wright*	*			*	*
—— Scillæ, *Wright*	*				
Clypeaster altus, *Leske*		*			
—— tauricus, *Desor*	*				
—— marginatus, *Lamarck*		*			
—— Reidi, *Wright*	*				
—— portentosus, *Desmoulins*		*			
—— latirostris, *Agassiz*					*
Scutella subrotunda, *Leske*					*
Pygorhynchus Vassali, *Wright*				*	
—— Spratti, *Wright*				*	
Echinolampas Hayesianus, *Desor*		*			
—— Laurillardi, *Agassiz*			*	*	
—— hemisphæricus, *Lamarck*	*				
—— scutiformis, *Leske*					*
Amblypygus Melitensis, *Wright*	*				
Conoclypus plagiosomus, *Agassiz*		*		*	
Hemiaster Cotteaui, *Wright*				*	*
—— Scillæ, *Wright*				*	*
Brissopsis Duciei, *Wright*	*				
—— Grateloupi, *Sismonda*				*	*
Schizaster Scillæ, *Desmoulins*	*	*		*	*
—— Parkinsoni, *Defrance*	*			*	*
—— Desori, *Wright*				*	
Pericosmus latus, *Agassiz*				*	
Toxobrissus crescenticus, *Wright*				*	
Prenaster excentricus, *Wright*	*				
Brissus latus, *Wright*	*				
—— cylindricus, *Agassiz*	*	*			*
—— imbricatus, *Wright*	*				
—— tuberculatus, *Wright*	*				
Eupatagus Konincki, *Wright*				*	*
Spatangus ocellatus, *Defrance*				*	
—— delphinus, *Defrance*	*	*			
—— pustulosus, *Wright*				*	

EXPLANATION OF PLATES XXI. AND XXII.

Plate XXI.

Fig. 1 *a*. *Spatangus ocellatus*, Defrance. Upper surface, natural size.
1 *b*. —— ——, Defrance. Under surface, natural size.
2. —— *pustulosus*, Wright. Upper surface, reduced one-half.
3 *a*. *Amblypygus Melitensis*, Wright. Upper surface, natural size.
3 *b*. —— ——, Wright. Under surface, natural size.
3 *c*. —— ——, Wright. Lateral view, natural size.
4 *a*. *Echinolampas scutiformis*, Leske. Upper surface, reduced one-half.
4 *b*. —— ——, Leske. Lateral view, reduced one-half.
5. *Cidaris Adamsi*, Wright. Interambulacral areas, natural size.



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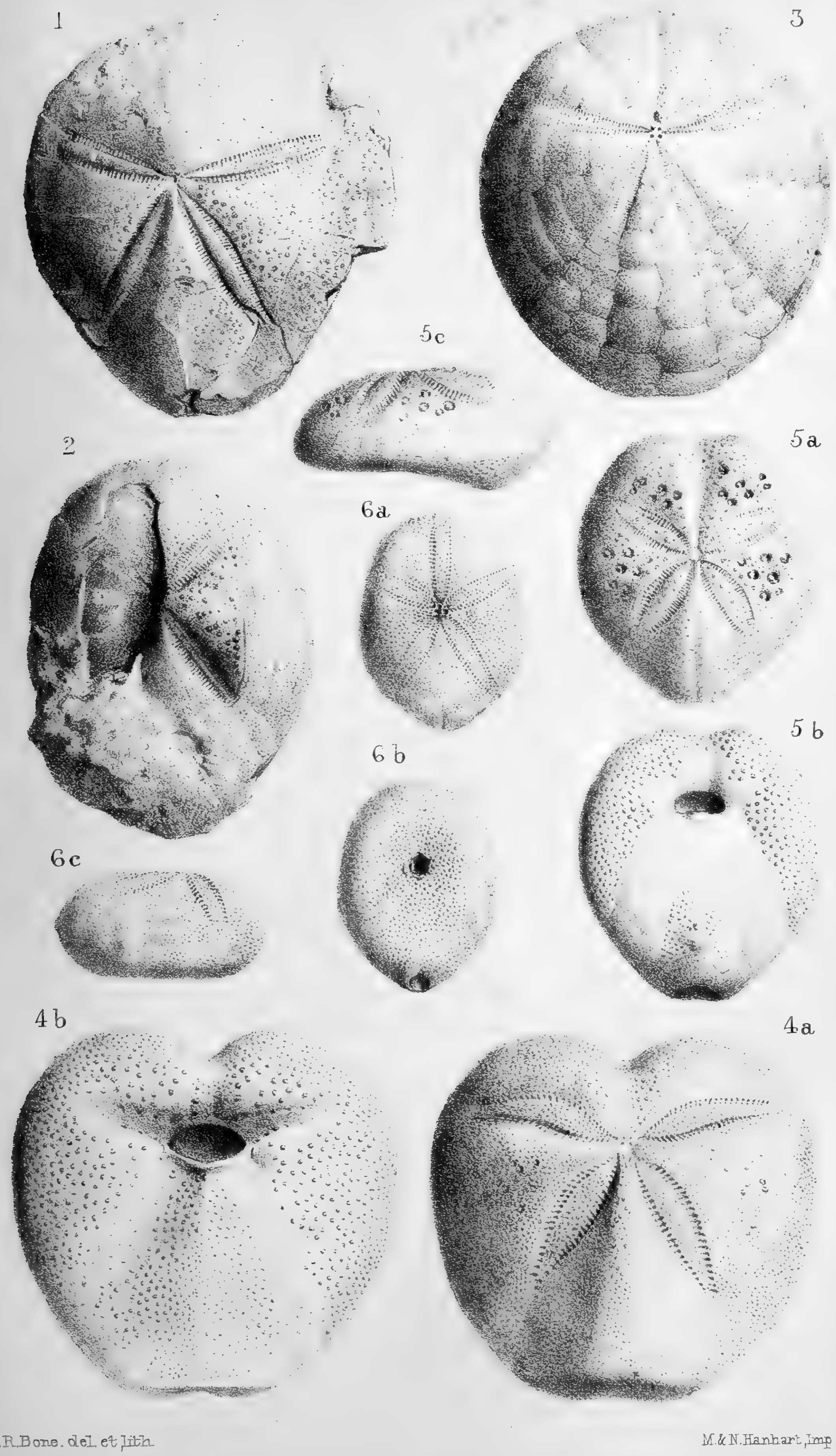

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Fig. 6 *a*. *Pygorhynchus Spratti*, Wright. Upper surface.
6 *b*. —— ——, Wright. Under surface, magnified.
6 *c*. —— ——, Wright. Lateral view, magnified.
6 *d*. —— ——, Wright. Apical disk, magnified.

Plate XXII.

Fig. 1. *Brissus tuberculatus*, Wright. Upper surface, reduced one-half.
2. —— *imbricatus*, Wright. Upper surface, reduced one-half.
3. *Prenaster excentricus*, Wright. Upper surface, natural size.
4 *a*. *Spatangus delphinus*, Defrance. Upper surface, reduced one-half.
4 *b*. —— ——, Defrance. Under surface, reduced one-half.
5 *a*. *Eupatagus Konincki*, Wright. Upper surface, natural size.
5 *b*. —— ——, Wright. Under surface, natural size.
5 *c*. —— ——, Wright. Lateral view, natural size.
6 *a*. *Pygorhynchus Vassali*, Wright. Upper surface, natural size.
6 *b*. —— ——, Wright. Under surface, natural size.
6 *c*. —— ——, Wright. Lateral view, natural size.

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THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE TWENTIETH.

1864.

PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the Names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the FUSION *of* CARBONATE *of* LIME, *and on the* PRODUCTION *of* ARTIFICIAL MARBLE. By HERR GUSTAV ROSE.

[Ueber die Schmelzung des kohlensaures Kalkes und Darstellung künstlichen Marmors. Von Herrn Gustav Rose.—Poggendorff's Annalen, Band cxvii. p. 565, 1863.]

IN this paper Professor Gustav Rose gives an account of a series of new and variously modified experiments which he has made, with the object of testing the truth of Sir James Hall's conclusions upon the formation of marble*. He concludes as follows:—

"These experiments were attended with many difficulties: it was at first not easy to find a material which, when exposed to a great heat, would be impervious to the aëriform bodies given out by the enclosed substances; that is, the material might be so to a certain extent, but it was not safe to venture very far; for the crucible or tube became softened, and there was a danger that no effect whatever would be produced upon the carbonate of lime. It is, therefore, to a great extent, a matter of accident whether the experiment succeeds or not. Nevertheless it did succeed in several instances; *and these successful experiments were quite sufficient to confirm the conclusions to which Sir James Hall arrived, namely, that carbonate of lime, when exposed to a great heat under pressure, is changed into marble.* Although the marble obtained from pieces of lithographic limestone and chalk was finer grained than that of Carrara, it was so, likewise, when pieces of arragonite were operated upon; and the result was most certainly the same, under favourable circumstances, whether limestone or chalk was used. It seems, therefore, probable that all marbles which form beds in mica-slate and clay-slate, or which are in the immediate vicinity of granite or basalt, must be held to have been ordinary limestone or chalk which had been altered by heat. The marble found in proximity with chalk on one side, and with a basaltic dyke on the other, near Belfast, closely resembles the grey product of the lithographic limestone."

[L. H.]

* Respecting the former opinions of Professor Gustav Rose on this subject, see Mr. Horner's Anniversary Address to the Geological Society, on February 15, 1861, Quarterly Journal of the Geological Society, vol. xvii. p. xlii.

On some new Genera *of* Fossil Fishes. By Prof. Kner.

[Proceed. Imp. Acad. Vienna, April 28, 1863.]

Amongst the fossil Fishes of the Neocomian strata of Comès, near Gorizia, Professor Kner has recently discovered the types of two new genera. One of them, *Amiurus pretiosus,* is characterized by the presence of an intercalar caudal vertebra, and is therefore nearly related to the genus *Amia,* which still exists in North America. The other, *Scombroclupea pinnata,* has the conformation of the mouth, the characters of the scales, and the ventral carinæ characteristic of the family of the *Clupeïdæ,* while the presence of "pinnulæ" behind the anal fin shows its close relationship to the *Scomberoïdæ.* A Gadoïd related to the genus *Brosmius* has also been found, with other fossil Fishes, in the Tertiaries of Pod Sused (Croatia). [Count M.]

On the Terrestrial Faunæ *of the* Vienna Basin. By Prof. Suess.

[Proceed. Imp. Acad. Vienna, May 15, 1863.]

The careful study of the aquatic faunæ within this Basin has enabled the author to show that local freshwater deposits have been followed first by marine, then by brackish deposits, and that the whole series has been ended by the deposition of lacustrine sediments. The remains of Mastodons, Dinotheria, and other Mammals, as Horses, Pigs, and Tapirs, buried in the first three of the above-named deposits, are indicative of an unchanged association of genera, and even species, during the whole period. The terrestrial fauna of the lacustrine epoch, although of the same general character as that of the preceding periods, is yet characterized by notable specific differences. The first of these terrestrial faunæ is identical with those of Sansons, Georgensgemünd, Oeningen, &c.; it may have begun simultaneously with the formation of the strata of the Vienna Basin, and so have ended with the great upheaval of the Tertiaries, the traces of which are visible in Switzerland. The second terrestrial fauna of the Vienna Basin corresponds with those of Eppelsheim, Athens, &c. A fauna of still later date than this, evidences of which occur in the Val d'Arno, near Florence, has not yet been traced within the area of the Vienna Basin; nor is its existence there very probable, as stratigraphical facts prove that the extent of dry land which then existed in that area was too considerable to have left any space for notable aqueous deposits. The last terrestrial fauna of the Vienna Basin, characterized by the remains of *Elephas primigenius* and *Rhinoceros tichorhinus,* as well as (in contemporaneous sediments) *Reindeer* and *Musk-ox,* is of "Diluvial" age.

[Count M.]

On the Foraminifera *of the* Vienna Basin. By Herr Karrer.

[Proceed. Imp. Acad. Vienna, June 18, 1863.]

The sand and plastic clay ("Tegel") strata of this Basin include a peculiar, well-characterized, and independent Foraminiferan fauna. Although less rich than the more ancient and strictly marine fauna, it is remarkable for the continuity of its appearance and the immense number of individuals sometimes composing it.

The brackish-water Foraminifera may be said to be a selection from those in the marine deposits, and they neither include any new generic nor even specific types. The greater portion of them belong to the most minute and least conspicuous groups; but their chief representatives (*Nonionina, Polystomella,* and *Rosalina*) are members of families characterized by the complicated structure of their shells. As a whole, the fauna in question stands next to that of the Nullipore-marls. The bottom of the Tertiary sea having been upheaved previously to the appearance of these Foraminifera, they could not have lived at considerable depths. Consequently deep-sea forms are not found among them, although there are specific differences essentially connected with the variations of level. The plastic clay of Herrnals, corresponding to the deeper level of brackish deposits, is characterized by the presence of *Triloculinæ, Quinqueloculinæ, Nonioninæ,* and *Rosalinæ,* while the Cerithium-sands deposited at lower levels nearer to the shore contain immense accumulations of *Polystomellæ.* The Foraminiferan fauna runs, therefore, in a parallel with the long-known Molluscan fauna of the Viennese brackish Tertiaries. [Count M.]

On the Lead- *and* Zinc-ores *of* Carinthia. By Herr Lipold.

[Proceed. Imp. Geol. Instit. Vienna, April 7, 1863.]

According to the latest investigations, the strata containing deposits of these ores belong to the Hallstatt strata, and not, as has hitherto been believed (chiefly on account of the occurrence in them of *Megalodus triqueter*), to the Lower Liassic Dachstein-strata, which, indeed, could only be accounted for by supposing enormous disturbances and dislocations to have taken place. It may be remarked that the specimens of *Megalodus triqueter* from the metalliferous strata of Bleiberg are one inch, and less, in diameter, while those from the genuine Dachstein-limestone attain a size of from two to three inches, or more, in diameter. It may be inferred that the species in question appeared first during the Hallstatt (Upper Triassic) period, but became fully developed only in the Dachstein (lowermost Liassic) period. The deposits of lead- and zinc-ores in Carinthia are either coeval with the Hallstatt strata including them, or secondary, having been formed by chemical or mechanical agents at the expense of the pre-existing interstratified deposits. These secondary deposits appear in the form of veins—fragments of ores and limestone,—mixed with a yellow clay, having filled up crevices pre-existing in the Guttenstein (Older Triassic) strata. It has been stated that such veins occur only beneath the stratified (primary) metalliferous deposits, that they are frequently cut off by planes of stratification, and that they constantly grow narrower and at last disappear in depth. The same phenomena have been shown, through M. Gümbel's careful observations, to occur among the lead- and zinc-ore deposits in the Alps of Bavaria. [Count M.]

On the Relations *between the* Fossil *and the* Existing Species *of* Hyæna. By M. A. Gaudry.

[Sur les liens que les Hyènes fossiles établissent entre les Hyènes vivantes ; par Albert Gaudry. Bulletin de la Société Géologique de France, deuxième Série. Juillet 1863, vol. xx. p. 404.]

There are three recent species of Hyæna—the spotted, the striped or common, and the brown. The first two differ so much as regards their dentition as to lead many naturalists to consider the spotted species entitled to a place as a subgenus under the designation of *Crocotta*. This Hyæna (*Hyæna crocuta*, Schreb.) has a small tubercular upper carnassial tooth, and its lower carnassial has no internal denticule in contact with the second lobe; on the contrary, the Striped Hyæna (*Hyæna vulgaris*) has the upper carnassial largely tuberculated, and the lower possesses an internal denticule. The Brown Hyæna (*Hyæna villosa*, Smith; *Hyæna fusca* auct.) is intermediate between these two extremes, for it has the large tuberculated upper carnassial, but the internal denticule of the lower is rudimentary. The author states that he is acquainted with several fossil Hyænas, one of which, the Hyène de Montpellier, is so closely allied to the recent *Hyæna vulgaris* that it is not unreasonable to admit their specific identity; another, the Cave Hyæna, is closely allied to the recent Spotted Hyæna; and, finally, the Hyæna of Pikermi (*Hyæna eximia*) enters into the group of *Hyæna fusca*, and is still more intermediate between *H. crocuta* and *H. vulgaris* than that species, for while it has a large tuberculated upper carnassial, the lower has no rudiments of a denticule. The magnificent head of *Hyæna brevirostris*, found near Puy by M. Aymard, presents the same peculiarities in its dental arrangement as the Grecian species.

[P. M. D.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Demarcation *of the* "Oligocene" Division *of the* Tertiary Period. By Prof. Beyrich.

[Ueber die Abgrenzung der Oligocänen Tertiärzeit. Von Herrn Prof. Beyrich. Berichte der königlichen Akademie der Wissenschaften zu Berlin, 1858, pp. 51—69.]

In a communication made by Professor Beyrich to the Academy of Sciences at Berlin, in 1854, on the age of the Tertiary beds of Hesse*, the term "Oligocene" was proposed for a division of the Tertiary period, to which belong most of the Tertiary beds in Northern Germany, certain of those in Central Germany, and also the members of the so-called Mayence Basin. In a more recent memoir, written chiefly as an explanation of a geological map of Northern Germany†, he described the probable extension of the various Tertiary formations of that area, and endeavoured to prove their connexion with those of like age in other districts. Since the appearance of the latter memoir, and partly simultaneously with it, the question of the most convenient Tertiary nomenclature, and the more important one of the natural limits of the Oligocene period, have been so often discussed by other authors, and in such different modes, that Professor Beyrich in the present communication has endeavoured to give a general and critical review of the opinions of geologists upon these subjects.

The middle term of the Oligocene series includes the "Fontainebleau Sands"—the youngest marine member of the Paris Basin,—about the classification of which (whether in the Eocene or the Miocene period) there has been so much discussion. Professor Beyrich gives a brief sketch of this discussion, and of the investigations which led to the adoption of the terms Eocene, Miocene, and Pliocene, proposed by Sir Charles Lyell, and then proceeds to show that more recently this discussion has been revived, and has acquired a greater interest and importance, in consequence of its having gradually become known that beds of like age, containing a peculiar and rich fauna, occurred very extensively in other European regions; and while it was admitted on all hands that these beds should have a definite and determined position in one of the great divisions of the Tertiary period, the old question of "Eocene or Miocene" was altered in this new dispute, at first to that of whether all these beds should be classed as

* Berichte der k. Akad. der Wissenschaften zu Berlin, 1854, pp. 640 *et seq.*

† "Ueber den Zusammenhang der norddeutschen Tertiärbildungen, &c.," Abhandl. der k. Akad. der Wissensch. zu Berlin. Aus dem Jahre 1855, pp. 1 *et seq.*

Upper Eocene or as Lower Miocene, and at last to that of the desirability of instituting a fourth principal division of the Tertiary period for their reception.

The only reason why the equivalents of the Fontainebleau Sands had not been made known before was the incomplete knowledge which formerly existed of the organic contents of that formation; but this want has since been removed by the publication of Deshayes's great work on the Tertiary Shells of the Environs of Paris. It should not, however, be forgotten that, in the general remarks at the conclusion of that work, M. Deshayes does not express any decided opinion of the age of the Mayence Basin, which is contemporaneous with the Fontainebleau Sands, but merely observes that the former probably belongs to the Middle-Tertiary period, from which, however, he excludes the latter. So also Bronn*, after an examination of a great number of Shells from the Mayence Basin, came to the conclusion that they indicated a high Miocene horizon.

In the introduction of the later work of M. Deshayes†, that author describes how the railway-works near Étampes have contributed to our knowledge of the fauna of the Fontainebleau Sands, chiefly through the exertions of MM. Raulin and Hébert, and thus to the determination of the parallelism of that formation with Tertiary beds of other districts, more especially its correlation, as determined by Hébert‡, with a part of the Belgian Tertiary formation, the Shells from which had been already described by M. Nyst. Thus Sir Charles Lyell was enabled§ to draw up a scheme of a classification of the Tertiaries of Belgium and French Flanders, in which the Fontainebleau Sands were referred to the middle portion of the Upper Eocene period; and this memoir was the foundation of the rapid progress made so soon afterwards towards a better understanding of the German Tertiaries.

Shortly afterwards, in 1853, Dr. Fridolin Sandberger showed|| the close relationship of the Mayence beds to those of Belgium, which were considered Upper Eocene by Sir Charles Lyell. Previously to this, it had been shown that the Hermsdorf Clay was of the same age as that of Boom and Basele in Belgium, and that the interpretation of the remaining beds of Northern Germany must be arrived at through the study of the Belgian Tertiaries. In 1853, in the introduction to his work on the Tertiary Shells of Northern Germany, Professor Beyrich was the first to show the connexion of the German Tertiaries, according to their received relations, with those of Belgium according to the new classification of Sir Charles Lyell; but it was only in 1854 that he was enabled, through the investigation of the clay which occurs south of Antwerp and near Berlin, as well as at Cassel, where it overlies freshwater beds containing layers of brown coal, which are connected with the younger beds of the Mayence

* Leonhard und Bronn's Neues Jahrbuch, 1837, pp. 153 *et seq.*

† Descr. des Animaux sans vertèbres découverts dans le Bassin de Paris, 1857, p. 16.

‡ Bull. Soc. Géol. de France, deuxième série, vol. vi. pp. 459 *et seq.*

§ Quart. Journ. Geol. Soc. vol. viii. pp. 277 *et seq.*

|| Untersuchungen über das Mainzer Tertiärbecken.

Basin, fully to make out the correlation of the Tertiary formations of the Mayence Basin, Belgium, and Northern Germany.

Swiss geologists had for some time been well aware * that certain of the beds in the valleys of the Northern Jura and in the neighbourhood of Basel corresponded with the deposits of the Mayence Basin; and this fact was, in 1855, rendered still more certain by M. Hébert, who published a catalogue of the Shells of the Delsberg district †, comparing them with those of France, Germany, and Belgium.

As a general result of these various researches, besides different views on special points, there are two general conclusions of the greatest importance, and the truth of which can no longer remain in doubt: namely, (1) that during the deposition of the Fontainebleau Sands the sea was inhabited by a peculiar and rich fauna, equally distinct from that which existed before it and that which succeeded it; (2) that the beds contemporaneous with the Fontainebleau Sands, and those which most nearly approximate in age to them, occur in particular areas, which do not correspond with the areas of occurrence of the older deposits, or with those of the newer. Professor Beyrich then observes that, in his opinion, these two facts not only justify, but also render necessary the establishment of a great division of the Tertiary period for the reception of these strata,—that is, if the general classification of the Tertiary formations is to remain in accordance with our knowledge both of the changes in the organic contents of the strata and the alterations in the physical features of the earth's crust during their deposition; and he, therefore, felt himself justified in establishing an "Oligocene" period as already noticed.

In support of his view, and to show that the necessity of such a subdivision had been recognized before the reading of his paper in which he first used the term, he cites the memoir on the Tertiaries of Northern Europe by M. Hébert ‡, already noticed, who considered the evidence so strong in favour of M. Elie de Beaumont's earlier view of the age of the Fontainebleau Sands, that he observed that, if Sir Charles Lyell considered that formation an essential part of his "Eocene," the terms "Eocene," "Miocene," and "Pliocene" must be abolished. At the same time he remarked that it would probably be better to divide the Tertiary formations into four great groups instead of three, if it could be shown that the extension of the sea at the time of the deposition of the Faluns of Touraine differed as much from that during the deposition of the Fontainebleau Sands as during that of the Calcaire grossier.

On other grounds, Deshayes arrived §, in 1857, at a very similar conclusion; for, while he admitted that the very peculiar fauna of the Fontainebleau Sands contained but few species in common with the Calcaire grossier, yet he considered that it presented a still greater contrast to that of the Faluns of Touraine, and he added, "si nous avions à nous prononcer et à formuler une opinion conforme aux faits

* Studer's Geologie der Schweitz, vol. ii. 1853, p. 403.

† "Note sur le terrain tertiaire moyen du nord de l'Europe," Bull. Soc. Géol. de France, deuxième série, 1855, vol. xii. p. 762.

‡ *Ibid.* p. 771.

§ Animaux sans vertèbres du Bassin de Paris, Introduction, p. 17.

tels que nous les concevons, nous admittrions pour les sables de Fontainebleau un quatrième membre parmi les terrains tertiaires aussi indépendant de l'étage moyen que de l'étage inférieur."

Again, in 1857, Herr Karl Mayer, of Zurich, published a tabular view of the European Tertiaries, in which he divided them into three groups, the middle corresponding to the Oligocene, and the upper to the "Neogene" of Hörnes, including the Miocene and the Pliocene.

Recently Sir Charles Lyell* has altered his view of the boundary-line between Eocene and Miocene, so as to bring it in accord with that of M. Elie de Beaumont, and he now calls "Upper Miocene" what was formerly his "Miocene," and "Lower Miocene" what used to be called "Upper Eocene." Professor Beyrich believes that this change entails certain consequences, the knowledge of which had probably withheld Sir Charles Lyell from adopting this view before, and which are connected with the question, Where is naturally the boundary between the Oligocene and the Eocene?

As regards the Paris Basin, it is well known that the Fontainebleau Sands are separated, on the one hand, from the Calcaire grossier by the freshwater Paris Gypsum, and, on the other hand, from the younger beds of Touraine by the freshwater limestone known as the "Calcaire de la Beauce." The occurrence of these freshwater formations is alone sufficient to prove that considerable local changes in the relations of land and sea occurred at the beginning and at the end of the deposition of the Fontainebleau Sands; but it leaves open the question whether those changes were contemporaneous with the general alterations in the configuration of the continent, through which the dissimilar distribution of the three principal Tertiary groups resulted. As regards the Paris Basin, the question also stands thus:—If the Fontainebleau Sands be termed Oligocene, is the freshwater formation with the Gypsum of Montmartre to be called Eocene or Oligocene?—and is the Calcaire de la Beauce to be considered Oligocene or Miocene? The answer cannot be obtained by a study of the relations of the Paris beds alone, but naturally only by a comparison of them with the strata of other districts, where the French freshwater beds are represented partly by brackish-water and partly by marine formations. Such formations occur in Belgium, the North of Germany, and the South of England.

In Belgium, the beds considered to belong to the Oligocene period form so closely connected a series, that Sir Charles Lyell substituted for Dumont's terms "Tongrien" and "Rupélien" a single designation, calling them the "Limburg Beds;" but a freshwater formation similar to the Paris Gypsum does not exist. Professor Beyrich then observes that the uppermost formation—the Bolderberg deposit—belongs to the Miocene period, and the lowermost strata—the Laeken Beds—are doubtfully Eocene, so that it is very probable that the Belgian beds not only include the period of the Fontainebleau Sands, but also that of the freshwater Paris Gypsum and that of the Calcaire de la Beauce; but he remarks that the different distribution of the

* Supplement to the Fifth Edition of a Manual of Elementary Geology, 1857, pp. 5 *et seq.*

organic remains in the members of the Belgian Oligocene furnishes evidence that in them is developed a palæontological division into parts, which does not exist in the Fontainebleau Sands, and that they decide only in part the question of the time-equivalent of this French marine formation.

M. Hébert's Catalogue of Shells common to the Fontainebleau Sands and the Belgian Tertiaries comprises 24 species which, as already noticed by Sir Charles Lyell, occur jointly in the Upper and Middle Limburg beds, and 15 of which are confined to beds of that age; but none of these 24 species are peculiar to the Lower Limburg beds—Dumont's "Tongrien inférieur,"—so that it is extremely probable that the latter formation is unrepresented in the Fontainebleau Sands; and the more the relations of the Paris freshwater beds to the overlying marine formations of neighbouring districts are studied, the less probable does it appear that, between the Gypsum of Montmartre and the first appearance of species belonging to the succeeding marine fauna, there should exist a gap, represented in Belgium by the Lower Limburg beds. The conclusion, therefore, seems inevitable that the last-named formation is partly contemporaneous with the French freshwater strata. In fact, a similar conclusion has already been drawn by Dumont*, who considered the Lower Tongrian (sable glauconifère de Lethen) equivalent to the Paris freshwater formation, and the succeeding beds (Middle Limburg of Sir Charles Lyell) to correspond to the Fontainebleau Sands.

The results of the researches of Dr. Fridolin Sandberger on the Mayence Basin are also quite in harmony with the above conclusion, for he finds that the oldest bed of that series—the marine sand of Alzey,—about the contemporaneity of which with the Fontainebleau Sands there is no doubt,—corresponds, not with the Lower Limburg beds, but with the Middle. The Alzey Sand is, however, of the same age as the marine beds of Basel and the Northern Jura, which, near Delsberg, repose on a freshwater formation equivalent to the Gypsum of Montmartre, so that here also there is no marine equivalent of the Lower Tongrian beds of Belgium.

It is, therefore, apparent that it is necessary to include Dumont's "Système Tongrien inférieur" in the Eocene period if, in the French series, the boundary-line be drawn between the Gypsum of Montmartre and the Fontainebleau Sands, that is to say, where M. Elie de Beaumont originally drew the line between Older and Middle Tertiary. Sir Charles Lyell could not but consider the Limburg beds as a natural whole, while, in his earlier classification, he terminated his Middle Eocene with the equivalents of the Sandstones of Beauchamp, and called all above them, and below the Faluns, Upper Eocene; but it is not admissible, as in his newer classification, to place all the Limburg beds together above the Gypsum of Montmartre and call them Miocene, while the Gypsum itself remains Eocene. Against the adoption of this classification are, moreover, the stratigraphical relations of the Limburg Beds, as well as their geographical and organic connexion; and still more strongly against

* Bull. Acad. Roy. de Belg. vol. xviii., No. 8.

it is the important fact that there exists near Egeln, in Northern Germany, a formation contemporaneous with the Belgian Lower Tongrian, where the equivalents of the younger Limburg beds were afterwards deposited.

Professor Beyrich accordingly considers his classification of the Oligocene beds to hold good. In his Lower Oligocene he includes all the beds of the age of Dumont's "Système Tongrien inférieur," and also the strata which occur between the Sandstones of Beauchamp and the Fontainebleau Sands, that is to say, the Paris Gypsum and its equivalents, whether they represent the whole or only a part of that formation. In Northern Germany, to this division belong the Egeln beds, as well as the underlying Brown Coal; because there is, as yet, no evidence of a freshwater formation in Germany contemporaneous with the Calcaire grossier, and also because, according to Dumont, the manner in which the Belgian beds are spread out on those beneath them bears evidence of a gap, which is elsewhere filled by still older formations.

The large number of species (amounting to at least 50) common to the Belgian Oligocene and the English so-called Eocene is also advanced by Professor Beyrich as a further justification of his classification. About one-half of these species occur in the Middle and Upper Limburg beds, while the rest, even if not found in those strata, occur in the Lower Tongrian. In this numerical relation the author also finds a support to the conclusion already arrived at, that the proper position of the Belgian Lower Oligocene is between the Fontainebleau Sands and the Barton Clay, or the Sable de Beauchamp, close to the Gypsum of Montmartre.

After remarking that M. Hébert's hypothesis of a general catastrophe is not supported by facts, as numerous species of the youngest English Eocene occur in association with many characteristic forms of newer strata, Professor Beyrich proceeds to describe the geographical distribution of the Oligocene strata. The lowermost Oligocene strata, occurring in Northern Germany and containing many Eocene species, are older than the Fontainebleau Sands, and do not occur in districts south of the Hartz. On the other hand, the marine beds of Alzey, the oldest Middle-Oligocene German equivalents of the Fontainebleau Sands, scarcely extend beyond the banks of the Rhine; they do not occur in Central and Northern Germany, but, with the corresponding Swiss beds, are more probably in connexion with the strata in the neighbourhood of Orleans than with those of Tongres and Maestricht. These strata are succeeded in Germany by an extended series of brackish- and fresh-water beds, which are overlain, near Cassel, by the equivalent of the youngest Belgian Oligocene series—the Clay of Boom, this formation being widely distributed in Northern Germany.

Professor Beyrich then notices the important memoir by MM. Hébert and Renevier *, in which they endeavour to show that the Upper

* "Description des fossiles du terrain nummulitique supérieur des environs de Gap, des Diablerets, et de quelques localités de la Savoie," Bull. Soc. Statistique du Dép. de l'Isère, Grenoble, 1854.

Nummulitic formation of the Western Alps is contemporaneous with the Fontainebleau Sands.

As regards the Fluvio-marine series of the Isle of Wight, Professor Beyrich gives a general sketch of the relative position of its various parts, and notices the conclusion of Prof. Forbes *, that they form one natural series, and that it is quite artificial to consider one portion as Miocene and the rest as Eocene. He then remarks that the Hempstead beds correspond to the Middle Limburg beds of Belgium, and that, like the marine and brackish-water beds of the Mayence Basin, they cannot be placed in parallelism with the Lower Limburg, or Lower Tongrian, beds. In the underlying Bembridge beds have been found species of Mammalia which occur in the Paris Gypsum, and, on this account, the two formations have been considered contemporaneous; but the few marine Shells hitherto found permit no more rigorous comparison of the marine fauna of this formation with that of other marine equivalents of the Paris freshwater strata. The Osborne beds contain only fresh- and brackish-water Shells; by Prof. Forbes they were closely connected with the Headon Beds, which, on account of their including a middle stratum containing marine Shells, are of the highest importance to the classification of the freshwater formations of the Isle of Wight. In this bed occur two species, whose association in every other marine fauna has alone been considered sufficient proof of its Oligocene relation. The first of these is the *Cytherea incrassata*, which is quite foreign to the Barton Clay, but which first appears in the Headon beds, and, in its many forms, occurs in all succeeding Oligocene faunas; with it is associated the second species, *Cerithium plicatum*. And it is remarkable that the accompanying Eocene species of the Barton Clay are such as are also found, in Belgium or near Egeln, associated with *Cytherea incrassata* in the Lower Tongrian marine fauna. Amongst the peculiar marine forms of the Headon beds the occurrence of the genus *Borsonia* is noteworthy, as it is present in all German Oligocene faunas. Of freshwater species, *Melania muricata* is very important, as it occurs in all the freshwater beds of the Isle of Wight, and is also found in the Middle Oligocene freshwater strata of Hesse, from which it was described by Dunker†, in 1853, as *Melania horrida*. All these facts lead to the conclusion that the Headon beds and the succeeding freshwater strata all belong to the Oligocene period. If the Barton Clay be the equivalent of the Beauchamp Sands, as considered by Sir Charles Lyell and M. Hébert, then the Headon, Osborne, and Bembridge beds must together be considered the equivalents of the undivided French freshwater formation, which is of Lower Oligocene age, and which separates the youngest Eocene beds from the Middle Oligocene Fontainebleau Sands—the equivalent of the Hempstead beds. This classification is quite in accordance with the conclusions arrived at by Prof. Forbes, and also with Sir Charles Lyell's original

* Quart. Journ. Geol. Soc. vol. ix. 1859, p. 259.

† Programm der höheren Gewerbschule in Cassel zu Michaelis, 1853, p. 17.

classification; but it is, on the other hand, equally antagonistic to Sir Charles's newer classification of the English Tertiary beds.

The parallelism of the Calcaire de la Beauce with the Upper Oligocene cannot be determined with the same certainty as that of the Paris Gypsum with the Lower Oligocene. The fauna of the Sternberger Gestein has so distinct an Oligocene facies, that M. Deshayes referred all the beds of that period (Cassel, Bünde, and Osnabrück) to the horizon of the Fontainebleau Sands. On the other hand, however, so many forms belonging to newer faunas occur in these beds, that German authors, laying too much weight upon the latter, have assigned to the Sternberger Gestein much too high a position, some having considered it to be of even Pliocene age. Prof. Beyrich, from a number of considerations, comes to the conclusion that the formation in question occupies a position intermediate between that of the youngest Belgian Oligocene beds and that of the Newer Tertiary strata of the period of the Shell-beds of Touraine. In England and Belgium strata of this age do not occur, and their intermediate position, just defined, is the only certain ground for considering that they are probably the equivalents in time of the Calcaire de la Beauce. On account of their geographical distribution, it appears more natural to consider them the youngest member of the Oligocene period than the oldest of the Miocene.

The following Table may be of assistance in reading the foregoing Memoir, although it does not represent all the minor differences in the ages of the individual beds.

Table showing the Correlation of the Oligocene Beds of Belgium and Germany with those of England, France, and Switzerland.

Districts.	Upper Oligocene.	Middle. Oligocene.	Lower. Oligocene.
Isle of Wight ...	....	Hempstead beds.	Bembridge beds? Osborne and Headon beds.
Paris Basin	*a.* Calcaire de la Beauce.	Fontainebleau Sands.	Gypsum of Montmartre.
Belgium...........	*b.* Upper Limburg of Lyell (Clay of Boom, &c.); Rupélien of Dumont.	Middle Limburg of Lyell; Tongrien supérieur of Dumont.	Lower Limburg of Lyell (Lethen sands, &c.); Tongrien inférieur of Dumont.
North Germany	*a.* Sternberger Gestein of Cassel, Bünde, and Osnabrück. *b.* Hermsdorf Clay.	Brackish and freshwater beds of Cassel.	Egeln marine beds, and underlying Brown Coal.
Mayence Basin...	....	Brown Coal, Alzey marine beds, and intervening strata.	
Switzerland	....	Marine beds of Bâle and Delsberg.	Freshwater beds near Delsberg.

[H. M. J.]

ELEMENTS *of* CHEMICAL *and* PHYSICAL GEOLOGY. By Dr. GUSTAV BISCHOF, For. Mem. G.S., &c. Vol. I. Second Edition.

[Lehrbuch der chemischen und physikalischen Geologie. Von Dr. Gustav Bischof, Geheimen Bergrath und Professor der Universität Bonn, For. Mem. G.S., &c. Zweite gänzlich umgearbeitete Auflage, Band I.]

ALTHOUGH a new German edition of the author's 'Elements of Chemical and Physical Geology' has been required for several years, the first being quite out of print, his various engagements (among others an English edition of the above work, published by the Cavendish Society, London, 1854–59) prevented his complying with this want until last year. The distinction lately conferred upon him by the Council of the Geological Society, namely, the award of the Wollaston gold medal, has induced him to consider it his pleasing duty to dedicate to the Society this new German edition, containing the results of his continued researches.

The more systematic arrangement of the chapters in the English than in the first German edition has been adopted and improved in this new German edition, which has also been enriched by many new facts.

Amongst the more novel and important contributions to Chemical and Physical Geology contained in this volume, are the observations on the secular elevations and other dislocations of the earth's crust, contained principally in Chapter VI.

Dr. Bischof's argument may be stated as follows:—Exhalations of carbonic acid are of universal occurrence, and originate at great depths, for the deeper we penetrate, the more abundant they become. Rocks occurring at such great and inaccessible depths are chiefly silicates, like the oldest of the known formations—a fact which the volcanic eruptions of lava confirm; these silicates are decomposed by carbonic acid ascending to the surface, the decomposition being facilitated by the increase of temperature towards the interior of the earth. The products are silicate of alumina and certain carbonates, silica being displaced. When minerals or rocks combine with other substances, not only an increase of matter, but also an increase of volume takes place, provided that such combination does not involve an increase of specific gravity. On the other hand, if the latter be decreased, the volume must be increased in a still greater proportion than the matter. Such is the case when silicates are decomposed by carbonic acid: the specific gravity of the products of decomposition being below that of the undecomposed minerals, their volume must necessarily be greatly increased.

If a mountain composed of silicates be supposed to exist, its upper parts being exposed to decomposition by carbonic acid and rain, then, if there be amorphous silicate of alumina in the lower parts of this mountain, and if the soluble products of decomposition (say, alkaline silicates) were carried downwards by means of water, crystals of felspar may be produced, increasing the bulk of the mountain, and thus causing elevation. Not only will the upper parts be thus elevated from below, but they will also raise themselves should their increase, through combination with water, be greater than the decrease of bulk caused by substances carried downwards.

As a geological proof of the action, in the elevation of rock-masses, of the cause here explained, Professor Bischof cites the slow rising of portions of the Scandinavian area, remarking that the elevation takes place where crystalline rocks (containing silicates) occur, and that where they are absent, as in the south of Sweden, there is no upheaval. Again, where a hydrated silicate becomes altered, and a consequent decrease of volume ensues, a depression of the land is the result, as is now taking place on the coast of Greenland.

Professor Bischof also brings forward many facts, drawn from various sources, to show how causes apparently slight, resulting in a small increase of the volume of the body acted upon, may produce an important effect through the magnitude of the mechanical force thus called into action.

According to Von Dechen, oak props, as much as 1 foot in diameter, used in driving levels through clay-layers in coal-mines at Saarbrücken, are crushed by the expansion of clay in combining with water. This extraordinary force is not even a consequence of chemical affinity, but merely a mechanical action caused by expansion of the individual particles of clay.

The roots of trees and shrubs growing downwards also cause an elevation of the soil, as they find least resistance towards the surface, but more downwards and at the sides. This elevation, after long geological periods, Dr. Bischof considers would become a considerable item in primæval forests, where most of the products of vegetation are never removed, and where new roots replace old decayed ones, the latter forming bituminous coal.

Bulbous plants prove what vegetation may accomplish even in a few months. A potato weighing five pounds was found in the neighbourhood of Bonn, in 1863; its specific gravity was=1·1; it measured 119 Prussian cubic inches, or was very nearly equal to a cube 5 inches in length. Thus it must have displaced an equal bulk of soil. Just as carbon and water are assimilated by plants, so are they fixed when decomposition of silicates by means of inorganic processes takes place, carbonic acid, however, being assimilated without decomposition.

The author also lays down general formulæ of the increase of volume through decomposition by means of chemical affinity, and applies them to several minerals and rocks. Suppose the volume of the undecomposed substance equal to 1, he finds the following figures to represent the average volume of the decomposed substances:—

Felspar	=1·70
Augite	=1·79
Granite and Gneiss	=1·24
Basalt	=1·88
Lava	=1·94
Clay-slate	=1·349

The following example is given as illustrating the importance of these figures:—If such a rock as the basalt of Wickenbach, near Querbach, in Lower Silesia (according to Loewe's analysis), be the substratum of a mountain, and if this basalt extended to a depth of one German mile, and were by degrees entirely decomposed by carbonic acid, then the mechanical force of its expansion would have been sufficient to raise the height of the mountain by one German mile, which is equal to the height of the highest mountain on the face of the earth. [G. B., Jun.]

On the Water-bearing Strata *in the* Neighbourhood *of* Vienna. By Herr H. Wolf.

[Proceed. Imp. Geol. Instit. Vienna, July 21, 1863.]

Two sections across Vienna have lately been constructed by the author, one running from N. to S. through the Neogene deposits, the other from N.W. to S.E., crossing the former in the "Getreide-Markt," midway between the city and the western suburbs. The data used in compiling these sections were obtained by the boring of one hundred and thirty Artesian wells, together with a careful investigation of the organic remains found during each sinking. Three alluvial, as many diluvial, and eleven Neogene beds are marked on the sections. The deepest layers passed through in sinking the well in the "Getreide-Markt" include the same organic remains as those in the brick-loam of Attakring and Hernals, north-west of Vienna; the difference of height (600 to 780 feet) in the two localities proves that the beds dip towards the centre of the basin at an angle of from 4° to 5°. Four horizons may be distinguished within the section. The first of them, consisting of "Congerian" or "Inzersdorf" (freshwater Neogene) strata, reaches a depth of between 276 and 366 feet above the sea-level. The three others are of brackish-water origin, the uppermost containing *Polystomella*, *Crassatella dissita* (*Enoilia Podolica*, Hörnes), *Bulla Lajonkaireana*, and *Cardium plicatum*, Eichw.; all of which likewise occur in the strata above the Cerithian sands and sandstone, which crop out west and south-west of Vienna. The middle portion, of a more arenaceous nature, contains many specimens of *Cerithium pictum*, Eichw., and crops out south-west, west, and north-west of Vienna at a height of 768 feet, ending at a height of between 96 and 132 feet above the sea-level. The nethermost portion, not sunk through at depths of 42 and 78 feet beneath the sea-level, includes several species of *Rissoa*.

The truly marine strata of the Vienna basin have, perhaps, been reached in sinking wells to the depth of 198 and 264 feet in the western environs, and by another well in the same region, which, after having been bored through 96 feet of a plastic clay (answering to the truly marine "Tegel" of Baden, S. of Vienna), has attained a depth of 396 feet beneath the sea-level. This lower or marine Neogene formation contains two water-bearing horizons, probably the best of all in and around Vienna, although not yet accessible by sinkings. Their regions of infiltration lie between 16,800 and 21,600 feet west of the well in the "Getreide-Markt," at a height of between 600 and 840 feet. In the middle or brackish formation five water-bearing horizons are at present known, but the nethermost has not been reached within the precincts of Vienna; its region of infiltration lies from 6800 to 8700 feet west of the above-mentioned well, at a level of from 540 to 768 feet. The uppermost (Congerian) strata, probably deposited subsequently to a partial destruction of the brackish-water strata, are best known; the water from them is most used for domestic purposes, and comes out generally under powerful pressure. Their region of infiltration lies from 6000 to 8400 feet from the well in the "Getreide-Markt," in levels between 480 and 660 feet. Two other systems, above those just mentioned, only give infiltrated water. One of them, situated within the higher regions of the city, derives its water from merely local infiltrations through the Belvedere (Diluvial) gravel; it extends as far as 6000 feet westward from the well of the "Getreide-Markt," and reaches a level of from 480 to 690 feet. The newest water-bearing horizon is that of the Danube; its water, infiltrating from east to west, saturates the loose ground near the "Getreide-Markt," at a level of from 468 to 504 feet above the sea-level. Where it meets with the local infiltration-water of the Belvedere gravel (about 468 feet above the sea-level), it occasionally stops the latter, raising it to a higher level. [COUNT M.]

On the SMALLER MAMMALIA *of the* LOESS. By Professor PETERS.

[Proceed. Imp. Geol. Institute, Vienna, Nov, 3, 1863.]

MANY of these remains have lately been found in the "Loess" of Nussdorf (north-west of Vienna), in which an extremely large skull of *Elephas primigenius* was also discovered. The most abundant species of these minor forms is the common Mole (*Talpa Europæa*), whose remains are so completely characterized that there can no longer be any doubt about the specific identity of the diluvial with the existing form. Of *Sorex vulgaris*, Linn., var., only one specimen has been found—a lower jaw with its teeth complete. It indicates a form intermediate between the common Wood-Shrew and the Alpine Shrew, differing from *Sorex pygmæus* by the slight sinus between the unbent apex and the first tubercle of the fore tooth, and from *Sorex alpinus* by the single pointed form of the first molar. Nevertheless the general aspect of this jaw, especially in its coronal process, and in the shortly pointed crooked process, extending backward in a straight line, offers a striking resemblance to the jaw of *Sorex alpinus*. The first (pointed) molar, instead of having a conical profile, as in *Sorex vulgaris*, shows a rather lengthened and even somewhat sinuated posterior edge; so as to stand intermediate between the normal form and the two-edged molar of *Sorex alpinus*. The form of the anterior tooth and other characters sufficiently distinguish the species in question from *Crossopus* (*Sorex*) *fodiens*, Pallas. The digging-mice (*Arvicola*) are represented by a great number of remains, especially of loose molars. Among them, a robust variety of *Arvicola amphibius*, Linn., and *A. glareola*, Schreb., have been ascertained, these two species being of extensive vertical and horizontal range at the present day. Three well-preserved lower jaws belong to *Arvicola ratticeps*, Blas., a species having, at present, a range from Kamtschatka to Lapland, but which does not now exist south of the Baltic. Its fossil remains are undoubtedly characterized specifically by the seven enamel loops (the first two of them not being completely separated) of the first molar, and by the peculiar form of the second molar. The other Mammalian remains are unimportant. Among them is a nasal piece of *Rhinolophus*, with very strong and flat canine teeth, not admitting of identification with any living or fossil species; and some few loose teeth and fragmentary upper jaws of a small species of *Lepus*, scarcely different from the common Rabbit. Remains of Ophidians and Batrachians seem to be completely wanting. A small tooth of Crocodile may have been washed in from the neighbouring brackish-water clay, together with some few minute Shells of *Enoilia Podolica*, Eichw., and some marine Miocene Bivalves. The Mollusca found in the diluvial clay here in question are:—*Planorbis leucostomus*, Mich. (very abundant, the species being now extremely common in the stagnant water of Lower Austria, Hungary, and Moravia); *Pisidium fontinale*, Drap. (not rare, and now common in the Alpine and Carpathian mountain-sources); *Helix circinata*, Stud., and *Succinea oblonga*, Drap. (both somewhat rare). The clay-bed in which the above-mentioned skull of *Elephas primigenius* was found is remarkably plastic and of a deep-grey colour, while the beds overlying it have the dry character and yellowish tint characteristic of the common diluvial clay of the Danube valley. The dead body of the Elephant must have undergone decomposition on a moory ground, and, at the same time, have been gradually surrounded and, finally, covered with lacustrine deposits, which were periodically interrupted by seasons of dryness, during which the district was visited by Moles, Shrews, *Arvicolæ*, and land-mollusks, at last destroyed by subsequent floods; but some of the bones may also have been washed in from neighbouring mountain-sources.

The diluvial fauna, just described, has some characteristic forms in common with the osseous breccia of Beremend (Hungary), only the prevailing form in this breccia is not a genuine Shrew, but rather a *Crossopus* (*C. fodiens*?, Pallas). [Count M.]

On the Geology *of the* Dobrudscha. By Professor Peters.

[Proceed. Imp. Geol. Instit. Vienna, November 3, 1863.]

Near Semlin, the steep cliffs on the right of the Danube, from thirty to sixty feet high, are formed of Loess; but near Tultscha, the thickness of this Loess is reduced to from six to eighteen feet, and beneath it there appears a rather varied series of older strata, through which the Danube has cut its way. One Austrian mile west of Tultscha, at a place called "Girba," limestones dipping eastward at a low angle are exposed, both by erosion and in quarries. These limestones are probably of the age of the Lower Trias of the Alps; near the Danube they are cut through by a vein of augite-rock, decomposed into dark-brown argillaceous iron-ore. Beneath the fortress of Old Tultscha appear (almost conformable to the before-mentioned limestones) red and white quartzites, with occasionally imbedded layers of reddish-brown or greenish-grey slaty marls, identical with the "Quartzite Series" so extensively developed in Hungary, Transylvania, and Banat; and although its geological age is still imperfectly known, it should probably be placed between the Carboniferous formation and the typical "Werfen" (Lower Triassic) slates. These quartzites, with an abrupt easterly dip, rise east of Tultscha, so as to form a cliff from sixty to seventy feet high, well known to the Danubian navigators. South of this cliff, a hill, rising out of the Loess to a height of 480 feet above the sea-level, is composed of sandstones and dark-coloured limestones overlying the before-mentioned Triassic limestones, and probably of Liassic age. A considerable mountain-range south of Tultscha, striking from west to east, and rising in one of its peaks ("Krasni-Most," south-west of Tultscha) to an altitude of about 3000 feet above the sea-level, is composed of an augitic eruptive rock, nearly allied to some augite-porphyries of the south-west of Transylvania. The specimens obtained from the inner valleys of the Dobrudscha, south and south-east of Tultscha, show the occurrence of several varieties of sandstone of probably newer Tertiary age, Crinoidal limestone, phonolite rocks with distinct tabular crystals of sanidine, compact sandstone with carbonized vegetable remains, specular iron-ore in veins, &c. As far as the organic remains (merely casts) transmitted by M. Tchihatcheff and Prof. Szabó admit of determination, the following species may be said to occur in the Dobrudscha:—*Natica macrostoma*?, Roem., *Diceras* (a small form differing from *D. arietina*, although associated with it in typical localities of western Europe), *Nerinæa Visurgis*, *Pterocera*, sp., *Chama*, sp. (similar to *C. ammonia*, with well-preserved traces of the hinges); all of them Upper Jurassic, and imbedded not in a compact or oolitic limestone, but in a yellowish-white, chalk-like substance, very much resembling certain varieties of Kimmeridge clay. A specimen of this rock with *Nerinæa Visurgis* is filled with fragments of Corals and Echinoderms. The Cretaceous specimens are imbedded in an argillaceous marl. A rock-specimen, collected by Prof. Szabó near Czernawoda, bears lithologically, and from the numerous casts of *Tapes gregaria*? which it contains, a striking resemblance to the argillaceous brackish Cerithian strata of the Hungarian Miocene deposits.

[Count M.]

On the ROTHLIEGENDE *of* BOHEMIA. By HERR POSEPNG.

[Proceed. Imp. Geol. Institute, Vienna, Nov. 17, 1863.]

THE late Geologist, Herr Jokely, made out three subdivisions of the extensive deposits of this formation, spread along the southern foot of the Sudetian Mountains, especially in the western portion of that district. He founded these divisions on lithological characters and mutual transitions, without taking into account the organic remains included in them. In fact, the cupriferous beds are not peculiar to any of these three subdivisions; those worked at Hermans Eisen, in the lower subdivision, are bituminous marly slates, undoubtedly identical with those of Mansfield, and others of Northern Germany. Those worked at Chrast are imbedded in the arkose of the middle subdivision, while others belong to the uppermost horizons. The fossil Plants, as far as hitherto known, have more a Carboniferous than a Permian facies. The greatest proportion of *Asterophyllites* is known to occur within the uppermost horizon. Ferns, and among them especially *Cyatheites arborescens*, Schl., together with a Lycopodiaceous form, *Walchia pinnata*, and several species of *Araucaria*, extend through the whole of the formation. *Nœggerathiœ* are exclusively confined to the inferior horizons, as *Psaronites* are to the middle ones.

[COUNT M.]

On the PÉRIGORD CAVES, *and on the* ENGRAVED *and* CARVED OBJECTS *of* PREHISTORIC DATE *found in* WESTERN EUROPE. By MM. LARTÊT and CHRISTY. 1864.

[Cavernes du Périgord. Objets gravés et sculptés des temps pré-historiques dans l'Europe occidentale. Par MM. Lartêt et Christy. Revue Archéologique, 1864.]

IN this communication are given the results of the explorations of MM. Lartêt and Christy during the last five months of 1863, as well as notices of previous discoveries by other observers. Amongst the caves examined, the *Grotte de la Combe-Granal* was found to contain bones of *Hyæna spelœa, Cervus elaphus*, Wolf, Fox, Hare, Horse, Wild Boar, Ox, Wild Goat, and Chamois, mixed with worked flints carelessly fashioned. An ornament made from the ear-bone of the Ox was found, as also were some bones of birds; but no traces of the Reindeer. The *Grotte du Pey de l'Azé* contained worked flints and the bones of *Ursus spelœus*, the Reindeer, Horse, &c. In the *Grotte de Liveyre* occurred Reindeer-, Horse-, and other bones, with worked flints. The *Grotte du Moustier* contained the usual animal-remains, in addition to separated laminæ of the teeth of *Elephas primigenius*. The arms and stone implements are very numerous and peculiar, many being of the types found at St. Acheul, while others are of great size and strength. The *Grottes de la Gorge d'Enfer* also contained the bones of the Reindeer, &c., with flint implements. In the osseous breccia of the *Grotte des Eyzies* were flint implements, rounded and angular pebbles, and schistose flakes from rocks generally differing from those of the neighbourhood. The long bones were invariably found broken; but the inter-articular cartilages were intact, and there were no gnawed bones. The authors liberally sent specimens of the breccia to various museums, and in one of them Mr. Francks of the British Museum has discovered a little needle of Reindeer-bone, and in another Prof. Peters of Vienna has found a human incisor. The deposit contained flint implements of various forms, arrows with jagged lateral points, made from bones of the Reindeer and the Horse, little harpoon-shaped hooks of birds' bone, a vertebra of a young Reindeer pierced through by a flint flake, which remains *in situ*, and a whistle made from one of the phalanges of a Deer. The most remarkable objects, however, were engraved schistose plates, on one of which was represented the anterior part of a horned ruminant, and on another the head of an animal with a half-opened mouth and distinct nostrils.

The fauna of this cave resembles that of the others; there were found: a fragment of an Elephant's tusk artificially marked, the canine tooth of a Lynx pierced for suspension, and a metacarpal bone of a young *Felis* of great size (*F. spelæa*?), cut and scored in the same manner as other bones which belonged to animals eaten by the aborigines. The fauna of the *Station de la Madelaine* is the same as that of Eyzies; but in the midst of the deposit a fragment of a human cranium was found, together with half a lower jaw, and several long bones, all belonging to a large animal. They were covered over by a mixture of bones of animals and flint implements. There were also found barbed arrows, needles, and imperfectly carved figures of animals, all made with Reindeer-horn. The cave of *Laugerie-Haute* has a fauna like that of the other deposits; but it also contained teeth of the *Cervus euryceros* and laminæ of those of *Elephas primigenius*, together with numerous flint heads of lances and scrapers. The grotto of *Laugerie-Basse* presented a fauna like the others, but is specially interesting on account of the quantity of worked Reindeer's horns it contains, all of which had been sawn, but not with a metallic saw. Here the largest collection of instruments and arms of Deer-horn was found; some of the implements were ornamented with carvings in relief, or with long sinuous lines, while on one the ornamentation in relief is symmetrical and elegant, and it would make a fair marrow-spoon. On the palms of Reindeer's horns, either simply etched or carved in relief, were representations of the hinder parts of a large herbivorous animal, of a portion of the figure of an ox (*Bos primigenius*?), and of the almost entire figure of a horned animal with the hind legs drawn close to the abdomen. There was also found a staff-like harpoon, ornamented with the engraved head of a Reindeer and also that of a Fish; and in addition to these occurred perhaps the most interesting object yet discovered, a poniard with a small handle made from Reindeer's horn, in which the figure of an animal (Reindeer) is sculptured in such a position as to suit the shape of the weapon. [P. M. D.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

GEOLOGICAL *and* PALÆONTOLOGICAL NOTICES *on the* ALPS *of the* PAYS DE VAUD *and the surrounding Districts.* By E. RENEVIER, Professor of Geology, Lausanne.

[Notices géologiques et paléontologiques sur les Alpes Vaudoises et les régions environnantes, par E. Renevier, Professeur de Géologie à l'Académie de Lausanne. I. Infralias. Tiré de Bulletin de la Société Vaudoise des Sciences Naturelles, tome viii. p. 39. Lausanne, 1864.]

THE object of this memoir by M. Renevier is to describe the true position of certain beds near the eastern extremity of the Lake of Geneva, the fossils of which have been observed since 1854, and which have been placed between the Triassic and Liassic formations. Some of these have already been identified with the Rhætic beds, while others range upwards into the zone of *Ammonites planorbis* and the Lower Lias beds of Hettange; but the fossils of the separate beds have not yet been sufficiently distinguished.

After describing the successive discoveries of various geological inquirers, M. Renevier then states—"In 1863 I again explored the above-mentioned districts, and was fortunate enough to discover other localities in the neighbourhood of Villeneuve, which afforded me both new characteristic fossils and valuable stratigraphical details. Below the Commun des Chainées, on the right bank of the Tinière, I found two deposits containing beds of *Avicula contorta*; and in the ravine of the Pissot, but higher up than the spot discovered by M. Chausson, I found a collection of fossils entirely analogous to those of Taulan, Luan, and Douvaz.

"The stratigraphical position of this last formation being evidently superior to the beds with *Avicula contorta* at Pissot, I became convinced of what I had already suspected the previous year, namely, that the fossils which I had been working at did not all belong to the same geological level, but that they should be referred to two fossiliferous zones, closely connected, but yet characteristically distinct. The *upper zone,* shown at Taulan, Luan, Douvaz, and the upper Pissot, corresponds with the true *Infralias* of Valogne, Hettange, the Lyonnais, &c., and with the beds with *Ammonites angulatus* and *A. planorbis* of Würtemberg. The *lower zone,* which occurs at Taulan, Luan, the Chainées, and the lower Pissot, is the true zone with *Avicula contorta* of the Alps, parallel to the bone-bed of England and Würtemberg, for which M. Gümbel has proposed the name of *Rhætische Stufe* (Etage Rhætien), subsequently adopted by English geologists."

The author then describes the stratigraphical features of the various localities in which these two fossiliferous zones, forming as it were the junction beds between the Triassic and Liassic formations, occur, distinguishing the different members of each section with their imbedded fossils from the Trias upwards. The first locality described is the ravine of Pissot, which descends from the north-east extremity of the Mont d'Arvel, and enters the valley of the Rhone behind the town of Villeneuve, in the immediate vicinity of which place the lower beds are seen to rise towards the north. The other localities are Luan, Yvorne, and Fontanney, Douvaz (above Aigle), Chainées (near Villeneuve), and Taulan (near Montreux).

Then, after describing 71 fossil species, with their separate localities in these two zones, the author sums up with the following conclusions :—

"*Upper Zone.*—Of 38 species contained in the *Ostrea-irregularis* zone of the Vaudois Alps, 31, or 82 per cent., are quoted as occurring in the Infralias of various localities; 5 of these last, or 13 per cent., are also found in the Gryphæa-limestone, or Sinémurien formation of D'Orbigny; 5 are new or uncertain; and two species, or 5 per cent., already existed in the *Avicula-contorta* zone. One of these, *Mytilus semicircularis,* occurs only on the southern slope of the Alps, while the other, *Placunopsis Schafhäutli,* appears to have lived at two different epochs in the district now occupied by the Alps. From these numbers we may infer that the beds in question correspond to the Infralias properly so called, namely, to the zones of *Ammonites planorbis* and *A. angulatus.* The greatest degree of analogy exists with the Infraliassic sandstone of Hettange, and the upper zones of the Infralias of the Côte d'Or, which together contain 19 of my species, or 50 per cent. These proportions may be slightly modified by future discoveries, but the parallelism which I have mentioned appears to be founded on too great a number of species to run any risk of being controverted."

"This is the first time, so far as I am aware, that the Hettange horizon has been positively pointed out in the Alps. It is true that M. Stoppani, in his 'Tableau Synoptique de l'Etage Infraliasien,' has paralleled with the sandstones of Hettange the Dolomia Superiore of Lombardy, and the Dachsteinkalk of the Austrian and Bavarian Alps; but his statement is not supported by any list of fossils, and on the other hand the list of the fossils of the Dachsteinkalk given by M. Gümbel (Geogr. Bayr. Alpen-Geb. p. 419) evidently proves that this formation belongs to the zone of *Avicula contorta,* and not to the Hettange group. I am therefore disposed to believe that this is the first time that a well-established Alpine equivalent of the fauna of the Infraliassic sandstones of Hettange has been pointed out."

"*Lower Zone.*—Out of 34 species hitherto recognized in this zone, 26, or 76 per cent., are also found in some one of the beds of the *Avicula-contorta* zone, either in the Alps or without. Of the 8 remaining species, 4 are new and 3 uncertain. The proportion is not quite so great as in the upper zone, but it is sufficient to remove all doubt as to the identity of the lower zone with the *Avicula-contorta* beds known in different countries under the names of Bone-bed, Kössener Schichten, Infralias, Upper Keuper or Arkose. The principal analogy exists, as might have been expected, with the Alpine deposits, and especially with those on the northern flank of the chain. 53 per cent. of my species are found in the Infralias of Lombardy, and 62 per cent. in the Upper Keuper or Kössen beds of the Eastern Alps, whereas the species quoted in the extra-Alpine formations are only nine for each bed, or 26 per cent. only."

"*Independence of the two Faunas.*—I have only found in our Alps one species common to the Upper and Lower zone, *Placunopsis Schafhäutli*. With regard to other districts, however, the connexion between the two formations is greater. *Pecten Valoniensis* and *P. Lugdunensis* of the lower zone appear in the Lyonnais to belong to the Infralias. *Mytilus semicircularis* of the upper zone is said to occur in Lombardy, in the *Avicula-contorta* bed; and *Spondylus liasinus* of the upper zone is probably the same as *Plicatula interstriata* of the *Avicula-contorta* zone. Admitting these identifications to be correct, there would at the outside be only 10 per cent. of the species common to the two faunas, whereas at least 13 per cent. of the species of the upper zone pass upwards into the Gryphæa-limestone. My two zones are therefore at least as independent one of the other as the Infralias can be of the Sinémurien."

"This independence is fully admitted by those geologists who, like MM. Oppel, Gümbel, Winkler, Wright, and Moore, place the Infralias (the zone of *Ammonites planorbis* and *A. angulatus*) in the Lias, and the *Avicula-contorta* zone in the Trias. But others, as MM. D'Archiac, Hébert, Martin, and Stoppani, consider these two geological horizons merely as subdivisions of the same formation—the Infralias or Etage Infraliasien (Stopp.), which they look upon as the lower division of the Lias. Both the geological and palæontological facts observed in our Alps are, however, contrary to such an approximation, and lead me to consider these two fossiliferous zones as two distinct formations, as much as the Keuperien, Sinémurien, Liasien, &c."

The author then proceeds to criticise what he considers the undue extension of the term Infralias to the *Avicula-contorta* beds. When originally introduced by M. Leymerie, it was confined to those upper beds which are the equivalents of the author's upper zone, and he further thinks that to apply the term Infralias to the *Avicula-contorta* beds, as well as to those containing the *Ammonites planorbis* and *A. angulatus*, is to prejudge the controverted question as to whether the *Avicula-contorta* beds belong to the Trias or the Lias. He proposes that the term should be rejected altogether, and that the upper zone should be called the Etage Hettangien, and that the *Avicula-contorta* beds should be called the Etage Rhætien. This term, proposed by M. Gümbel, and adopted in England by MM. Moore, Rupert Jones, &c., and also, as it appears, in Austria by M. Suess, has the great advantage that it can be adopted by all geologists, whatever may be their opinion respecting the controverted question.

After mentioning the different geologists who have advocated the Triassic or Liassic theory for the *Avicula-contorta* beds, the author concludes as follows:—"The question, after all, is not very important; the main point is the stratigraphical position of the formation, on which all are agreed. Systems are more or less artificial arrangements necessary for the general classification of formations, and which ought, as far as possible, to comprise in the same group those formations of which the faunas are the most analogous. At the same time, in proportion as the gaps between recognized systems are filled up by new discoveries, the lines of demarcation become more vague and uncertain........

"Now as the fauna of a formation does not everywhere consist of the same species, but varies considerably in different localities, it is not impossible that the fauna of one of these transition-formations should in one district have a greater analogy with those of the overlying beds, whilst in another locality it might have the greatest affinities with the fauna of the underlying beds. I will not, therefore, give any positive opinion respecting the Triassic or Liassic age of the Rhætic beds; I only wish to point out what are the prevailing affinities in the region which I have studied."

The author then shows that the 21 genera hitherto found in the Rhætic beds of the Vaudois Alps have a much greater affinity with the Liassic and Jurassic beds than with the Trias, inasmuch as there are only 2 genera common to it and the Trias, and 13 genera common to the Rhætic and the overlying formations; so that, as far as concerns the Vaudois Alps, he considers the Rhætic formation as belonging rather to the Liassic system. This result is intermediate between the two contending theories. With the one, he recognizes the independence of the two formations, Hettangien (Infralias) and Rhætic; and with the other, he is disposed to consider the Rhætic as belonging to the Liassic rather than to the Triassic system.

[W. J. H.]

The Avicula-contorta Zone: *its* Extent *and* Organic Contents. By Dr. A. von Dittmar.

[Die Contorta-Zone (Zone der *Avicula contorta*, Portl., ihre Verbreitung, und ihre organischen Einschlüsse, von Dr. Alphons v. Dittmar. München, 1864.]

In the year 1828, when L. von Buch noticed the beds containing *Avicula inæquivalvis* and *Gervillia pernoides*, we had the first indication of a geological horizon which, in extent and importance, is scarcely surpassed by any other. It was not, however, until the year 1856 that attention was called, for the first time, to the perfect accordance of the bivalves and other fossils of the Swabian "Bone-bed-sandstone" with those of the "Gervillia-beds" of Kössen.

A new impulse was then given to the study of the equivalents of the Kössen beds; and this zone, to which so little attention had hitherto been paid, was carefully examined and compared in different districts, and sought for in new localities. Then it was that the controversy regarding the geological position of these beds became more animated, and began to command greater attention.

This bed, having the same abundance of characteristic fossils, was found all through Germany, in England, Norway, Sweden, Bohemia, Hungary, Lombardy, and the south-east of France. In all the northern localities it occurs as a thin zone, which might be easily overlooked; but in the Alps and in Lombardy it is of immense thickness, and forms entire mountains. Nowhere is it wanting in organic remains: here, as in Würtemberg and England, we find the accumulated fragments of numerous teeth and of spines of Fish and Saurians; there, as in the Bavarian Alps, Lombardy, Würtemberg, and France, it is crowded with Bivalves, especially *Avicula*, *Gervillia*, and *Pecten*; elsewhere, as in Sweden, Franconia, and perhaps also in the "Gresten-beds" of the Alps, remains of Plants abound.

Everywhere we find, forming a safe guide and sign-post, the *Avicula contorta*, Portl., whence the beds in question may justly be designated as the "Zone of *Avicula contorta*," or the "Contorta-beds." All the other names which these strata have received the author considers as one-sided, and consequently unsatisfactory, and he gives reasons for so regarding them.

The object of the author in this work is to point out the extent of these beds, to portray and compare their different forms of development, and, lastly, to give his contribution towards the solution of the question whether they are Triassic or Jurassic.

Dr. von Dittmar considers in some detail the geographical extension of this zone, and points out the diversity, both in its lithological and palæontological characters, which is met with in tracing it over a large area—a diversity such as we find under similar circumstances in almost every other formation.

In the northern and southern subalpine regions this Contorta-zone consists of grey limestones and dark-coloured marls, forming at times entire mountain-chains. Outside this district it occurs on a much smaller scale as a more or less brown-coloured ferruginous sandstone, which only in certain localities attains to a thickness of 100 feet or more.

In France, where, on the right bank of the Saône and Rhone, it follows for a considerable distance the upper surface of the Keuper Marls, or lies directly on the granite of the Côte d'Or, it is constantly accompanied by certain bands of a granitic conglomerate, and is there usually designated "Arkose."

In Würtemberg, where there is no trace of this conglomerate, it occurs as a light grey or yellow fine-grained sandstone, from 1 to 30 feet thick, with thin layers of yellow loam or greyish clay. This is sharply marked off from the lowest dark limestone-bands of the Lias, and is accompanied, near the upper and lower surface, by a hard sandstone-breccia, which abounds in numerous fragments of Fish-teeth, bones, &c. This latter is the "Schwäbische Kloake," of Quenstedt, and the "Bone-bed" of English geologists. Such a bone-bed is altogether absent in the Alps, and only traces of it occur in the French "Arkose."

In Franconia, the Saxon Principalities, and Hanover, this zone attains a much greater thickness, being from 100 to 150 feet. It consists here principally of a series of sandstones and clays, together with the breccia of the bone-bed.

Still greater interest is attached to the diversity in the fauna and flora in the various localities than to the lithological differences. As the bone-bed is almost confined to Würtemberg, Northern Germany, and England, so also we find other forms of organic remains restricted to particular regions. The large *Gervillia inflata* is only met with in the Alps, as also are the different Corals (*Lithodendron*, *Thamnastrea*, &c.), and the various Brachiopods, Cephalopods, and Echinoderms. Plants, beautifully preserved, form large deposits in Sweden and Franconia. In Northern and Central Germany the sandstones of the Contorta-zone are full of Equisetum and Cycads; and in Würtemberg and Luxemburg, traces of such Plants occur in the form of small carbonaceous layers and particles. In England, and in the French Arkose, no traces of Plants are met with, except certain undistinguishable Fucoid remains.

But few forms are of universal occurrence, notwithstanding the considerable number of species. The following are the leading forms of the Contorta-zone, though one or other of these may be wanting in certain localities.

Avicula contorta.	Schizodus præcursor.
Gervillia præcursor.	Pecten acutiauritus (Valoniensis.)
Cardium Rhæticum.	Lima præcursor.
Mytilus minutus.	Leda percaudata.
Anatina præcursor.	Sargodon Tomicus.
Anatina Suessi.	Acrodus minimus.

The author next considers the geological position of the Contorta-zone, and the vexed question as to whether it should be regarded as belonging to the Keuper or the Lias. All attempts to obtain decided distinguishing characters, whether palæontological, lithological, or stratigraphical, have hitherto been unsuccessful, and the Contorta-zone continues to stand out as a natural passage-bed, equally allied to the Lias and to the Keuper.

Lithologically the dark grey sandy and shaly clay of the bone-bed is, in England, as closely allied to the variegated marls of the Keuper as to the black limestone of the Lias. The Arkose of Central France is equally related to both the older and newer beds. The hard brown bone-bed sandstone and its associated clays in the east of France and in Würtemberg are closely connected with beds of a similar nature in the Keuper, and form a marked contrast to the black limestone-bands of the Lower Lias. In the Alps there is an equal resemblance, lithologically, to the older and to the newer strata.

The stratigraphical bearings of the Contorta-beds indicate rather a relationship with the Keuper; and by alternation they are much more closely connected with it than with the Lias; for the sandstone of this zone in extra-alpine regions, as well as in the French Arkose, alternates with the marls and clays of the Keuper, bnt never with the limestone of the Lias. If we regard the conformability or unconformability to older or younger beds, we find not only everywhere a marked *unconformability to the Lias,* but also a *conformability with the Keuper,* which is nowhere disturbed.

Palæontology affords evidence of the most intimate relationship of the fauna and flora of the Contorta-zone with those of the preceding and succeeding strata. Dr. v. Dittmar gives tables showing the characteristic fossils of the Contorta-beds and their affinities to older and newer forms. From these it appears that, of 162 species which are enumerated, 90 have allies in the older and 72 in the newer strata, and 12 species pass through.

Another argument, not strictly a scientific one, though sometimes made use of in discussing this question, consists in comparing the number of authors who regard this zone as Keuper with those who regard it as Liassic. The result of this is not more decisive than that obtained from other points of view. Many geologists regard this zone as a passage-bed. Such a view is considered by others as most impractical and unsatisfactory for systematic purposes. If, however, it tends to simplification, and is not unnatural, it ought to be adopted. In this case it should be left unconditionally to some high authority to fix the boundary. For this reason, as V. Alberti refers the Würtemberg Bone-bed to the Keuper, and Quenstedt classes it as the youngest member of the Trias, the author decides in favour of placing the Contorta-zone with the Keuper, the stratigraphical relations of the zone also appearing to justify this view.

Dr. von Dittmar concludes by giving a catalogue of the organic remains found in the Contorta-beds, with critical remarks thereon.

[F. G. F.]

On the Geology *of* New Caledonia, *and on some* Triassic Fossils *from the* Island *of* Hugo. By M. Eugène Deslongchamps.

[Documents sur la Géologie de la Nouvelle-Calédonie, suivis du Catalogue des roches recueillies dans cette île par MM. Jouan et Emile Deplanches, et de la description des fossiles Triasiques recueillies à l'île Hugon. Par M. Eugène Deslongchamps. Bull. Soc. Linn. de Normandie, vol. viii. pp. 332–378.]

Amongst the rock-specimens collected in the Island of Hugo, near New Caledonia, by MM. Deplanches, are some presenting a peculiar appearance on account of the immense numbers of an *Avicula* in them. They so nearly resemble *A. salinaria,* Goldf., that they are doubtfully distinguished from that species, and they form the var. *Richmondiana,* Zittel. The rocks of the Island of Hugo resemble in every respect those of the Upper Trias of the Alps, at Dorrenberg, where the *Avicula salinaria* is found by myriads; and although the appearance of the New Caledonian rock, the aspect of which resembles the Devonian Grauwacke, contrasts with the Triassic rocks of St. Cassian, Hallstatt, &c., M. Deslongchamps does not hesitate to regard the limestone of the Island of Hugo as belonging to the Upper Trias. The *Avicula* is associated with three species of Brachiopoda having a St. Cassian facies, including *Spirigera Caledonica*, *S. Planchesi*, and *Spirifer* —— ? The interest of this discovery is enhanced by its application to M. Zittel's researches in the Trias of New Zealand, at Richmond, near Nelson, where *Avicula salinaria*, var. *Richmondiana*, Zittel, is a dominant form. The extension of the Trias in Turkey, the Himalayas, New Caledonia, New Holland, and New Zealand is now incontrovertible. [P. M. D.]

The Jurassic Rocks *of* Hanover. By Karl von Seebach.

[Der Hannoversche Jura, &c. 4to. 1864, Berlin, pp. 160; one map and ten plates.]

The author occupied himself with the researches on which this work is based, in the summers of 1861 and 1862, for the sake of describing the geology of the district and of getting together a collection of North-German fossils for the museum of the Göttingen University, the authorities of which, indeed, helped him with a liberal grant. In the prosecution of his work, and in preparing the results for the press, Herr von Seebach acknowledges the kind assistance of Blasius, Braum, Credner, A. Roemer, H. Roemer, F. Roemer, A. Schlönbach, W. Schlönbach, von Strombeck, Unger, Völkner, and Witte.

In the autumn of 1862 he visited England to study the Oolitic strata, especially their upper division, and to see the type-specimens of Sowerby's 'Mineral Conchology'; and he offers his thanks to Messrs. Damon, Etheridge, Leckenby, Lycett, Moore, Morris, Phillips, Wright, and especially H. Woodward, for ready aid freely given. At Berlin also von Seebach studied Jurassic fossils, at the University Museum and the Mining School, and in Dr. Ewald's collection; and he acknowledges Prof. Beyrich's important assistance, with which he was favoured.

Whilst his work was at press, other memoirs on North-German geology appeared, of which he was not able to avail himself, namely, H. Credner on the Members of the Upper Jura-formation and the Wealden in North-west Germany, W. Schlönbach on the Ironstone of the Middle Lias in North-western Germany, and R. Wagener on the Jurassic Formations of the district between the Teutoburger Walde and the Weser. Two other works, by Dr. Braum and Dr. H. Credner, are expected to appear before long.

Von Seebach offers these results of his examination of the Jurassic rocks and fossils of Hanover (or, rather, of North-west Germany), not as a perfect work, to be compared with Quenstedt's Swabian 'Jura,' the labour of fifteen years, but as a prodromus, serving as a basis for further work in details, and to supply a general sketch such as may enable foreign geologists to compare their own with the Jurassic formation of North-western Germany,—the special works by A. Roemer, F. Roemer, and Von Strombeck having mainly local characters. A short account of the geographical conditions of the "Jura" in North-western Germany forms the first section of this work (pp. 9-13), with references to published maps and memoirs.

Von Seebach's accompanying map shows the several outcropping patches of Lower, Middle, and Upper "Jura" between Hanover and Gotha, and from the Rhine to the Elbe. The several divisions of this formation in North-west Germany form the subject of the second part of the geognostical half of the book (pp. 13-60), beginning with a few lines on the Avicula-contorta-beds, which, whether really Triassic or Jurassic, naturally are not separable from the base of the Lias in a full description of strata. Von Seebach takes as the lowest really Jurassic bed in Hanover an iron black shale, which lies on the uppermost bituminous sandstone (with *Cardium Rhæticum*) of the Avicula-contorta-zone, and is 10–12 feet thick, without fossils, but quite similar to the true Lias above.

A. *The Lias.*—The Lower Lias in North-western Germany has four members, the Middle three, and the Upper two, according to the divisions established for France and South Germany. The Lower Lias in North Germany is difficult to work out, though most minutely subdivided in Swabia. 1. The Psilonotus-beds, with *Ammonites Johnstoni.* 2. The Angulatus-beds, with *A. angulatus* and *Unicardium cardioides.* 3. The Arietes-beds, with *A. Bucklandi, Lima gigantea, A. Conybeari,* and *Gryphœa arenata.* 4. The Planicosta-beds, with *A. planicosta* and *A. ziphius.* 5. The Brevispina-beds, with *A. brevispina, A. binotatus, A. Jamesoni, Rhynchonella furcillata, Terebratula numismatis,* and *Spirifer rostratus.* 6. The Capricornus-beds, with *A. capricornus, A. curvicornus,* and *Avicula cygnipes.* 7. The Amaltheus-beds, with *A. margaritatus, A. spinatus, Belemnites compressus, Gresslya ventricosa, Inoceramus substriatus,* and *Pecten æquivalvis.* 8. The Posidoniæ-beds, with *Belemnites irregularis, A. Lythensis, A. borealis, A. communis, Inoceramus amygdaloides, Avicula substriata,* and *Discina papyracea.* 9. The Jurensis-beds, with *Belemnites irregularis, A. dispensus, A. striatulus, A. Germanii, A. insignis,* and *A. Jurensis.*

B. The Dogger, between the Jurensis-beds and the Macrocephalus-beds, is in North-western Germany divisible into six, perhaps seven members, rather difficult of recognition lithologically, but well marked by fossils. 1. Opalinus-beds, with the following, placed according to their value:—*Nucula Hammeri, A. radiosus, Trigonia navis, Cerithium armatum, A. affinis, Astarte complanata, Belemnites Rhenanus,* and *A. opalinus.* 2. The Inoceramus-polyplocus-beds, with *I. polyplocus, Gresslya donaciformis, Pholadomya transversa, P. decorata,* Goldf. (Zieten?), *A. Murchisonæ,* and *A.* near *A. cycloides.* The Coronatus-beds, with *Belemnites giganteus* in both its subdivisions, and with *Gresslya abducta, A. Breckenridgii, A. pinguis, A. Gervillii, A. Sauzei, Modiola cuneata,* and *Belemnites Gingensis* in the lower, and *Perna isognomonoides* and *A. Humphriesianus* in the upper division. 4. The Parkinsoni-beds. 5. The Ostrea-Knorii-beds, with *Rhynchonella varians, Avicula echinata*(?), *Ostrea Knorii, Astarte pulla, Avicula ferruginea, Belemnites Beyrichi, Trigonia interlævigata,* and *A. orbis.* 7. The ferruginous limestone of the Cornbrash, with *Avicula echinata, Echinobrissus clunicularis, A. posterus,* and *Belemnites hastatus.*

C. The Upper Jura, of relatively small extent in North-western Germany, and well opened out by the limestone-quarries, is well known in its subdivisions, of which the author makes ten. 1. The Macrocephalus-beds, with *A. macrocephalus, A. Gowerianus, A. funatus, A. calvus,* and *Pleuromya donacina.* 2. The Ornatus-clay, with *A. cordatus* (?), *Nucula Pollux, A. Lamberti, A. ornatus, A. Jason,* and *Gryphæa dilatata* (more abundant higher up). 3. The Hersum beds, with *Gryphæa dilatata, A. dicatilis, A. cordatus* (in lowest part), *Belemnites excentralis, A. perarmatus, Modiola bipartita, Lima pectiniformis, A. mendax,* and *Terebratula Galliennei.* 4. The Coral-beds, with *Isastræa helianthoides.* 5. The Coral-oolite, with *Cerithium limæforme, Cidaris florigemma, Rhynchonella pinguis, Pecten varians, Astarte lævis, A. plana,* and *Lucina aliena.* 6. The Nerinæa-Visurgis-beds, with *N. Visurgis, Cerithium septemplicatum, C. astartinum, Chemnitzia Bronnii, C. abbreviata,* and *Astarte scutellata.* 7. The Pteroceras-beds, with *Terebratula subsella* (especially in the higher part), *Avicula modiolaris, Lucina substriata, Astarte circularis, Trigonia gibbosa,* and *Pteroceras Oceani.* 8. The Exogyra-virgula-beds, with *E. virgula,* and *Pholadomya acuticosta.* 9. The Ammonites-gigas-beds. 10. The Purbeck beds, covering the Portland beds, with, 1st, more than 200 feet of limestone (the Einbeckhäuser Plattenkalk), containing coniferous wood, *Corbula inflexa,* and a little *Estheria* ; 2nd, the red Purbeck marls, unfossiliferous, and more than 100 feet thick; 3rd, The Serpula-rock ("Serpulit"), about 20 feet thick, made up largely of *Serpula coarcervata,* and containing teeth of *Pycnodus.* The true Wealden beds succeed.

General remarks on these groups of strata follow (pp. 61–70); and at page 70 Von Seebach says:—The Hanoverian Jura-formation is in its lower portion, up to the Cornbrash, most like that of South Germany, and was evidently closely connected with it in its origin. Contemporaneously with the formation of the Baltic Jura commenced an approach to the Franco-English type. This similarity holds good for all the Oxfordian Group. The Kimmeridgian Group is in many respects peculiar; but it shows some alliance with that of Northern France. The Purbeck beds are peculiar,

In the Palæontological half of the book (pp. 71 &c.), an extensive table shows the geological distribution, vertical range, and relative abundance of the Liassic, Oolitic, and Purbeck fossils of Hanover, 373 in all—10 Corals, 7 Crinoids, 1 Starfish, 11 Echinoids, 22 Brachiopods, 160 Conchifers, 52 Gasteropods, 188 Cephalopods, 4 Fishes, 4 Reptiles, besides a few Annelids, Crustaceans, Plant-remains, and other obscure fossils.

The last portion of the volume (pp. 85–158) consists of critical remarks on known species (66) and description of new species (25), and is accompanied with ten well-lithographed plates illustrating forty-one old and new species. [T. R. J.]

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

THE END.

Printed by TAYLOR and FRANCIS, Red Lion Court, Fleet Street.