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 EIGHTEENTH.

1862.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, GREEN, LONGMANS, AND ROBERTS.

PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; BAUDRY, 9 RUE DU COQ, PRES LE LOUVRE; LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLXII.

List

OF THE

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OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February 21st, 1862.

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Clerk.

Mr. G. E. Roberts.

Library and Museum Assistant.

Mr. H. M. Jenkins.

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ERRATA ET CORRIGENDA.

Part I.—Proceedings.

Page xxxiii, line 20, *for* flints *read* fluids.
" xxxix, lines 3 and 4 from bottom, *transpose* of which *and* position of.
" 16, line 10, *for* Fluoric *read* Hydrofluoric.
" 69, description of the woodcut, *for the upper* * *read* ×.
" 100, line 28 of Table, for *Cricacathus* read *Cricacanthus.*
" 107, line 3, *after* as *insert* in.
" 109, line 21, *for* with *read* as to the woody cylinder in.
" 131, line 24 from bottom, *for* vlaley *read* valley.
" 133, line 9, *after* had *insert* their.
" 137, line 35, *for* Charnworth *read* Charnwood.
" " last line, *insert* during the deposition of that rock.
" 138, line 41, *for* in *read* on.
" 198, line 26, *for* 685 *read* 646.
" " line 28, *for* 1940 *read* 1979.
" 201, line 15, *for* 1992 *read* 1979; *for* 1043 *read* 1229.

Pages 238–244. Dr. Dawson having informed the Editor of the Quarterly Journal of the Geological Society that some errors in Professor Owen's paper on Fossil Reptilia from the Coal-measures of the South Joggins had been caused by an accidental intermixture of the specimens, which was not detected until after the publication of the August Number of the Journal, a complete list of the *Errata* thus rendered necessary has been given in the Appendix at page 244.

Page 263, Diagram-section, *for* b^3 *read* sea-level; *below* b^2 *insert* b^3.
" 271, line 8, *for* Woolwich *read* the Isle of Sheppey.
" 275, line 17, *add* Shaft No. 10.
" 276, line 11, *add* Shaft No. 11.
" 279, last line, and line 7 from bottom, *for* Hall *read* Hull.
" 280, line 28, *after* Proceedings *insert* vol. iv. No. 53, 1861.
" 281, line 24, *after* Epoch *insert* (10 plates).
" 283, line 27, *for* Tynside *read* Tyneside.
" " last line, *after* portion *insert* (21 plates).
" 284, line 4, after *grandis.*) *insert* (7 plates).
" " line 6, *after* portion *insert* (13 plates).
" 287, line 27, *for* Barnell *read* Burnell.

Pages 296–329 inclusive. A delay in the transmission to Dr. Dawson of a proof of his paper having occurred, the Author's corrections were not received until after its publication, and the following list of *Errata* has consequently become necessary:—

Page 299, line 30, *for* M'Clakeney's *read* M'Closkeney's.
" " line 30, *for* Cones *read* Coves.
" " line 39, *for* Fort House *read* Fort Howe.
" 305, line 8, second column, for *decurrens* read *discrepans.*
" " line 11, first column, for *Goeppert* read *Lesquereux.*

Page 309, line 26, *for* Skaneatales *read* Shenectales.
,, 310, line 4 from bottom, *for* specimen *read* specimens.
,, 313, line 14, *for* Haughton *read* Houghton.
,, 314, line 9 from bottom, for *pinnæformis* read *pennæformis.*
,, ,, line 7 from bottom, *for* were *read* was.
,, 321, line 25, for *Davallioides* read *Davalliæ.*
,, 323, line 27, for *Rimeriana* read *Rœmeriana.*
,, 324, line 5, *for* Mr. Lann *read* Mr. Lunn.
,, ,, last line, for *lineata* read *hirsuta.*
,, 325, line 12, for *invested* read *inverted.*
,, 327, Table, No. 57, *for* decurrens *read* discrepans.
,, 329, Description of Plate XIII. fig. 25, for *C. acutum* read *C. obliquum.*
,, ,, ,, ,, XV. fig. 39, for *obtusilobus* read *curtilobus.*
,, ,, ,, ,, ,, fig. 40, for *decurrens* read *discrepans.*
(See also the Appendix to Dr. Dawson's paper, p. 329.)

Page 342, line 8 from bottom, *for* mispickle *read* mispickel.
,, 395, line 1, *for* suppositian *read* supposition.
,, ,, line 7, *for* that valley *read* Cork valley.
,, 400, line 4 from bottom, *for* E.S.E. *read* W.S.W.
,, 401, line 2, *for* N.N.E. *read* N.N.W.
,, ,, line 8, *for* E.S.E. *read* W.S.W.
,, ,, lines 14 & 15, *for* Dranse and Durance and their tributaries *read* Drance and its tributaries.
,, 402, line 9, *for* Durance and Dranse *read* Drance.
,, 421, line 4, *after* Paisley *insert* (Twice the natural size.).
,, 541, line 4, *before* Very *insert* 6.

Part II.—Miscellaneous.

Page 6, *after* line 35, *insert* By Fr. von Hauer.
,, 10, line 36, *for* those *read* then.
,, 28, line 5, *for* seiner *read* seinen.
,, ,, line 33, *for* rom *read* from.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 21, 1862.

REPORT OF THE COUNCIL.

The Council of the Geological Society, in presenting their Annual Report to the Fellows, have great satisfaction in pointing out the increasing numbers and general usefulness of the Society.

They have, in common with the entire nation, to lament the loss of H.R.H. the Prince Consort, one of our extraordinary Members, from the small number of whom we have also lost H.M. King Frederick William IV. of Prussia.

In all, the Society has lost by death twenty-seven, some of whom were among the oldest and most highly honoured of its Members. But during the past year forty new Fellows have been elected, thirty-four of whom have duly paid their fees, which, with eight previously elected, who have since paid their admission-fees, makes up the considerable number of forty-two new Fellows.

The resignation of three persons has been accepted. Two Foreign Members have died during the past year, and the place of one of them has been filled by the election of a new Member. The total number of Fellows at the close of 1860 was 922; at the close of 1861, 939.

During the years 1860 and 1861, some heavy special expenses have been incurred, by order of the Council, which have been defrayed out of a special source of income, viz. the Bequest-fund, of which £500 have been drawn, leaving a balance of £300 yet undrawn. Taking these unusual sources of income and expenditure into account, the Income of the Society for the past year has exceeded the Expenditure by the sum of £125 3*s*. 8*d*.

The amount of the Funded property of the Society is £4350.

Among the unusual items of expenditure may be cited the donation of £70 to Mr. Nichols, the Society's late clerk, authorized by the General Meeting; £50 ordered by the Council towards the further arrangement and naming of the Foreign Collections; £40 19*s.* for Cabinets for Australian specimens; and a sum of £43 9*s.* 6*d.* for the Library.

The Council have to announce the completion of Vol. XVII. of the Quarterly Journal, and the First Part of Vol. XVIII. They have authorized the distribution of the Journal to the Foreign Members of the Society.

The arrangement of the Foreign Collections has been diligently continued, and for this purpose the second temporary Assistant, engaged at the recommendation of the Special Museum Committee, has been retained up to the present time.

The question of the amount and nature of the permanent assistance required for the efficiency of the Library and Museum has engaged the attention of the Council, and is at present in the hands of a Special Committee.

With reference to the Greenough Map, the Council have to announce that, after unavoidable delays, the third sheet will soon be ready for publication.

In conclusion, the Council have to report that they have awarded the Wollaston Medal to Mr. Robert A. C. Godwin-Austen, for his various researches during the last twenty-eight years, illustrating in a very original and remarkable manner the physical geography of a large region of Europe during by-gone periods, as mainly comprised under the four following heads:—

1st. For his elaborate "Memoir on the Geology of the South-east of Devonshire;" wherein he pointed out the different periods of disturbance from palæozoic to almost recent times in that complicated tract, as based upon actual observations made between the years 1834 and 1840, both inclusive*.

2ndly. For his observations on the Geology of the South-east of Surrey†, which, with his Memoir on the Gravel Accumulations of the Valley of the Wey‡, are explanatory of the changes of land and water in the South-eastern region of England and adjacent parts of France; whilst his paper "On the Sands of Farringdon" treated of that deposit as an intermede between the Lower Greensand (Neocomian) and the Portland Oolite§. This memoir, together with other papers in our Journal, indicate his views of the probable configuration of the land and water in the Western European area during the Mesozoic or Secondary period‖.

3rdly. For his original and striking Memoirs on the Valley of the English Channel and the superficial accumulations on its coasts, which define the former physical geography of the South of England and adjacent parts of France, particularly during the Pleistocene period. And,

4thly. For his bold and ingenious hypothesis, founded on the relations of the older rocks in the North of France and the South of

* Geol. Trans. 2nd series, vol. vi. p. 433. † Proc. Geol. Soc. vol. iv. pp. 167, 196.
‡ Quart. Journ. Geol. Soc. vol. vii. p. 278.
§ Quart. Journ. Geol. Soc. vol. vi. p. 454.
‖ Quart. Journ. Geol. Soc. vol. vi. p. 69, and vol. vii. p. 118.

England, which suggested the probable extension of the younger palæozoic (Carboniferous) deposits* beneath the Cretaceous group around our metropolis, to the exclusion, in that area, of the Triassic, Liassic, and Oolitic deposits†.

The balance of the proceeds of the Wollaston Fund has been awarded to Professor Heer, to assist him in his important investigations into the fossil botany of the Tertiary Strata.

Report of the Library and Museum Committee, 1861–62.

The Museum.

Your Committee have much pleasure in reporting that several important additions have been made to the Foreign Collection since the last Anniversary. Among them may be noticed the large collections of Rocks and Fossils from several German localities, presented by the President; a most valuable series of Reptilian and other fossils from the coal of Nova Scotia, presented by Dr. Dawson, F.G.S. Fossils from Gothland, presented by Dr. Lindström, and from the Andes by Mr. David Forbes, F.G.S. Also a number of South African specimens, presented by Dr. Bowerbank, Dr. G. Grey, Mr. G. W. Stow, the Royal Geographical Society, and Dr. A. G. Atherstone; while Rocks and Fossils from British localities have been presented by the President and other donors.

The Library and Museum Committee stated in their last Report that the collection of European Fossils, occupying 48 cabinets containing 336 drawers, had been nearly re-arranged according to the plan determined upon by the Special Museum Committee at their Meeting on the 25th of June, 1860, and that a catalogue of those collections had been prepared by the President.

Since that time the remaining Foreign Collections have been similarly re-arranged under the direction of the President and Assistant-Secretary, and Catalogues of them have been made by the President uniform with that of the European Collections, in accordance with the wish expressed by the Committee in their last Report. They occupy 68 cabinets, containing 490 drawers as follows:—

	Cabinets.	Drawers.
Asia	21	145
Africa	12	72
North America	24	144
West Indies	5	35
South America	2	22
Australasia	3	48
Miscellaneous	1	24
	68	490

* Quart. Journ. Geol. Soc. vol. xix. p. 384.
† See Notices of the Proceedings of the Royal Institution, part 8. p. 511.

On the 19th of April, 1861, the Council granted the sum of £50 to the Special Committee, to be expended in re-naming the specimens in the European Collections; and the services of Mr. J. W. Salter, F.G.S., Mr. R. Etheridge, F.G.S., of Mr. H. Woodward, and of Mr. S. P. Woodward, F.G.S., were secured for that purpose. Of the specimens named by them the following have been placed upon tablets, labelled, and numbered; and a detailed catalogue of the contents of each drawer has been made and placed therein.

		Drawers.
Norway	Silurian	5
Uddevalla, &c.	Postpliocene	2
Sweden	Silurian	2
Antwerp	Pliocene	1
Touraine	Miocene	2
Paris Basin	Eocene	9
Normandy	Jurassic	6
North America	Cretaceous	1
		28

The naming of the Tertiary fossils has not yet been verified by Mr. S. P. Woodward: for the accuracy of the rest, Messrs. Salter and Etheridge are responsible.

Furthermore, ten drawers of fossils, chiefly from the Eifel and the Rhenish provinces, have been tabletted, labelled, and named, but not arranged zoologically or certified.

The Rev. T. Wiltshire, F.G.S., is making progress with the re-naming and re-arrangement of the British specimens of Cretaceous fossils, which he has been good enough to undertake.

In addition to the foregoing Report of the work done in the Museum during the past year, the Committee subjoin for the information of the Council the following summary of the present state of the Foreign Collection as a whole, viz.:—

28	Drawers of Fossils are now completely arranged and named.
10	Drawers of Fossils are nearly complete.
479	Drawers of Fossils are arranged, but require naming,
And 234	Drawers of Rock-specimens are arranged, but not named.
751	

A series of Coloured Maps, illustrative of the Geological Areas to which the several divisions of the Foreign Collection belong, have been provided under the care of the President.

Those specimens of Fossils from Foreign localities, which are too bulky to be placed in drawers, have been carefully washed and labelled; each one has also been packed in a separate paper, and the name, locality, &c. written upon its outside.

The glass doors of an old cabinet have been converted into a wall-case for the reception of a number of large specimens, chiefly coal-plants from Nova Scotia and Cape Breton.

Two new cabinets, ordered by the Council at the cost of £44 14*s*., have been supplied for the reception of certain of the Foreign Collections; one, consisting of 24 drawers, contains specimens from the West Indies and South America; the other, consisting of 64 drawers, contains the Australasian Collections. The latter cabinet is placed in the tea-room.

The Special Committee have distributed duplicates to public bodies, donations having been made to the British Museum, the Museum of University College, and the Royal Military College at Sandhurst. A considerable number of duplicates still remains for disposal.

In conclusion, the Committee desire to record their sense of the great and unremitting labour (whose value has already been recognized by the Council) which the President has bestowed on the re-arrangement and general superintendence of the Museum.

The Library.

In addition to the usual increase by donation and purchase, the Library has received important additions in consequence of the special vote by the Council of £35, for the purchase of various *desiderata*, among which may be mentioned—

Kaup's 'Urweltliche Säugethiere,' Pander's Monographs upon Silurian and Devonian Fishes, Sartorius's 'Atlas von Ætna,' Rammelsberg's 'Mineralchemie,' Carus and Engelhardt's 'Bibliotheca Zoologica,' H. D. Rogers's 'Geology of Pennsylvania,' Ure's 'Dictionary of Arts, Manufactures, and Mines,' and Dumont's Geological Map of Europe.

The supply of periodicals by exchange, gift, and purchase continues to be large. Books and pamphlets, presented or purchased, have, as usual, been catalogued, shelved, and, when necessary, bound.

The Assistant-Secretary reports that he has received valuable assistance in the Library and Museum from Mr. Jenkins and Mr. Stair.

The Committee are glad to find that, though on an average above 100 works are simultaneously absent from the Library, and in use by the Fellows of the Society, but one case of irregularity in the return of such books has come under their notice, one Member of the Society, notwithstanding repeated applications, having as yet failed to return a work taken out by him two years ago.

JOHN J. BIGSBY.
ROBERT W. MYLNE.
THOMAS WILTSHIRE.
THOMAS H. HUXLEY.

Comparative Statement of the Number of the Society at the close of the years 1860 *and* 1861.

	Dec. 31, 1860.		Dec. 31, 1861.	
Compounders		119		126
Residents		214		225
Non-residents		531		535
		864		886
Honorary Members	5		4	
Foreign Members.........	50		49	
Personages of Royal Blood	3	—58	1	—54
		922		940

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1860 *and* 1861.

Number of Compounders, Residents, and Non-residents, December 31st, 1860			864
Fellows reported as dead in two successive Reports, 1859 and 1860			2
Fellows not included in last Report (Residents) ..			2
Add Fellows elected in 1860 and paid in 1861	Residents		0
	Non-residents		8
Add Fellows elected and paid in 1861	Residents	13	
	Res.-compounders ..	2	
	Non-residents	15	
	Non-res.-compounders	4	
		—	34
Add Fellow re-admitted			1
			911
Deduct Compounders deceased........................		3	
Residents ,, ...		6	
Non-residents ,, ...		10	
Residents resigned		3	
		—	22
			889
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, Dec. 31, 1860			58
Add Foreign Member elected during 1861			1
			59
Deduct Foreign Members deceased		2	
Honorary Members deceased		1	
Personages of Royal Blood deceased		2	
		—	5
As above			54

Number of Fellows liable to Annual Contribution, as Residents, at the close of 1861, *with the alterations during the year.*

Number at the close of 1860		214
Add Elected and paid in 1860, but not included in last Report	2	
Add Fellow counted as Non-resident in making out last Report	1	
Add Elected in former years, and paid in 1861........	13	
Fellow re-admitted..............................	1	
Non-residents became Residents	3	
	—	20
		234
Deduct Deceased	6	
Resigned	3	
	—	9
As above......		225

DECEASED FELLOWS.

Personages of Royal Blood (2).

His Royal Highness the Prince Consort.
His Majesty the King of Prussia.

Compounders (3).

Dr. Fitton.
F. Perkins, Esq.
Lieut.-Gen. Sir C. Pasley.

Residents (6).

T. W. Atkinson, Esq.
Sir W. Cubitt.
Lieut.-Col. Dawson.
J. Otté, Esq.
Dr. A. R. Sutherland.
G. E. H. Vernon, Esq.

Non-residents (10).

Sir A. de Capel Brooke, Bart.
Sir T. Cartwright.
J. J. Forrester, Esq.
A. Hambrough, Esq.
Rev. Prof. Henslow.
E. Hodgkinson, Esq.
W. Hutton, Esq.
J. MacAdam, Esq.
Col. Hon. M. L. Onslow.
Rev. J. M. Traherne.

Foreign Members (2).

M. Cordier.
M. C. Lardi.

The following Persons were elected Fellows during the year 1861.

January 9th.—William Charles Lacy, Esq., Gloucester; Robert Dukinfield Darbishire, Esq., B.A., 1 Heald Grove, Rusholme, Manchester; George Charles Wallich, M.D., 17 Campden Hill Road, Kensington.

January 23rd.—William Weston, Esq., of Birkenhead.

February 6th.—William Rutherford Ancram, Esq., 75 Inverness Terrace, Kensington Gardens; Thomas William Jeffcock, C.E., Woodside, Sheffield.

—— 20th.—J. Frederick Davis, Esq., Walker Iron-works, Newcastle-upon-Tyne; John Frederick Collingwood, Esq., 13 Old Jewry Chambers; Joseph Milligan, Esq., F.L.S., Hobart Town, Tasmania; Henry Porter, M.D., Fellow of Queen's College, Birmingham, Peterborough; Richard Charles Oldfield, Esq., Bengal Civil Service, Farley Hill, Reading.

March 6th.—Francis George Shirecliff Parker, Lieut. H.M. 54th Regiment, Roorkee; J. Gwyn Jeffreys, Esq., F.R.S., 25 Devonshire Place, Portland Place.

April 10th.—James Hector, M.D. Edinb., 13 Gate Street, Lincoln's-Inn-Fields.

—— 24th.—Daniel Mackintosh, Esq., Chichester; Richard Payne Cotton, M.D., Fellow R. Coll. Phys. Lond., 46 Clarges Street, Piccadilly.

May 8th.—Robert Mills, Esq., F.S.A., Rochdale; Edmund William Ashbee, Esq., 14 Rutland Street, Mornington Crescent; Captain Willoughby Osborn, C.B., Madras Army, Brunswick Hotel, Jermyn Street.

—— 22nd.—Silas Bowkley, Esq., Mining Engineer, Batman's Hill, near Bilston, Staffordshire; John Edward Forbes, Esq., 3 Faulkner Street, Manchester; Captain Francis William Henry Petrie, H.M. 11th Regiment, Portsmouth.

June 5th.—Joseph Tolson White, Esq., Mining Engineer, Wakefield, Yorkshire; William Boyd Dawkins, Esq., B.A., Jesus College, Oxford.

—— 19th.—John Atkinson, Esq., Mem. Phil. Geol. Soc., Manchester, Thelwall near Warrington; Major Nathaniel Vicary, Westgate, Wexford; Lord Rollo, 18 Upper Hyde Park Gardens.

November 20th.—Charles Sanderson, Esq., C.E., Engineer-in-Chief, Bombay and Baroda Railway, Surat, Bombay; Ralph Tate, Esq., Teacher of Natural Science, Philosophical Institution, Belfast, 42 Eglington Street, Belfast; James Ray Eddy, Esq., C.E., Carleton Grange, Skipton; Henry Worms, Esq., of the Inner Temple, 27 Park Crescent, Portland Place; Haddock Dennys, Esq., 3 Percy Terrace, Lower Road, Islington.

December 4th.—Samuel Harradan, Esq., 6 Westbourne Terrace, Barnsbury, London; Frederick Merryweather Burton, Esq., Gainsborough; Jonathan Sparrow Crowley, Esq., Lavender Hill, London, S.W.; William Henry Paine, Esq., Stroud, Gloucestershire; Edwin Witchell, Esq., Stroud, Gloucestershire; Henry Tibbats Stainton, Esq., F.L.S., Mountsfield, Lewisham, Kent; Captain Auguste Frederic Lendy, F.L.S., Sunbury House, Sunbury, Middlesex; Isaiah Booth, Esq., Mining Engineer, Oaks Colliery, Oldham; Don Ramon da Silva Ferro, Consul for Chile, 43 Moorgate Street, E.C.

The following Personage was elected a Foreign Member.

Professor Gustav Bischof, University of Bonn.

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

British Specimens.

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

Two specimens of Flint with mammillated surface from church-tower, in illustration of Mr. Rose's observations, published in the Proc. Geol. Assoc., No. 5, p. 624; presented by the Rev. J. S. Henslow, F.G.S.

313 specimens of British Rocks and Fossils; presented by L. Horner, Esq., Pres.G.S.

Specimen of Cyrena-bed from New Cross; presented by J. Sparks, Esq.

Specimens of Mountain-limestones (rocks and fossils) from cuttings at Casterton, near Kirkby Lonsdale, on the line of the Lune Valley Railway; presented by G. Jackson, Esq.

Large mass of Anthracosia, from Coal-bed near Oldham; presented by J. O. Middleton, Esq.

Plant-bed from Upper Tilestones of Kidderminster, with Lycopodites (*Pachytheca sphærica*); presented by Mr. G. E. Roberts.

Cast of Flint-Implement from Icklington; presented by J. Evans, Esq.

Suite of Fossils from Coniston Limestone and Shale; presented by J. O. Middleton, Esq.

Boulders from the Gravel of Kelsey Hill and the Boulder-clay of Paul Cliff, near Hull; presented by J. Prestwich, Esq., F.G.S., and F. J. Smith, Esq., F.G.S.

Two specimens of Boulders (Granite) from the West Rosewarne Mine, Gwinear, Cornwall; presented by H. C. Salmon, Esq., F.G.S.

Specimens of Bones and Rocks from the Cuttings and Tunnels of the Worcester and Hereford Railway; presented by the Rev. W. S. Symonds, F.G.S.

Specimen of Conglomerate with Tin-stone, from Relistian Mine, Cornwall; by A. Majendie, Esq., F.G.S.

Specimens of Bones of Mammalia, from Wickham-lane Brick-field; presented by W. E. Dawson, Esq.

Specimens of Ventriculites, Serpulæ, &c., Upper Greensand, Compton Bay, Isle of Wight; presented by Major R. J. Garden, F.G.S.

Foreign Specimens.

105 specimens of Foreign Rocks and Fossils; presented by L. Horner, Esq., Pres.G.S.

Specimens of Fossils from the Bolivian Andes; presented by D. Forbes, Esq., F.G.S.

A group of *Kraussia rubra* from Algoa Bay, and specimens of Fossil Ferns, &c., from South Africa; presented by Dr. A. G. Atherstone.

A suite of specimens from Natal, collected by A. Holden, Esq.; presented by the Royal Geographical Society.

Nine specimens of Flint-Tools with specimens of Gravel, Brick-earth, and Bones from St. Acheul, Amiens; presented by T. R. Jones, Esq., F.G.S.

A suite of Rocks and Fossils from Western Australia; presented by T. F. Gregory, Esq.

Specimens of Titaniferous Iron-sand from Taranaki, New Zealand, and of Stream-tin, South Australia; presented by Prof. Tennant, F.G.S.

Specimens of Bones in Stalactite from Natal; presented by Major R. J. Garden, F.G.S.

Suite of Fossils from Pangadi, India; presented by Captain Stoddard.

Suite of Fossils from Sunday River, South Africa; presented by G. W. Stow, Esq., and Captain Rock.

Specimens from the Bryozoan Limestone of Mount Gambier, South Australia; presented by the Rev. J. E. Woods, F.G.S.

118 specimens of Rocks and Fossils from 26 localities in Saxony, 35 specimens of Rocks and Fossils from 15 localities in Bohemia, and 7 specimens of Fossil Plants from Œningen; presented by L. Horner, Esq., Pres.G.S.

Specimens of Fossils from near Harrow, on the River Glenelg, Victoria; presented by the Rev. J. E. Woods, F.G.S.

A suite of Upper Silurian Fossils from Gothland; presented by Dr. Lindström.

Specimens of Volcanic Rocks from Lipari and Ascension; presented by Sir C. Bunbury, Bart., F.G.S.

Twenty Rock-specimens from Borneo; presented by Mr. Russell.

Fossil Bird-bone and Fossil Bone of Mammal from New Zealand; presented by Prof. Huxley, Sec.G.S.

Ten specimens of Wealden Coal, &c., from Obernkirchen, Dornberg, Osterwald, &c.; presented by T. R. Jones, Esq., F.G.S.

Specimens of Dicynodon from Cradock, South Africa; presented by Dr. G. Grey.

Specimens of Fossil Bones from Lunel Viel; presented by M. Chrestien.

Specimens of Fossils from South Africa; presented by Dr. Bowerbank, F.G.S.

Specimens of Posidoniæ, Jurassic and Devonian, from Germany; presented by T. R. Jones, Esq., F.G.S.

Specimens of Rocks from the Interior of Australia, collected by Mr. Macdougall Stewart; presented by Sir R. I. Murchison, V.P.G.S.

Charts, Maps, etc. presented.

Section of a Well at Hastings; Section of Mr. Gurney's Well at Red Hill; Section of the Well at the Northampton Water-works;

Section of a Well at Warnham, Sussex; Section of Well at Birkenhead Water-works; presented by G. R. Burnell, Esq., F.G.S.
Section of Well at Thames Bank; presented by T. R. Jones, F.G.S.
Geological Map of Western Australia, from the researches of Messrs. Gregory; presented by J. Arrowsmith, Esq., F.R.G.S.
MS. Geological Map of Cornwall and part of Devon, showing the strike of the Slate-beds, 1858; presented by R. Whitley, Esq.
Carte Hydrologique de la Ville de Paris, par M. Delesse; presented by M. Delesse, For.M.G.S.
Carte Géologique souterraine de la Ville de Paris, 1858. A. Delesse, For.M.G.S.
Carte des anciens Glaciers du Versant Italien des Alpes, par Gabriel de Mortillet; presented by M. G. de Mortillet.
Carte Géologique de la Néerlande, Nos. 19, 20; presented by the Geological Commission of the Netherlands.
Sixty-six Hydrographic Charts and Plans; presented by the Ministre de la Marine, Paris.
Geological Map of a portion of Central India; Saugor and Nerbudda Territories; presented by Prof. Oldham, F.G.S., Director of the Geological Survey of India.
Geological Map of a part of Bundelcund; H. B. Medlicott, Esq., F.G.S.
Map of Sarawak; presented by Mr. Russell, F.G.S.
Physical Atlas of Great Britain and Ireland, by Walter M^cLeod, F.R.G.S.; presented by W. M^cLeod, Esq.
Carte Physique et Industrielle de la Néerlande (in 15 sheets); presented by the Geological Commission of the Netherlands.
Karten und Mittheilungen des Mittelrheinischen Geologischen Vereins: Section Dieburg von F. Becker und R. Ludwig. Presented by the Geological Society of the Middle Rhine.
Map of the British Coal-fields, showing the extent and depth of the Coal-formation, by E. Hull; presented by E. Hull, B.A., F.G.S.
Geological Survey of Great Britain. Vertical Section, Sheet 26. Horizontal Sections, Sheets 58 to 61. Whole sheets, Nos. 12 and 13. Quarter sheets, Nos. 45 N.W.—53 N.E.; 53 S.E.—63 S.E.; 80 N.W.; 82–89 S.W.
Chart of the British Isles, showing the Lines of Deepest water, and Lines of Depression and Elevation, 1861. The Rev. R. Everest, F.G.S.
Schoolkaart voor de Natuurkunde en de Volksvlijt van Nederland. 1860. 15 sheets. Dr. W. C. H. Staring.
Photograph of a remarkable surface of Coal-measure Sandstone at Swansea; presented by M. Moggridge, Esq., F.G.S.
Lithographed Panoramic View of the Kashmir Mountains, by T. G. Montgomerie, 1859; presented by R. Godwin-Austen, Esq., F.G.S.

The following Lists contain the Names of the Persons and Public Bodies from whom Donations to the Library and Museum have been received since the last Anniversary, February 15, 1861.

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 at.
Berwick. Naturalist's Field Club.
Bogota. Natural History Society of New Granadians.
Bordeaux, Société Linnéenne de.
Boston (U. S.), Natural History Society of.
Breslau. Silesian Society for Fatherland Knowledge.
——. Imperial Leopold Academy of Naturalists of Germany.
British Government.
British Museum, Trustees of.
Brussels. L'Académie Royale des Sciences.

Caen. Société Linnéenne de Normandie.
Calcutta. Geological Survey of India.
——. Bengal Asiatic Society.
Cambridge (Mass.). American Academy of Arts and Sciences.
Canada, Geological Survey of.
Cherbourg, Société des Sciences Naturelles de.
Christiania, Royal University of.
Copenhagen. Royal Danish Academy of Sciences.
Cornwall, Royal Polytechnic Society of.

Darmstadt. Geological Society of the Middle Rhine.
Dijon, Academy of Natural Sciences of.
Dorpat, Natural History Society of.
Dublin, Geological Society of.
——, Royal Irish Academy at.

Edinburgh, Royal Society of.

France, Geological Society of.
Frankfurt, Senckenberg Natural History Society of.
—— (Kentucky). Geological Survey of Kentucky.

Geneva. La Société de Physique et d'Histoire.

Halle, Saxony and Thuringian Natural Society in.
Hamburg. Natural History Society.
Hanau. Natural History Society of the Wetterau.
Heidelberg, Natural History Society of.
Hobart Town. Geological Survey of Van Diemen's Land.

India, Secretary of State for.

Lausanne. Société Vaudoise des Sciences Naturelles.
Leeds, Philosophical Society of.
Liége, la Société Royale de.
Liverpool. Lancashire and Cheshire Historical Society.
——, Philosophical Society of.
——, Geological Society of.
London Commissioners for the Exhibition 1861–1862.
London. Geological Survey of Great Britain and Ireland.
——. Royal Astronomical Society.
——. Royal Asiatic Society of Great Britain.
——, Art-Union of.
——. British Association.
——, Chemical Society of.
——. College of Surgeons of England.
——. College of Physicians of England.
——. Royal Geographical Society.
——. Geologists' Association.

London, Royal Horticultural Society of.
——. Institute of Actuaries of Great Britain and Ireland.
——. Institute of Civil Engineers.
——. King's College.
——, Linnean Society of.
——, Mendicity Society of.
——, Meteorological Society of.
——, Microscopical Society of.
——, Photographic Society of.
——, Palæontological Society of.
——, Royal Society of.
——. Royal Institution of Great Britain.
——. Science and Art Department.
——, Statistical Society of.
——, Zoological Society of.
——. London Institution.
——. Board of English Ordnance.
Louis. Academy of St. Louis.
Lyons, les Commissionnaires Hydrométriques de.

Madrid, Academy of Sciences of.
Manchester, Geological Society of.
Melbourne. Mining Surveyors of Victoria.
——. Colonial Mining Journal.
Milan, Imperial Institute of.
Montreal, Natural History Society of.
Moscow, Imperial Academy of Naturalists of.
Munich, Academy of Sciences of.

Netherlands, Geological Commission of.
New Haven (U.S.). Editor of American Journal of Science.
New York. Cooper Union for Advancement of Science and Art.
——, State Library of.
——, Lyceum of Natural History of.

Offenbach, Natural History Society of.

Palermo. Agricultural Society of Sicily.
Paris, l'Académie des Sciences de.
——, Dépôt Générale d'Annales des Sciences Naturelles à.
——, Dépôt de la Marine à.
——. Impériale Zoologique d'Acclimatation.
——. L'Ecole des Mines.
Pesth, Academy of Sciences of.
Philadelphia, Academy of Natural Sciences of.
Plymouth Institution.
Puy-en-Velay, la Société d'Agriculture et Sciences du.

Stockholm, Academy of.
St. Petersburg, Imperial Academy of.
Stuttgart. Fatherland Natural History Society of Wurtemberg.

Toronto (Government of Canada), Public Library of.
——. Canadian Institute.
Turin, Academy of Sciences at.
Tyneside Naturalists' Field Club.

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

Warwickshire Naturalists' Field Club.
Washington. United States War Department.
——. Smithsonian Institution.
Wiesbaden. Natural History Society of the Grand Duchy of Nassau.

Yorkshire (West Riding). Geological and Polytechnical Society.
——, Philosophical Society of.

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

American Journal of Science and Art, Editor of the.
Arkansas, Governor of.
Arrowsmith, J., Esq.
Athenæum Journal, Editor of the.
Atherstone, Dr. A. G.
Atlas Newspaper, Editor of the.
Austin, Major, F.G.S.

Barrande, M. J., For.M.G.S.
Beke, Dr.
Belt, T., Esq.
Biden, W. D.
Binkhoorst, M.
Bland, T., Esq., F.G.S.
Botfield, B., Esq., M.P., F.G.S.
Bowerbank, Dr., F.G.S.
Bristow, H. W., Esq., F.G.S.
Bronn, Prof., For.M.G.S.
Bunbury, Sir C., Bart., F.G.S.
Burnell, G. R., Esq.

Cabral, Don.
Carpenter, Dr. W. B., F.G.S.
Chapuis, M. F.
Charlton, Mr.
Chemist and Druggist, Editor of the.
Chrestien, M.
Clarke, Rev. W. B., F.G.S.
Colliery Guardian, Editor of the.
Critic, Editor of the.
Cumming, Rev. J. G., F.G.S.

Daubeny, Dr., F.G.S.
Daubrée, M. A.
Davidson, T., Esq., F.G.S.
Dawson, Dr. J. W., F.G.S.
Dawson, W. E., Esq.
Delesse, M., For.M.G.S.
Deshayes, Prof., For.M.G.S.
Deslongchamps, M. E. E., For. M.G.S.

Evans, J., Esq., F.G.S.

Favre, M. A.
Ferrel, W., Esq.
Forbes, D., Esq., F.G.S.
Forbes, Prof., F.G.S
Fournet, Prof.
Freke, Dr.

Gabb, Dr.
Garden, Major, F.G.S.
Gaudry, M.
Gemmellaro, Sig. G. G.
Geologist, Editor of the.
Gibb, Dr. G. D., F.G.S.
Godwin-Austen, R., Esq., F.G.S.
Grant, Dr.
Gray, Dr. Asa.
Gregory, T. F., Esq.
Grey, Dr. G.
Guyot, Dr.

Haast, J., Esq.
Hall, Prof., For.M.G.S.
Hauer, H. von.
Haughton, Rev. S., F.G.S.
Hébert, M. E.
Hector, Dr., F.G.S.
Heer, Prof. O.
Helmersen, G. von, For.M.G.S.
Henslow, Rev. J. S., F.G.S.
Henwood, W. J., F.G.S.
Hopkins, E., Esq., F.G.S.
Horner, L., Esq., Pres.G.S.
Horton, W. S., Esq., F.G.S.
Hull, E., Esq., F.G.S.
Huxley, Prof. T. H., Sec.G.S.

Jackson, G., Esq.
Jamieson, T. F., Esq., F.G.S.
Jeffreys, J. G., Esq., F.G.S.
Jones, T. R., Esq., F.G.S.

King, Prof. W.

Lartet, M., For.M.G.S.
Lea, Dr. I.
Lindsay, Dr.

Lindström, Dr. G.
Literary Gazette, Editor of the.
London, Edinburgh, and Dublin Philosophical Magazine, Editor of the.
London Review, Editor of the.
Longman and Co., Messrs.
Longman, W., Esq., F.G.S.
Lovén, M. S.
Lubbock, J., Esq., F.G.S.
Lyell, Sir C., F.G.S.

McAndrew, J., Esq.
McLeod, W., Esq.
Majendie, A., Esq., F.G.S.
Marcou, M. J.
Mechanics' Magazine, Editor of the.
Michelin, M.
Middleton, J. O., Esq.
Mining Review, Editor of the.
Moggridge, M., Esq., F.G.S.
Mortillet, M.
Murchison, Sir R. I., V.P.G.S.

Naumann, Dr. C. F., For.M.G.S.
Newberry, J. S., Esq.
New Zealand Examiner, Editor of the.
Nicol, Prof. J., F.G.S.

Oldham, Dr., F.G.S.
Ordway, A.
Owen, Prof. R., F.G.S.

Parker, W. K., Esq.
Perry, M.
Perthes, B. de.
Pictet, M. F. J.
Pirona, Dr.
Porter, Dr., F.G.S.
Prestwich, J., Esq., F.G.S.

Quarterly Journal of Microscopical Science, Editor of the.
Quarterly Journal of the Chemical Society, Editor of the.

Ramsay, Prof. A. C., F.G.S.
Reeve, L., Esq., F.G.S.
Russell, Prof.
Rutimeyer, Dr.

Salmon, H. C., Esq., F.G.S.
Sandberger, Dr.
Sars, Dr. M.
Scharff, Dr.
Schvarcz, Dr.
Scott, R. W., Esq.
Sorby, H. C., Esq., F.G.S.
Sparks, J., Esq.
Stoddard, Captain.
Stoliczka, M. F.
Stoppani, A.
Stow, G. W., Esq.
Street, G., Esq.
Studer, Prof. B., For.M.G.S.
Suess, Prof. E.
Symonds, Rev. W. S., F.G.S.

Tennant, Prof. J., F.G.S.
Tylor, E. B., Esq.
Tyson, P., Esq.

Weizel, T. O.
Whitley, N., Esq.
Whitley, R., Esq.
Willis and Sotheran, Messrs.
Woods, Rev. J. E., F.G.S.

Zigno, Signor A. de.

List of Papers *read since the last Anniversary Meeting, February* 17*th*, 1861.

1861.

Feb. 20th.—On the Coincidence between the Stratification and Foliation of the Altered Rocks of the Scottish Highlands, by Sir R. I. Murchison, V.P.G.S., and A. Geikie, Esq., F.G.S.

———— On the Relations of the Strata of some parts of the Scottish Highlands (South of the Caledonian Canal) and in the North of Ireland, by Prof. Harkness, F.G.S.

March 6th.—On the Succession of Beds in the Hastings Sand, by F. Drew, Esq., F.G.S.

———— On the Permian Rocks of South Yorkshire, and their Palæontological relations, by J. W. Kirkby, Esq.; communicated by T. Davidson, Esq., F.G.S.

March 20th.—Notes on a Collection of Fossil Plants from Nágpur, by Sir C. J. F. Bunbury, F.G.S.

———— On the Age of the Fossiliferous Thin-bedded Sandstone and Coal of the Province of Nágpur, India, by the Rev. Stephen Hislop; communicated by the President.

———— On the Relative Positions of certain Plants in the Coal-bearing beds of Australia, by the Rev. W. B. Clarke, F.G.S.

April 10th.—On Elevations and Depressions of the Earth in North America, by Dr. Abraham Gesner, F.G.S.

———— On the Geology of the Country between Lake Superior and the Pacific Ocean (between the 48th and 54th parallels of latitude) visited by the Government Exploring Expedition under the command of Captain J. Palliser (1857–60), by J. Hector, M.D.; communicated by Sir R. I. Murchison, V.P.G.S.

April 24th.—On the Occurrence of the *Cyrena fluminalis*, together with Marine Shells of Recent Species, in beds of Sand and Gravel over beds of Boulder-clay near Hull; with an Account of some Borings and Well-sections in the same District, by J. Prestwich, Esq., Treas.G.S.

———— On the "Symon Fault" in the Coalbrook-dale Coalfield, by M. W. T. Scott, Esq., F.G.S.

May 8th.—On two Bone-caverns in the Montagne du Ker at Massat, in the Department of the Ariège, by M. Alfred Fontan; communicated by M. Lartet, For.M.G.S.

———— Notes on some further discoveries of Flint Implements in Beds of Post-pliocene Gravel and Clay; with a few Suggestions for Search elsewhere, by J. Prestwich, Esq., Treas.G.S.

———— On the *Corbicula* (or *Cyrena*) *fluminalis* geologically considered, by J. Gwyn Jeffreys, Esq., F.G.S.

May 22nd.—On the Geology of a part of Western Australia, by F. T. Gregory, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

———— On the Zones of the Lower Lias and the *Avicula contorta* Zone, by C. Moore, Esq., F.G.S.

June 5th.—On the Occurrence of large Granite Boulders, at a Great

1861.

Depth, in West Rosewarne Mine, Gwinear, Cornwall, by H. C. Salmon, Esq., F.G.S.

June 5th.—On an erect *Sigillaria* from the South Joggins, Nova Scotia, by Dr. J. W. Dawson, F.G.S.

———— Note on a *Carpolite* from the Coal-formation of Cape Breton, by Dr. J. W. Dawson, F.G.S.

———— On some of the Higher Crustacea from the British Coal-measures, by J. W. Salter, F.G.S.

———— On a Reconstructed Bed on the top of the Chalk and underlying the Woolwich and Reading Beds, by W. Whitaker, B.A., F.G.S.

June 19th.—On the Lines of Deepest Water around the British Isles, by the Rev. R. Everest, F.G.S.

———— On the Old Red Sandstone Rocks of Forfarshire, by James Powrie, Esq., F.G.S.

———— On the Ludlow Bone-bed and its Crustacean Remains, by J. Harley, M.B.; communicated by Prof. Huxley, Sec.G.S.

———— On the Outburst of a Volcano near Edd, on the African Coast of the Red Sea, by Capt. R. L. Playfair; communicated by Sir R. I. Murchison, V.P.G.S.

———— Notice of the Occurrence of an Earthquake on the 20th of March, 1861, in Mendoza, Argentine Confederation, South America, by C. Murray, Esq.; communicated by the President.

———— On the Increase of Land on the Coromandel Coast, by J. W. Dykes, Esq.; from a letter to Sir C. Lyell, F.G.S.

Nov. 6th.—On the Bone-caves of Lunel-Viel, Herault, by M. Marcel de Serres; communicated by the President.

———— On the Petroleum-springs of North America, by Dr. A. Gesner, F.G.S.

———— On a Volcanic Phenomenon witnessed at Manilla, by J. G. Veitch, Esq.; communicated by Dr. Hooker.

———— Notice of the Discovery of Additional Remains of Land Animals in the Coal-measures of the South Joggins, Nova Scotia, by Dr. J. W. Dawson, F.G.S.

Nov. 20th.—On some Volcanic Cones at the foot of Etna, by Prof. Gemmellaro; communicated by Sir C. Lyell.

———— On the Deposits at Bovey Tracey, Devon, by J. H. Key, Esq.; communicated by Sir C. Lyell, F.G.S.

———— On some Carboniferous *Brachiopoda* from the Punjab, by T. Davidson, Esq., F.G.S.

Dec. 4th.—On the Bracklesham Beds of the Isle of Wight Basin, by the Rev. O. Fisher, F.G.S.

1862.

Jan. 8th.—On the Carboniferous Limestones of Oreton and Farlow, Clee Hills, Shropshire, by Prof. J. Morris, V.P.G.S., and Mr. G. E. Roberts; with a note on a new *Pterichthys*, by Sir P. de M. Grey Egerton, Bart., F.G.S.

———— On some Fossil Plants showing Structure, from the

1862.

Lower Coal-fields of Lancashire, by E. W. Binney, Esq., F.R.S., F.G.S.

Jan. 22nd.—On the further Discovery of Flint Implements in Gravel near Bedford, by J. Wyatt, Esq., F.G.S.

——— On Flint Arrow-heads (?) from the Drift in North Devon, by N. Whitley, Esq.; communicated by J. S. Enys, Esq., F.G.S.

——— On the Hyæna-den at Wookey-hole, near Wells, by W. Boyd Dawkins, Esq., F.G.S.

After the Reports had been read it was resolved,—

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

It was afterwards resolved,—

1. That the thanks of the Society be given to Sir R. I. Murchison, Prof. John Phillips, and G. P. Scrope, retiring from the office of Vice-President.

2. That the thanks of the Society be given to Dr. J. D. Hooker, Prof. W. H. Miller, Prof. J. Phillips, Major-General Portlock, and T. Sopwith, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

Professor A. C. Ramsay, F.R.S.

VICE-PRESIDENTS.

Sir P. G. Egerton, Bart., M.P., F.R.S. & L.S.
Sir Charles Lyell, F.R.S. & L.S.
J. Carrick Moore, Esq., F.R.S.
Professor John Morris.

SECRETARIES.

Prof. T. H. Huxley, F.R.S. & L.S.
Warington W. Smyth, Esq., M.A., F.R.S.

FOREIGN SECRETARY.

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

TREASURER.

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

COUNCIL.

John J. Bigsby, M.D.
Sir Charles Bunbury, Bart., F.R.S. & L.S.
Robert Chambers, Esq., F.R.S.E. & L.S.
Sir P. G. Egerton, Bart., M.P., F.R.S. & L.S.
Earl of Enniskillen, D.C.L., F.R.S.
Hugh Falconer, M.D., F.R.S.
William John Hamilton, Esq., F.R.S.
Leonard Horner, Esq., F.R.S. L. & E.
Prof. T. H. Huxley, F.R.S. & L.S.
John Lubbock, Esq., F.R.S. & L.S.
Sir Charles Lyell, F.R.S. & L.S.
Edward Meryon, M.D.
John Carrick Moore, Esq., F.R.S.
Prof. John Morris.
Sir R. I. Murchison, G.C.St.S., F.R.S. & L.S.
Robert W. Mylne, Esq., F.R.S.
Joseph Prestwich, Esq., F.R.S.
Prof. A. C. Ramsay, F.R.S.
G. P. Scrope, Esq., M.P., 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 FIFTY FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1862.

Date of Election.

1817. Professor Karl von Raumer, *Munich.*
1818. Professor G. Ch. Gmelin, *Tübingen.*
1819. Count A. Breunner, *Vienna.*
1819. Sign. 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, *Breslau.*
1828. M. J. M. Bertrand de Doue, *Puy-en-Velay.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Memb. R. S., *Paris.*
1828. Dr. B. Silliman, *New Haven, Connecticut.*
1829. Dr. Ami Boué, *Vienna.*
1829. J. J. d'Omalius d'Halloy, *Namur.*
1832. Professor Eilert Mitscherlich, For. Mem. R. S., *Berlin.*
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, *Paris.*
1847. Dr. M. C. H. Pander, *Riga.*
1847. M. le Vicomte B. d'Archiac, *Paris.*
1848. James Hall, Esq., *Albany.*
1850. Professor Bernard Studer, *Berne.*
1850. Herr Hermann von Meyer, *Frankfort on Maine.*
1851. Professor James D. Dana, *New Haven, Connecticut.*
1851. Professor H. G. Bronn, *Heidelberg.*
1851. Colonel 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, *Reval.*
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, *Heidelberg.*
1857. Professor Dr. H. R. Goeppert, *Breslau.*
1857. M. E. Lartêt, *Paris.*
1857. Professor Dr. H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *St. Petersburg.*
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 Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*

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. D. 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.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal (considered good)	50	0	0			
Due for Authors' Corrections	18	17	0			
Due for Arrears (See Valuation-sheet)	127	16	0			
				196	13	0
Ordinary Income for 1861 (estimated).						
Annual Contributions:—						
222 Resident Fellows at £3 3*s.*	699	6	0			
48 Non-resident Fellows at £1 11*s.* 6*d.*	75	12	0			
				774	18	0
Admission-fees (supposed)				200	0	0
Compositions (supposed)				150	0	0
Dividends on Consols				131	12	0
Sale of Transactions, Proceedings, Geological Map, Library-catalogues, and Ormerod's Index				50	0	0
Sale of Quarterly Journal				200	0	0
Due from Longman and Co. in June				60	9	4
Balance due from Bequest-Fund on account of Expenditure on Map, Museum, and Library				106	17	3
				£1870	9	7

JOSEPH PRESTWICH, TREAS.

Feb. 5, 1862.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes and Insurance	40	0	0			
House-Repairs	30	0	0			
Furniture	20	0	0			
Fuel	35	0	0			
Light	35	0	0			
Miscellaneous House-expenses	50	0	0			
Stationery	30	0	0			
Miscellaneous Printing, including Abstracts	30	0	0			
Tea for Meetings	20	0	0			
				290	0	0
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	90	0	0			
Assistants in Library and Museum	100	0	0			
Porter	90	0	0			
Housemaid	40	0	0			
Occasional Attendants	20	0	0			
Collector	30	0	0			
				570	0	0
Library: Ordinary and Special Expenditure				10	0	0
Museum: Ordinary Expenditure				50	0	0
Diagrams at Meetings				5	0	0
Miscellaneous Scientific Expenditure				50	0	0
Publications: Quarterly Journal				630	0	0
" Transactions				10	0	0
" Geological Map, special expenditure				80	0	0
				£1775	0	0
Balance in favour of the Society				95	9	7
				£1870	9	7

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1861				19	8	10
Balance in Clerk's hands				15	3	6
Compositions received, 1861				141	15	0
Arrears of Admission-fees				50	8	0
Arrears of Annual Contributions				63	0	0
Admission-fees for 1861				214	4	0
Annual Contributions for 1861, viz.—						
204 Resident Fellows	£636	16	6			
36 Non-Resident Fellows	51	19	0			
				688	15	6
Dividends on Consols	131	18	8			
Dividends on New South Wales Bond	7	4	4			
				139	3	0
Publications:						
Longman and Co., for Sale of Quarterly Journal in 1860	63	12	3			
Sale of Transactions	16	8	0			
Sale of Proceedings	0	10	0			
Sale of Journal, Vols. 1–6	10	2	6			
" Vols. 7–12	17	17	6			
" Vols. 13–15	19	9	0			
" Vol. 16	50	12	6			
" Vol. 17*	94	10	10			
Sale of Geological Map	6	12	3			
Sale of Library-catalogues	2	18	6			
Sale of Ormerod's Index	3	5	4			
				285	18	8
Journal-Compositions				18	0	0
Portion of the Greenough and Brown Bequest-Fund, ordered by the Council to be sold out on account of Special Expenditure on Map, Library, Museum, and House-repairs, as per general estimates for the year 1861†				490	2	6
Donation from Mr. Alfred Tylor				52	10	0
				£2178	9	0

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

THOMAS F. GIBSON, ALFRED TYLOR, } *Auditors.*

Feb. 1, 1862.

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XVII.	£60	9	4
Due from Fellows for Journal Subscription	50	0	0
† Balance due from the Bequest-Fund for expenditure on Map, Library, and Museum	106	17	3
	£217	6	7

Year ending December 31*st*, 1861.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	28	8	4			
Fire-Insurance	3	0	0			
House-Repairs:—Ordinary £15 14 6						
Special 148 4 6						
	163	19	0			
Fuel	34	3	0			
Light	32	18	9			
Miscellaneous House-expenditure, including Postage-stamps	87	4	7			
Stationery	23	17	2			
Miscellaneous Printing	20	8	6			
Tea for Meetings	17	15	8			
				411	15	0
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	76	5	0			
Assistants in Library and Museum	91	0	0			
Porter	90	0	0			
Housemaid	40	0	0			
Donation to Mr. Nichols	70	0	0			
Occasional Attendance	21	19	6			
Collector	25	5	9			
				614	10	3
Library:—Ordinary Expenditure	56	6	2			
Special ditto	43	9	6			
				99	15	8
Museum:—Ordinary Expenditure	37	13	9			
Special, Foreign Collection	50	0	0			
Ditto, Cabinets	40	19	0			
				128	12	9
Diagrams at Meetings				0	10	0
Miscellaneous Scientific Expenses				17	18	10
Publications:						
Geological Map	55	4	3			
Transactions and Ormerod's Index	6	3	5			
Proceedings and Abstracts	8	0	6			
Journal, Vols. VII.–XII.	0	15	3			
" Vols. XIII.–XV.	2	0	8			
" Vol. XVI.	4	13	7			
" Vol. XVII.	616	3	10			
				693	1	6
Balance at the Banker's and at Messrs. Longman's, Dec. 31, 1861				192	6	1
Balance in Clerk's hands				19	18	11
				£2178	9	0

Trust-Account.

Receipts.	£	s.	d.	Payments.	£	s.	d.
Balance at Banker's, 1st of January 1861, on the Wollaston Donation-fund	31	10	1	Award to Prof. Daubrée, 1861	21	0	1
Dividends on the Donation-fund of £1084 1*s.* 1*d.*, Red. 3 per Cents.	31	4	8	Cost of Striking Gold Medal awarded to Prof. Bronn, 1861	10	10	0
				Balance at Banker's (Wollaston-fund)	31	4	8
	£62	14	9		£62	14	9

Valuation of the Society's Property; 31*st December*, 1861.

Property.	£	s.	d.	£	s.	d.	Debts.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. XVII.				60	9	4	Balance in favour of the Society	4819	7	4
Due from Subscribers to Journal				50	0	0				
Due for Authors' Corrections in Journal				18	17	0				
Balance in Banker's hands				192	6	1				
Balance in Clerk's hands				19	18	11				
Funded Property :—										
Consols, at 95	4350*	0	0	4350	0	0				
Arrears of Admission-fees (considered good)	37	16	0							
Arrears of Annual Contributions	90	0	0	127	16	0				
				£4819	7	4		£4819	7	4

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

(Signed) JOSEPH PRESTWICH, *Treas.*

5th Feb. 1862.

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

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

21st FEBRUARY, 1862.

Award of the Wollaston Medal.

The Chairman, Sir Roderick Murchison, then addressed Mr. Godwin-Austen as follows:—

Mr. Godwin-Austen,—Valuing as I do the services you have rendered to geological science, I consider myself very fortunate in occupying this chair to perform the duty of the President in his unavoidable absence, by placing the Wollaston Medal in your hands.

Although there are two points in your numerous writings in which I have differed from you, viz., your theory of the synchronism of the Upper Silurian and Devonian rocks, and your view of the lacustrine or terrestrial nature of the Old Red Sandstone, yet even in these views I admire your originality of thought; whilst on all other grounds I am bound to say that I am convinced of the soundness of your speculations.

In truth, all your associates, as well as myself, are aware that you have distinguished yourself during a long series of years by your successful inquiries into the former changes of land and water from the Palæozoic age to modern times.

Persistently keeping that great object in view, you have put forth well-founded hypotheses, based on actual and numerous observations, which have raised the philosophical character of our science. Your sedulous study of the organic remains, as well as the materials of the beds themselves of each formation which you have examined, and your laborious tracings of various lines of dislocation, have all been made subservient to that one great end; and I am therefore proud to announce that you are this day justly rewarded with the Wollaston Medal as being pre-eminently the physical geographer of bygone periods.

In your latest remarkable researches, you have, by fair inductive reasoning, brought to the mind's eye of geologists the high probability of the extension of Upper Palæozoic, if not of Carboniferous strata beneath the surface of the Tertiary and Cretaceous rocks surrounding our metropolis; and you have thus made the value and importance of our science apparent even to the commercial classes of the country.

Pray receive this Medal as the hearty expression of our approbation; and may it stimulate you to extend to the study of the subsoil of those foreign lands into which you are about to travel the same energy and talent which enabled you to elaborate so ingeniously and so skilfully the former changes of land and water over so large an area in the west of Europe.

Mr. Godwin-Austen, on receiving the Medal, thus replied:—

I have so frequently been a member of the Council of this Society when the award of the Wollaston Medal has been under consideration, I so well know how many qualifications have been taken into account in its adjudication, that I am enabled to appreciate in the fullest the very high honour which I now receive, at your hands, from this Society. I am proud of such a record of the estimation in which the part which I have taken in our common work has been held by you. But when I speak in this way of the Wollaston Medal, I beg that you will feel assured, and by no idle form of words, that I should almost regret the honour if I thought for a moment that I could thereby deceive myself. I know how very unequal are the degrees of merit of those who receive the same honours; and I can myself, as well as anybody, draw the broad line which must separate me from others whom you have already placed in that distinguished list.

You have been pleased, Sir, to refer to some of those contributions which have been favourably considered by the Council. I will not follow you over that ground; but perhaps I may be allowed to say this much, that in every contribution I have endeavoured to work out and apply what has been seen and recorded to some of the ultimate aims and objects of geological investigation. It may have been no very difficult matter to restore the physical features of the north hemisphere for the Tertiary, or even for the Cretaceous and Oolitic periods of past time. The Permian area and that of old Coal-growths are both easy enough of definition. But, standing before you as I now do, I am forcibly reminded that when it came to the consideration of those vast masses of early Palæozoic deposit, now raised up into the mountains of Wales, so large a portion of which go to form your Silurian series, that then for the first time all landmarks seem to disappear, and that I was driven to steer for a Western Atlantis older and larger far than that of Plato.

Such speculations may by some have been thought hazardous; but little by little this Western sub-Atlantic land has acquired wonderful distinctness, and towards this chapter in ancient geography those researches which you have recently been engaged in in the north-western regions of these our British Islands have lent a most important aid.

You have alluded to the period of my connection with this Society: twenty-seven years become a serious retrospect to every man. I might perhaps not have thought so much of it, but it now strikes me that I lived too much in the Castle of Indolence: this Medal almost seems to reproach me by the suggestion that I might and ought to have done more. However, we are told "that it is never too late to mend;" and I hope to bear away this Medal, not as a solatium for labours that are ended, but as an incentive to work which may yet be accomplished.

Award of the Wollaston Donation-fund.

In delivering the purse containing the balance of the proceeds of the Wollaston Fund to Professor Huxley, the Chairman said:—

Mr. Secretary,—In handing to you the purse containing the proceeds of the Wollaston Fund, and in requesting you to convey it to Professor O. Heer, it is enough for me to remind the Meeting that this eminent botanist and entomologist has rendered great services to geology by his remarkable works on the 'Tertiary Insects of Oeningen and Radoboj,' by his 'Tertiary Flora of Switzerland,' by his 'Vegetation and Climate of the Tertiary Period,' and recently by throwing light on the true age of the lignite deposit of Bovey Tracey. For these important works Professor Heer is indeed well entitled to any honour we can give him; and these proceeds are awarded to him to enable him to prosecute with greater ease his praiseworthy and enlightened researches.

The Chairman next, before reading the following letter from the President, regretting his unavoidable absence in Italy, expressed his sense of the eminent services rendered to the Society since its foundation by Mr. Leonard Horner.

Florence, 11th February, 1862.

To Sir Roderick I. Murchison, F.R.S., Vice-President of the Geological Society.

My dear Sir Roderick,—You are aware that it was indispensable for me to leave England last autumn to pass the winter in Italy, for the benefit of a member of my family who had been long in bad health.

As senior Vice-President, you will, I hope, be in the chair at the ensuing Anniversary, and I request that you will assure the Meeting that no other consideration would have induced me to absent myself from my duties as President. The honour conferred upon me of being elected a second time to the highest office in the Society I felt as a very great distinction. It is now nearly fifty-four years since I began to take an active part in the affairs of the Society; and to have been called upon to exert myself for its honour and interest, I felt as a renewal of the pleasure of my younger days.

I beg you to convey my very sincere thanks to the Members of the Council and to the Society at large for the kind support I uniformly experienced from them on all occasions. So long as life and health may be left to me, I shall continue my devotion to geological science, and my attachment to the Society which has done so much to promote it.

I am, my dear Sir Roderick,
Faithfully yours,
LEONARD HORNER.

The Chairman then proceeded to read the following Obituary Notice of Dr. Fitton.

The record of the decease of Fellows of the Geological Society is naturally commenced this year with a sketch of the life of one of our most distinguished leaders. The late Dr. W. H. FITTON, who was born in Dublin in January 1780, and died in London on the 13th May, 1861, at the mature age of 81, was truly one of the British worthies who have raised modern geology to its present advanced position.

Descended from an ancient family in Cheshire, whose tombstones are still to be seen in the parish church of Gawsworth, Dr. Fitton's ancestors had been long settled in Ireland. As a little boy, he frequented the same school in Dublin as Thomas Moore, the poet, and Robert Emmett, the United Irishman ; and already in 1798, through his proficiency in classics, he gained the Senior Scholarship of Trinity College, which he held till 1803, whilst as early as 1799 he became Bachelor of Arts in that University. Even in those troublous times, as I am informed by his old friend, that distinguished linguist and geographer, the Rev. G. Renouard, young Fitton began to collect fossils, in doing which, having been unjustly suspected to be a rebel, he was for a short time kept in military durance.

From letters addressed to his learned friend, the Rev. J. Rogers, of Mawnan, in Cornwall, we learn that he made visits to that county to acquire a knowledge of its mineral structure ; and in one of these letters, dated from Trinity College, Dublin, in November 1807, we find that he had then determined the heights of the principal Irish mountains by barometrical admeasurement. In that letter he also speaks of an associate who has since given to the world the best geological map of Ireland—our eminent fellow-labourer the present Sir Richard Griffith.

Originally destined for the church, Mr. Fitton was soon attracted to the medical career and the pursuits of physical science by entering into the studies of the University of Edinburgh (1808–9), then so justly celebrated for its great philosophical teachers. There it was that he formed intimacies with other students of medicine who afterwards reached the summit of their profession. Attending the lectures of Professor Jameson, he then made the acquaintance of the Rev. Dr. John Fleming and other young men of science. There it was also that he learnt to admire the writings as well as to imbibe the liberal sentiments of Sydney Smith, Jeffrey, Brougham, and the founders of that 'Edinburgh Review' to which in subsequent years he himself became a distinguished contributor. Removing to London in 1809 or 1810, he kept house with his widowed mother and his three sisters—studying medicine and chemistry assiduously, and associating with all the rising men of science in that day, particularly with Wollaston, Holland, Roget, Chambers, Bright, and others.

In 1811 Dr. Fitton commenced to write on our science by communicating, through our respected President, Leonard Horner, to the then young Geological Society a memoir "On the Geological Structure of the Vicinity of Dublin," which appears in the 1st volume of our Transactions (Old Series). Again, in 'Nicholson's Journal' of 1813 we find one of his essays on the Geological System of Werner, as doubtless derived from his Scottish studies in the days of Jameson, Hall, Hutton, and Playfair; and in the following year he wrote upon the Porcelain Rocks of Cornwall, which he had personally examined, and also gave out his views on a new system of ventilating mines. In 1812 he removed with his mother and sisters to Northampton, to which place he was attracted chiefly through the patronage of the then Earl and Countess Spencer, and in the hope of succeeding to the practice of the venerable Dr. Kerr, the father of Lady Davy. Practising for eight years as a physician at Northampton, it appears that in 1816 he was admitted "*ad eundem*" M.D. of the University of Cambridge.

In 1817 Dr. Fitton began that series of articles in the 'Edinburgh Review,' to which he contributed at intervals until the year 1841, and which proved him to be a just and enlightened commentator on the progress of geological science during the eventful thirty years of which he treated. Thus, when we look back to his first article, which analysed the 'Transactions of the Geological Society' since its establishment in 1804 up to the publication of a new volume in 1817, or refer to his review in the following year of the first geological map of England, and the other original efforts of William Smith, we at once see how happily he seized upon and illustrated the prominent features in the foundations of our science, and the establishment of that British nomenclature which has become so generally current. Then again in 1823, when he indited his stirring pages on Buckland's 'Reliquiæ Diluvianæ,' or in 1839, when he reviewed the 'Elementary Geology' of Lyell, and put forth so much knowledge respecting the Huttonian theory of the earth, or in 1841, when he reviewed the succession of palæozoic periods, as explained in the Silurian System of Murchison*, we see how vigorously he watched over and rejoiced in the progress of all inquiries which unfolded the history of bygone ages and enabled us to read off the ancient legends of the former inhabitants of the earth, as

* Dr. Fitton also contributed to the 'Edinburgh Review' two articles connected with his profession as a medical man, viz. "Report on Lunatic Asylums," vol. xxviii., May 1817, and "Larrey's Surgical Campaign," vol. xxxi. No. 62, March 1819.

well as the mutations by which the present outline of our planet has been brought about.

The researches, however, by which the name of William Henry Fitton will be most surely handed down to posterity are those by which, during twelve active years of his life (from 1824 to 1836), he laboriously developed the true descending order of succession from the Chalk downwards into the Oolitic Formations, as exhibited in the south-east of England* and in the adjoining parts of France. Before these labours commenced, geologists had confused notions only as to the order of the strata beneath the Chalk, as well as of the imbedded fossil remains of each stratum. It was Fitton who made the Greensand Formations his own, by clearly defining the position and character of the Upper and the Lower Greensands, as separated by the Gault. On this point, the writer of this sketch may well gratefully testify to the clearness and truthfulness of the views of his lamented friend, and the hearty zeal with which they were communicated; for it was through the instruction given to him in the field by Dr. Fitton, in 1825, that he was enabled to write his first paper in the 'Transactions' of this Society†.

Ever striving to advance his favourite science, Dr. Fitton was the zealous instructor not only of young geologists, but also of many travellers and naval officers; and among those to whom he volunteered to give practical lessons, Captain Philip King, R.N., Admirals Sir John Franklin and Sir George Back, as well as Sir John Richardson, may be cited. He also devoted much of his time to the writings of his friends, invariably labouring zealously to improve their compositions.

Such gratuitous efforts, the care of a family, and other occupations necessarily delayed the completion of his great work on the Greensand Formations; but at length those memoirs were completed, both by very elaborate details regarding the succession of these deposits in various parts of England, in separating them from the ironsands of the inferior Wealden Formation, and also by showing how that great freshwater deposit passes down into the Purbeck beds, and from them into the Portland Rock.

On various occasions of his life Dr. Fitton displayed much honesty of purpose and a strong sense of the value of independence of character. Of his associates who survive, Herschel and Babbage, as well as Lyell and myself, can well remember when H. R. Highness the Duke of Sussex was suddenly brought forward as a candidate for the Chair of the Royal Society, that among the large body of men of science who then stood forward to vindicate the rights of their order, no one was a more ardent supporter of Herschel, in opposition to the Royal Prince, than the warm-hearted and honest Fitton, united as he then was with Wollaston, Robert Brown, and all the notabilities in science.

One of the claims of Dr. Fitton on the gratitude of geologists is, that after having been the Secretary of the Society during some

* Trans. Geol. Soc., 2nd series, vol. iv. pp. 103 to 388.

† Trans. Geol. Soc., 2nd series, vol. ii. p. 97.

years of his life, no sooner did he attain the honour of our Chair, than he established the publication of those 'Proceedings' which are the true synopsis of our labours, and have been imitated by the Royal Society and most of the scientific societies in the metropolis. He was also the first of our Presidents who adopted the practice of delivering an Anniversary Address, which under his management was a well-composed and accurate sketch of the progress we had made. Let me here add, that his two addresses contained much good matter in a very small compass; for the first of them occupied eleven pages, and the second twenty-two pages only of our 'Proceedings.'

In the first of these, Dr. Fitton energetically adverted to the then imperfect condition of our knowledge concerning the distribution of plants upon the former surfaces of the globe during epochs of geological deposition, as well as to the variations which such distribution may have undergone from changes of climate, either by alteration of internal temperature or elevation above the sea. Then let us turn to his just eulogy of the labours of von Buch, Humboldt, and McCulloch, in supporting the theory of Hutton, as illustrated by Playfair and Hall, and verified in Anglesea by the striking observations of Henslow, as well as by Davy's experiments on the flints in the cavities of crystals.

Then, again, let us look at his well-merited encomium on the wondrous effect in the progress of English Geology as produced by the publication of the 'Outlines of England and Wales,' by Conybeare and Phillips, which volume was well said by him to have had an effect to which nothing since the institution of the Geological Society and the diffusion of geological maps could then be compared. With just pride did he affirm that that work "acquired a new and a more dignified interest when we reflected that this island is in a great measure a general epitome of the globe, and that the observer who made himself familiar with its strata and the fossil remains which they include, had not only prepared himself for similar inquiries in other quarters, but was already acquainted by anticipation with what he may expect to find there." It can with truth be said that this advice and the exhortation which followed, calling upon all those who had leisure, health, and talent for such inquiries to carry them out, were truly the incitements which roused the then Secretary of the Geological Society, who pens this sketch, to undertake explorations abroad by which he has endeavoured to bring the structure of other countries into direct comparison with those of our own land.

It is indeed most gratifying to one of the olden time to reperuse in the address of Dr. Fitton of 1829 the brief, touching, and just eulogy which he pronounced on the character of our then recently deceased Member, the illustrious Wollaston. The words came from his heart, and specially marked the penetration, correct judgment, and high moral character of the deceased philosopher.

Dr. Fitton further signalized his presidency by drawing to the Society and engaging in its service, as Assistant Secretary, that remarkable man William Lonsdale, whose acquaintance it was my good fortune to have made in the field, and to have recommended strongly to the notice of the President. To no one man certainly has our body been more indebted than to the excellent and gifted Lonsdale, whether for his publications, his conduct of our affairs, or the zealous and disinterested labour he bestowed in aiding and improving the works of his associates.

Retiring from active participation in our business during the last few years of his life, Dr. Fitton still earnestly watched and appreciated our progress, and no act was ever more grateful to the feelings of the Council and of the then President, Mr. W. Hopkins, than when in 1852 they conferred on their veteran associate the highest honour in their gift, the Medal founded by his dear friend Wollaston.

United in marriage in the year 1820 to Miss James, a most amiable lady, who brought to him the means of a comfortable existence, Dr. Fitton not only reared his five sons and three daughters with untiring solicitude, but, just as in previous years he had been the solace of his venerable mother, so he continued to be the pride of his sisters, the youngest of whom, Miss Sarah Fitton, still living, possesses much of the genius of her lamented brother, and has distinguished herself in natural-history pursuits.

Giving throughout his life constant proofs of his hospitable and generous disposition, he opened his house during his Presidency to all the Fellows at evening soirées, when his cheerful and joyous countenance and kind manner encouraged many a beginner. Following the example of Sir Joseph Banks, who was probably the most popular President the Royal Society ever possessed, Dr. Fitton, as well as his predecessor, Mr. Greenough, held these agreeable scientific *conversazioni* on Sunday evenings. Up to that time, few persons thought there was any sin in so spending the latter part of a Sabbath eve; but remonstrances commencing on the part of the rigid sabbatarians, a stop was put to those instructive and innocent recreations; and the only remaining relic of that which was so long the custom of this land is now confined, as far as I know, to the social Sunday-evening meetings of the Dilettanti Society of Antiquaries.

It is however fair to observe, that the parties of Sir Joseph Banks, Mr. Greenough, and Dr. Fitton were composed chiefly of a few scientific men; the large and mixed assemblies which now flock to the soirées of the Presidents of Societies being scarcely compatible with the quiet of an English Sunday night.

In conclusion it may well be said, that Dr. Fitton was so single-minded, guileless, and affectionate, that every one who knew him loved him; and as his memory is cherished by all his contemporaries, so is this the fitting occasion to record, however imperfectly, the virtues and deeds of so good a man and so sound a geologist.

Dr. Fitton became a Fellow of the Royal Society in 1815; and he was also a Fellow of the Linnean, Astronomical, and Royal Geographical Societies.

Mr. W. W. Smyth, Secretary, next proceeded to read the following Obituary Notices.

Sir Arthur de Capell Broke, Bart., of Oakley Hall, in Northamptonshire, although not a contributor to the literature of our science, is known to the world as the author of several valuable books of travels, some of which were magnificently illustrated. More particularly may be cited his 'Travels in Lapland and to the North Cape,' and his 'Sketches of Spain and Morocco.'

The Rev. James B. Piggot Dennis took his degree as a member of Queen's College, Oxford, and resided for many years at the town of Bury St. Edmunds. Mr. Dennis devoted much of his time to microscopical researches bearing on geology, such as examinations into the structure of bone, and was the author of papers communicated to our Society and to the 'Journal of Microscopical Science.' He died at the early age of 45.

General Sir C. W. Pasley, K.C.B. This veteran officer, who died 19th April, 1861, at the age of 80, was actively engaged in warlike operations as a Royal Engineer for many years in the Mediterranean and in the Peninsula, commencing with the defence of Gaeta in 1806. After his publication of a work on Chatham's military policy, which excited great interest at the time, he was appointed in 1812 Director of the Engineer Establishment at Woolwich, which was established at his instigation for the training of the young officers in Practical Military Engineering; and he devoted himself to numerous inquiries in solving the application of science to the military art, and became the author of several works on purely professional subjects, as well as of one 'On Limes and Cements,' which exhibits a great amount of industry in the examination of the various mineral substances of this and of other countries, which had been or might be employed for such purposes. When it was determined in 1839 to attempt the removal of the wreck of the 'Royal George' at Spithead, the operations were confided to Colonel Pasley, who, during the years 1840–1–2, succeeded so fully in accomplishing the object—igniting charges of gunpowder by the galvanic battery—that he became the chief authority on similar subjects, and his results contributed greatly to the success with which galvanic blasting has since been introduced on a large scale into various engineering operations.

The Rev. John Stevens Henslow. Among the scientific men of the present century there are few whose career has been so fraught with usefulness to the public as that of the late Professor Henslow. He was born at Rochester in 1796, and at a very early age displayed a love of natural history, which was inherited from his father, who practised in that town as a solicitor. In 1818 he graduated at Cambridge as 16th wrangler, and declining to compete for the higher academic position, which, with his mathematical powers, he might easily have attained, he studied chemistry under Professor Cumming, mineralogy under Dr. Clarke, laboured hard at geology as an original inquirer, and became a Fellow of this Society in 1819.

In 1821, at the early age of 23, he communicated to the Society his "Supplementary Observations on Dr. Berger's Account of the Isle of Man," containing a map and sections, to the preparation of which he had devoted his spare time whilst spending two long vacations in the island with pupils. At about the same period he was led to explore the geology of Anglesey, and embodied the results in a most elaborate paper, printed in the first volume of the 'Cambridge Philosophical Transactions.' This paper raised its author at once to a high position among observers, and may to this day be quoted as a model of truthful and sagacious scientific research. It possesses also rare merit, as combining with great power of co-ordinating physical features skill and accuracy in the application of chemistry, mineralogy, mathematics and drawing to the illustration of a very complicated region.

In 1822 he was appointed to the Professorship of Mineralogy, a post which he held for three years, and in 1825 resigned it in order to succeed Professor Martyn in the chair of Botany, a subject to which he had devoted much labour for some years preceding. His lectures inaugurated a new era in botanical teaching at the University, and, aided by frequent excursions, awakened interest in a study to which some of the mathematicians of Cambridge had hitherto hardly accorded the dignity of a science.

In this career, as well as in the character of a country clergyman, when appointed by the Crown, in 1833, to the rectory of Hitcham in Suffolk, his admirable personal qualities endeared him to all who were brought in contact with him, and enabled him successfully to overcome difficulties which would have presented serious obstacles to a man endowed with less perseverance, mental power, and invariable good temper. Among the special services which he rendered to the scientific world must be particularly noticed the clear and judicious arrangement which he imparted to the Cambridge Botanical Museum, to the collections in the Royal Gardens at Kew, and to the Museum of Ipswich, which last, planned and carried out under his guidance, stands out in striking contrast to so many of our local museums as an institution in which the objects preserved have really an educational and scientific value.

The attention of Professor Henslow was constantly directed to subjects of geological interest, and frequently to phenomena little observed by others, of perhaps obscure character, but into the causation of which his ingenuity delighted to inquire. Of this order was the peculiar disintegration of flints, and the concentric bands of various colour often found in flint and other silicious pebbles. And he was equally ready in turning to practical account the results of his scientific observations. Thus his acquaintance with the chemistry of agriculture enabled him at once to appreciate the value to the farmer of the phosphate-nodules which abound in the Tertiary

Formations of the Eastern Counties. No credit, no reward, no consideration, even as the discoverer, was claimed by him, but he at once freely gave the widest publicity to his discovery; and the result has been that an enormous store of wealth has accrued alike to landlord and tenant over a very large area of country, whilst up to the day of his death no acknowledgment was ever made of his services to the public weal.

His sympathies were enlisted in every branch of science, and in many educational efforts. He was one of the first Examiners in the University of London, and was up to the last an efficient member of its Council. He aided actively in the Society for the Diffusion of Useful Knowledge, and in the working of the Ray Club and Palæontographical Society; and when assistance was needed for the publication of a useful work, or the relief of the needy in his own profession, or among naturalists, the kindly heart of Professor Henslow was never appealed to in vain.

Joseph James Forrester, created, for his services in developing the resources of Portugal, Baron de Forrester in that country, was a man of unusual vigour of intellect, who, in his capacity of a vine-grower in the Alto Douro district, paid much attention to the geological character of the subsoils. Several works published by him on the capabilities of Portugal and on the port-wine trade, and the elaborate map of the river Douro, which he exhibited at the Universal Exposition of Paris in 1855, attest the perseverance of his observations, and awakened a regret that, apart from his loss as an active and useful citizen of the world, we should so soon have lost a promising Fellow of the Society. It was one of his great pleasures to ascend and descend the Douro in his own boat, sketching and photographing the granite rocks, and the peculiarities of their junction with the clay-slate; and it was in one of these expeditions that he was unfortunately drowned, at the age of 51, by the upsetting of his boat in the rapids.

Mr. William Hutton, of West Hartlepool, was remarkable as one of the chief contributors to the geology and fossil botany of our northern coal-fields. In 1830 he communicated to the Natural History Society of Newcastle "Notes on the New Red Sandstone," and in the next following years contributed to our Society papers "On the Stratified Basalt associated with the Carboniferous Formations of the North of England," "On Coal," and "On the Occurrence of certain Minerals in Northumberland."

James MacAdam was born at Belfast in January 1801, and died 1st June, 1861. His family belonged to the commercial class, and he was himself actively engaged in business throughout his life. From boyhood he had a taste for classics, for continental literature, and for different departments of physical science. In early life he attended some of the college classes in the Royal Academical Institution of Belfast, and after a lapse of some years, amid the turmoil of commerce, he became a graduate of Trinity College, Dublin.

He was one of the eight original founders of the Natural History and Philosophical Society of Belfast, established in 1821; he took an active part in promoting the erection of their museum in 1830, and filled the office of President of that Society at the time of his death. He was also one of the founders of the Botanic Garden at Belfast. He took a warm and active interest in the various educational and scientific institutions of his native town, and his time and advice were ever at the service of the young who were entering on their studies and stood in need of the encouragement and assistance of their seniors. In this and various other ways, he exerted great local influence for the promotion of physical science, and especially of geology, his own favourite pursuit.

For a long period, the intervals of relaxation from business were steadily devoted by Mr. MacAdam to the investigation of the geological structure of the north of Ireland; the results being occasionally made known through the Geological Society of Dublin, the volumes of whose 'Transactions' bear testimony to his industry and ability as a geologist. The most important of his papers published there is one upon the structure of a very interesting district in the county of Donegal. But the service rendered to our science by his papers is perhaps less important than one which he was not spared to complete. By personal exertion continued through upwards of twenty years, and by expending considerable sums of money in employing intelligent collectors, he had succeeded in bringing together a vast assemblage of fossils from the Upper Secondary Rocks of Ireland; and in the arranging and naming of these he was still actively engaged at the time of his last illness. This collection is believed to contain many rare and not a few new species. It was intended to be employed in illustrating a memoir on the north-east of Ireland, to be contributed to our Society under the joint authorship of himself and Dr. Bryce of Glasgow, formerly of Belfast. A paper by the latter gentleman, on a portion of the Antrim coast, has already appeared in our 'Transactions;' and we may hope that he will in a short time carry out the plan arranged between him and his departed friend, and thus, while completing the survey of that coast, make known the riches of this fine collection of fossils, and the various important observations, hitherto unpublished, which have been made by our late associate.

Eaton Hodgkinson, F.R.S., Professor of the Mechanics of Engineering in the University College, London, was born at Anderton, near Northwich in Cheshire, on the 26th February, 1789, and died at Eaglesfield House, Manchester, on the 18th June, 1861. He lost his father in childhood, and was sent to the grammar-school at Northwich. He was originally intended for the church; but his mother's circumstances having compelled him to renounce this project and enter into trade, he went to reside in Manchester. During his residence in that city for nearly half a century, he devoted his time to making experiments on the strength of iron, stone, and wood, and gave to the world the *formulæ* for solid and hollow pillars of iron, which have been adopted in England and the Continent, and which are now the basis of calculation for all structures made of that metal. Mr. Hodgkinson was probably the most laborious and careful experimenter that has ever devoted himself to the study of the laws which regulate the strength of materials; and all his great labours were given to the investigation of truth for its own sake, without any pecuniary returns, but at a considerable loss to himself. He was for some years President of the Manchester Literary and Philosophical Society, in whose Memoirs most of his papers appeared. Although he did not write much on geology, he was warmly attached to the science, and possessed a good collection of coal-measure plants, which he delighted in showing to his friends. In private life his simple habits and kindly disposition endeared him to a large circle of acquaintances, who have sustained a loss which will not soon be replaced.

Thomas William Atkinson became a Fellow of this Society in 1859, on his return from the long wanderings in Asiatic Russia, described in his 'Travels in Siberia.' Originally an architect, he added high qualifications as an artist to the energy and endurance that distinguished him as a traveller. It may, however, be regretted that his connection with our Society had not commenced before rather than after his travels, destined as he was to visit so many of the most interesting districts of the Altai and of the chains bordering on the Kirghiz Steppe.

Sir Charles Fellows was born in 1799, and became well known to the public on producing, in 1838, the Journal of his 'Excursions in Asia Minor,' memorable for the discoveries of ancient buildings in the valley of the Lycian Xanthus. He subsequently published several other works on the antiquities of the same region, in the exploration of which he was associated with Edward Forbes, Captain Graves, and Captain Spratt. Sir Charles resided latterly in the Isle of Wight, where he took a leading part in the question of the establishment of a local museum, geological and antiquarian, at Carisbrook Castle.

M. L. A. Necker de Saussure, elected in 1808 a Foreign Member of the Society, was at one time Professor of Mineralogy at Geneva; and although for the last twenty years he had buried himself in close retirement at Portree in the Isle of Skye, where he died, was in the earlier part of his life an active contributor to scientific literature. In our own volumes he published papers "On a probable Cause of certain Earthquakes," and on the geological laws which govern the of which metalliferous deposits with regard to the rock-formations position of the crust of the earth is formed.

His 'Travels in Scotland,' published in Paris in 1821, record his observations made in 1806, 1807, 1808, in the scientific part of which work he endeavours judiciously to describe and explain phenomena without having recourse to the extreme views of either Werner or Hutton, between whose rival schools the controversy at that time ran high. In the 'Edinburgh Philosophical Journal' and in the 'Bibliothèque Universel' he published views on mineralogy which he afterwards gave to the world, in 1835, under the title of "Le Règne Minéral ramené aux méthodes de l'Histoire Naturelle." In this work he avoided the extreme views of previous authors, who had ascribed too great importance exclusively to external properties or to mere composition, and in a series of analytical tables conferred a great boon on the student working practically at the discrimination of minerals.

THE ANNIVERSARY ADDRESS.

By Prof. T. H. Huxley, Sec.G.S., &c., &c.

Merchants occasionally go through a wholesome, though troublesome and not always satisfactory, process which they term "taking stock." After all the excitement of speculation, the pleasure of gain, and the pain of loss, the trader makes up his mind to face facts and to learn the exact quantity and quality of his solid and reliable possessions.

The man of science does well sometimes to imitate this procedure; and, forgetting for the time the importance of his own small winnings, to re-examine the common stock in trade, so that he may make sure how far the store of bullion in the cellar—on the faith of whose existence so much paper has been circulating—is really the solid gold of truth.

The Anniversary Meeting of the Geological Society seems to be an occasion well suited for an undertaking of this kind—for an inquiry, in fact, into the nature and the value of the present results of palæontological investigation; and the more so, as all those who have paid close attention to the late multitudinous discussions, in which palæontology is implicated, must have felt the urgent necessity of some such scrutiny.

First in order, as the most definite and unquestionable of all the results of palæontology, must be mentioned the immense extension and impulse given to botany, zoology, and comparative anatomy by the investigation of fossil remains. Indeed, the mass of biological facts has been so greatly increased, and the range of biological speculation has been so vastly widened, by the researches of the geologist and palæontologist, that it is to be feared there are naturalists in existence who look upon geology as Brindley regarded rivers. "Rivers," said the great engineer, "were made to feed canals;" and geology, some seem to think, was solely created to advance comparative anatomy.

Were such a thought justifiable, it could hardly expect to be received with favour by this assembly. But it is not justifiable. Your favourite science has her own great aims independent of all others; and if, notwithstanding her steady devotion to her own progress, she can scatter such rich alms among her sisters, it should be remembered that her charity is of the sort that does not impoverish, but "blesseth him that gives and him that takes."

Regard the matter as we will, however, the facts remain. Nearly 40,000 species of animals and plants have been added to the Systema Naturæ by palæontological research. This is a living population equivalent to that of a new continent in mere number; equivalent to that of a new hemisphere, if we take into account the small population of insects as yet found fossil, and the large proportion and peculiar organization of many of the Vertebrata.

But, beyond this, it is perhaps not too much to say that, except for the necessity of interpreting palæontological facts, the laws of distribution would have received less careful study; while few comparative anatomists (and those not of the first order) would have been induced by mere love of detail, as such, to study the minutiæ of osteology, were it not that in such minutiæ lie the only keys to the most interesting riddles offered by the extinct animal world.

These assuredly are great and solid gains. Surely it is matter for no small congratulation that in half a century (for palæontology, though it dawned earlier, came into full day only with Cuvier) a subordinate branch of biology should have doubled the value and interest of the whole group of sciences to which it belongs.

But this is not all. Allied with geology, palæontology has established two laws of inestimable importance: the first, that one and the same area of the earth's surface has been successively occupied by very different kinds of living beings; the second, that the order of succession established in one locality holds good, approximately, in all.

The first of these laws is universal and irreversible; the second is an induction from a vast number of observations, though it may possibly, and even probably, have to admit of exceptions. As a consequence of the second law, it follows that a peculiar relation frequently subsists between series of strata, containing organic remains, in different localities. The series resemble one another, not only in virtue of a general resemblance of the organic remains in the two, but also in virtue of a resemblance in the order and character of the serial succession in each. There is a resemblance of arrangement; so that the separate terms of each series, as well as the whole series, exhibit a correspondence.

Succession implies time; the lower members of a series of sedimentary rocks are certainly older than the upper; and when the notion of age was once introduced as the equivalent of succession, it was no wonder that correspondence in succession came to be looked upon as correspondence in age, or "contemporaneity." And, indeed, so long as relative age only is spoken of, correspondence in succession *is* correspondence in age; it is *relative* contemporaneity, But it would have been very much better for geology if so loose and ambiguous a word as "contemporaneous" had been excluded from her terminology, and if, in its stead, some term expressing similarity of serial relation, and excluding the notion of time altogether, had been employed to denote correspondence in position in two or more series of strata.

In anatomy, where such correspondence of position has constantly to be spoken of, it is denoted by the word "homology" and its derivatives; and for Geology (which after all is only the anatomy and physiology of the earth) it might be well to invent some single word, such as "homotaxis" (similarity of order), in order to express an essentially similar idea. This, however, has not been done, and most probably the inquiry will at once be made—To what end burden science with a new and strange term in place of one old, familiar, and part of our common language?

The reply to this question will become obvious as the inquiry into the results of palæontology is pushed further.

Those whose business it is to acquaint themselves specially with the works of palæontologists, in fact, will be fully aware that very few, if any, would rest satisfied with such a statement of the conclusions of their branch of biology as that which has just been given.

Our standard repertories of palæontology profess to teach us far higher things—to disclose the entire succession of living forms upon the surface of the globe; to tell us of a wholly different distribution of climatic conditions in ancient times; to reveal the character of the first of all living existences; and to trace out the law of progress from them to us.

It may not be unprofitable to bestow on these professions a somewhat more critical examination than they have hitherto received, in order to ascertain how far they rest on an irrefragable basis, or whether, after all, it might not be well for palæontologists to learn a little more carefully that scientific "ars artium," the art of saying "I don't know." And to this end let us define somewhat more exactly the extent of these pretensions of palæontology.

Every one is aware that Professor Bronn's 'Untersuchungen' and Professor Pictet's 'Traité de Paléontologie' are works of standard authority, familiarly consulted by every working palæontologist. It is desirable to speak of these excellent books, and of their distinguished authors, with the utmost respect and in a tone as far as possible removed from carping criticism; indeed, if they are specially cited in this place, it is merely in justification of the assertion that the following propositions, which may be found implicitly or explicitly in the works in question, are regarded by the mass of palæontologists and geologists, not only on the Continent but in this country, as expressing some of the best-established results of palæontology. Thus:—

Animals and plants began their existence together, not long after the commencement of the deposition of the sedimentary rocks, and then succeeded one another in such a manner that totally distinct faunæ and floræ occupied the whole surface of the earth, one after the other, and during distinct epochs of time.

A geological formation is the sum of all the strata deposited over the whole surface of the earth during one of these epochs: a geological fauna or flora is the sum of all the species of animals or plants which occupied the whole surface of the globe during one of these epochs.

The population of the earth's surface was at first very similar in all parts, and only from the middle of the Tertiary epoch onwards began to show a distinct distribution in zones.

The constitution of the original population, as well as the numerical proportions of its members, indicates a warmer and, on the whole, somewhat tropical climate, which remained tolerably equable throughout the year. The subsequent distribution of living beings in zones is the result of a gradual lowering of the general temperature, which first began to be felt at the poles.

It is not now proposed to inquire whether these doctrines are true or false; but to direct your attention to a much simpler though very essential preliminary question—What is their logical basis? what are the fundamental assumptions upon which they all logically depend? and what is the evidence on which those fundamental propositions demand our assent?

These assumptions are two: the first, that the commencement of the geological record is coeval with the commencement of life on the globe; the second, that geological contemporaneity is the same thing as chronological synchrony. Without the first of these assumptions there would of course be no ground for any statement respecting the commencement of life; without the second, all the other statements cited, every one of which implies a knowledge of the state of different parts of the earth at one and the same time, will be no less devoid of demonstration.

The first assumption obviously rests entirely on negative evidence. This is, of course, the only evidence that ever can be available to prove the commencement of any series of phenomena; but, at the same time, it must be recollected that the value of negative evidence depends entirely on the amount of positive corroboration it receives. If A B wishes to prove an *alibi*, it is of no use for him to get a thousand witnesses simply to swear that they did not see him in such and such a place, unless the witnesses are prepared to prove that they must have seen him had he been there. But the evidence that animal life commenced with the Lingula-flags, *e.g.*, would seem to be exactly of this unsatisfactory uncorroborated sort. The Cambrian witnesses simply swear they "haven't seen anybody their way;" upon which the counsel for the other side immediately puts in ten or twelve thousand feet of Devonian sandstones to make oath they never saw a fish or a mollusk, though all the world knows there were plenty in their time.

But then it is urged that, though the Devonian rocks in one part of the world exhibit no fossils, in another they do, while the lower

Cambrian rocks nowhere exhibit fossils, and hence no living being could have existed in their epoch.

To this there are two replies: the first, that the observational basis of the assertion that the lowest rocks are nowhere fossiliferous is an amazingly small one, seeing how very small an area, in comparison to that of the whole world, has yet been fully searched: the second, that the argument is good for nothing unless the unfossiliferous rocks in question were not only *contemporaneous* in the geological sense, but *synchronous* in the chronological sense. To use the *alibi* illustration again. If a man wishes to prove he was in neither of two places, A and B, on a given day, his witnesses for each place must be prepared to answer for the whole day. If they can only prove that he was not at A in the morning, and not at B in the afternoon, the evidence of his absence from both is *nil*, because he might have been at B in the morning and at A in the afternoon.

Thus everything depends upon the validity of the second assumption. And we must proceed to inquire what is the real meaning of the word "contemporaneous" as employed by geologists. To this end a concrete example may be taken.

The Lias of England and the Lias of Germany, the Cretaceous rocks of Britain and the Cretaceous rocks of Southern India, are termed by geologists "contemporaneous" formations; but whenever any thoughtful geologist is asked whether he means to say that they were deposited synchronously, he says "No,—only within the same great epoch." And if, in pursuing the inquiry, he is asked what may be the approximate value in time of a "great epoch"—whether it means a hundred years, or a thousand, or a million, or ten million years—his reply is, "I cannot tell."

If the further question be put, whether physical geology is in possession of any method by which the actual synchrony (or the reverse) of any two distant deposits can be ascertained, no such method can be heard of; it being admitted by all the best authorities that neither similarity of mineral composition, nor of physical character, nor even direct continuity of stratum, are *absolute* proofs of the synchronism of even approximated sedimentary strata: while, for distant deposits, there seems to be no kind of physical evidence attainable of a nature competent to decide whether such deposits were formed simultaneously, or whether they possess any given difference of antiquity. To return to an example already given. All competent authorities will probably assent to the proposition that physical geology does not enable us in any way to reply to this question—Were the British Cretaceous rocks deposited at the same time as those of India, or are they a million of years younger or a million of years older?

Is palæontology able to succeed where physical geology fails? Standard writers on palæontology, as has been seen, assume that she can. They take it for granted, that deposits containing similar organic remains are synchronous—at any rate in a broad sense; and yet, those who will study the eleventh and twelfth chapters of Sir Henry

De la Beche's remarkable 'Researches in Theoretical Geology,' published now nearly thirty years ago, and will carry out the arguments there most luminously stated to their logical consequences, may very easily convince themselves that even absolute identity of organic contents is no proof of the synchrony of deposits, while absolute diversity is no proof of difference of date. Sir Henry De la Beche goes even further, and adduces conclusive evidence to show that the different parts of one and the same stratum, having a similar composition throughout, containing the same organic remains, and having similar beds above and below it, may yet differ to any conceivable extent in age.

Edward Forbes was in the habit of asserting that the similarity of the organic contents of distant formations was *primâ facie* evidence, not of their similarity, but of their difference of age; and holding as he did the doctrine of single specific centres, the conclusion was as legitimate as any other; for the two districts must have been occupied by migration from one of the two, or from an intermediate spot, and the chances against exact coincidence of migration and of imbedding are infinite.

In point of fact, however, whether the hypothesis of single or of multiple specific centres be adopted, similarity of organic contents cannot possibly afford any proof of the synchrony of the deposits which contain them; on the contrary, it is demonstrably compatible with the lapse of the most prodigious intervals of time, and with interposition of vast changes in the organic and inorganic worlds, between the epochs in which such deposits were formed.

On what amount of similarity of their faunæ is the doctrine of the contemporaneity of the European and of the North American Silurians based? In the last edition of Sir Charles Lyell's 'Elementary Geology' it is stated, on the authority of a former President of this Society, the late Daniel Sharpe, that between 30 and 40 per cent. of the species of Silurian Mollusca are common to both sides of the Atlantic. By way of due allowance for further discovery, let us double the lesser number and suppose that 60 per cent. of the species are common to the North American and the British Silurians. Sixty per cent. of species in common is, then, proof of contemporaneity.

Now suppose that, a million or two of years hence, when Britain has made another dip beneath the sea and has come up again, some geologist applies this doctrine, in comparing the strata laid bare by the upheaval of the bottom, say, of St. George's Channel with what may then remain of the Suffolk Crag. Reasoning in the same way, he will at once decide the Suffolk Crag and the St. George's Channel beds to be contemporaneous; although we happen to know that a vast period (even in the geological sense) of time, and physical changes of almost unprecedented extent, separate the two.

But if it be a demonstrable fact that strata containing more than 60 or 70 per cent. of species of Mollusca in common, and comparatively close together, may yet be separated by an amount of geological time sufficient to allow of some of the greatest physical changes the world has seen, what becomes of that sort of contemporaneity the sole evidence of which is a similarity of facies, or the identity of half a dozen species, or of a good many genera?

And yet there is no better evidence for the contemporaneity assumed by all who adopt the hypotheses of universal faunæ and floræ, of a universally uniform climate, and of a sensible cooling of the globe during geological time.

There seems, then, no escape from the admission that neither physical geology nor palæontology possesses any method by which the absolute synchronism of two strata can be demonstrated. All that geology can prove is local order of succession. It is mathematically certain that, in any given vertical linear section of an undisturbed series of sedimentary deposits, the bed which lies lowest is the oldest. In any other vertical linear section of the same series, of course, corresponding beds will occur in a similar order; but, however great may be the probability, no man can say with absolute certainty that the beds in the two sections were synchronously deposited. For areas of moderate extent, it is doubtless true that no practical evil is likely to result from assuming the corresponding beds to be synchronous or strictly contemporaneous; and there are multitudes of accessory circumstances which may fully justify the assumption of such synchrony. But the moment the geologist has to deal with large areas or with completely separated deposits, then the mischief of confounding that "homotaxis" or "similarity of arrangement," which *can* be demonstrated, with "synchrony" or "identity of date," for which there is not a shadow of proof, under the one common term of "contemporaneity" becomes incalculable, and proves the constant source of gratuitous speculations.

For anything that geology or palæontology are able to show to the contrary, a Devonian fauna and flora in the British Islands may have been contemporaneous with Silurian life in North America, and with a Carboniferous fauna and flora in Africa. Geographical provinces and zones may have been as distinctly marked in the Palæozoic epoch as at present, and those seemingly sudden appearances of new genera and species, which we ascribe to new creation, may be simple results of migration.

It may be so; it may be otherwise. In the present condition of our knowledge and of our methods, one verdict—"not proven, and not proveable"—must be recorded against all the grand hypotheses of the palæontologist respecting the general succession of life on the globe. The order and nature of terrestrial life as a whole are open questions. Geology at present provides us with most valuable topographical records, but she has not the means of working them up into a universal history. Is such a universal history, then, to be regarded as unattainable? Are all the grandest and most interesting problems which offer themselves to the geological student essentially insoluble? Is he in the position of a scientific Tantalus—doomed always to thirst for a knowledge which he cannot obtain?

The reverse is to be hoped; nay, it may not be impossible to indicate the source whence help will come.

In commencing these remarks, mention was made of the great obligations under which the naturalist lies to the geologist and palæontologist. Assuredly the time will come when these obligations will be repaid tenfold, and when the maze of the world's past history, through which the pure geologist and the pure palæontologist find no guidance, will be securely threaded by the clue furnished by the naturalist.

All who are competent to express an opinion on the subject are at present agreed that the manifold varieties of animal and vegetable form have not either come into existence by chance, nor result from capricious exertions of creative power; but that they have taken place in a definite order, the statement of which order is what men of science term a natural law. Whether such a law is to be regarded as an expression of the mode of operation of natural forces, or whether it is simply a statement of the manner in which a supernatural power has thought fit to act, is a secondary question, so long as the existence of the law and the possibility of its discovery by the human intellect are granted. But he must be a half-hearted philosopher who, believing in that possibility, and having watched the gigantic strides of the biological sciences during the last twenty years, doubts that science will sooner or later make this further step, so as to become possessed of the law of evolution of organic forms—of the unvarying order of that great chain of causes and effects of which all organic forms, ancient and modern, are the links. And then, if ever, we shall be able to begin to discuss, with profit, the questions respecting the commencement of life, and the nature of the successive populations of the globe, which so many seem to think are already answered.

The preceding arguments make no particular claim to novelty; indeed they have been floating more or less distinctly before the minds of geologists for the last thirty years; and if, at the present time, it has seemed desirable to give them more definite and systematic expression, it is because palæontology is every day assuming a greater importance, and now requires to rest on a basis whose firmness is thoroughly well assured. Among its fundamental conceptions, there must be no confusion between what is certain and what is more or less probable*. But, pending the construction of a surer foundation than palæontology now possesses, it may be instructive, assuming for the nonce the general correctness of the ordinary hypothesis of geological contemporaneity, to consider whether the deductions which are ordinarily drawn from the whole body of palæontological facts are justifiable.

The evidence on which such conclusions are based is of two kinds, negative and positive. The value of negative evidence, in connexion with this inquiry, has been so fully and clearly discussed

* "Le plus grand service qu'on puisse rendre à la science est d'y faire place nette avant d'y rien construire."—*Cuvier*.

in an address from the chair of this Society*, which none of us have forgotten, that nothing need at present be said about it; the more, as the considerations which have been laid before you have certainly not tended to increase your estimation of such evidence. It will be preferable to turn to the positive facts of palæontology, and to inquire what they tell us.

We are all accustomed to speak of the number and the extent of the changes in the living population of the globe during geological time as something enormous; and indeed they are so, if we regard only the negative differences which separate the older rocks from the more modern, and if we look upon specific and generic changes as great changes, which from one point of view they truly are. But leaving the negative differences out of consideration, and looking only at the positive data furnished by the fossil world from a broader point of view—from that of the comparative anatomist who has made the study of the greater modifications of animal form his chief business—a surprise of another kind dawns upon the mind; and under *this* aspect the smallness of the total change becomes as astonishing as was its greatness under the other.

There are two hundred known orders of plants; of these not one is certainly known to exist exclusively in the fossil state. The whole lapse of geological time has as yet yielded not a single new ordinal type of vegetable structure†.

The positive change in passing from the recent to the ancient animal world is greater, but still singularly small. No fossil animal is so distinct from those now living as to require to be arranged even in a separate class from those which contain existing forms. It is only when we come to the orders, which may be roughly estimated at about a hundred and thirty, that we meet with fossil animals so distinct from those now living as to require orders for themselves; and these do not amount, on the most liberal estimate, to more than about ten per cent. of the whole.

There is no certainly known extinct order of Protozoa; there is but one among the Cœlenterata—that of the rugose corals; there is none among the Mollusca; there are three, the Cystidea, Blastoidea, and Edrioasterida, among the Echinoderms; and two, the Trilobita and Eurypterida, among the Crustacea; making altogether five for the great subkingdom of Annulosa. Among Vertebrates there is no ordinally distinct fossil fish: there is only one extinct order of Amphibia—the Labyrinthodonts; but there are at least four distinct orders of Reptilia, viz. the Ichthyosauria, Plesiosauria, Pterosauria, Dinosauria, and perhaps another or two. There is no known extinct order of Birds, and no certainly known extinct order of Mammals, the ordinal distinctness of the "Toxodontia" being doubtful.

The objection that broad statements of this kind, after all, rest largely on negative evidence is obvious, but it has less force than might at first be supposed; for, as might be expected from the

* Anniversary Address for 1851, Quart. Journ. Geol. Soc. vol. vii.

† See Hooker's 'Introductory Essay to the Flora of Tasmania,' p. xxiii.

circumstances of the case, we possess more abundant positive evidence regarding Fishes and marine Mollusks than respecting any other forms of animal life; and yet these offer us, through the whole range of geological time, no species ordinally distinct from those now living; while the far less numerous class of Echinoderms presents three, and the Crustacea two such orders, though none of these come down later than the Palæozoic age. Lastly, the Reptilia present the extraordinary and exceptional phenomenon of as many extinct as existing orders, if not more; the four mentioned maintaining their existence from the Lias to the Chalk inclusive.

Some years ago one of your Secretaries pointed out another kind of positive palæontological evidence tending towards the same conclusion—afforded by the existence of what he termed "persistent types" of vegetable and of animal life*. He stated, on the authority of Dr. Hooker, that there are Carboniferous plants which appear to be generically identical with some now living; that the cone of the Oolitic *Araucaria* is hardly distinguishable from that of an existing species; that a true *Pinus* appears in the Purbecks and a *Juglans* in the Chalk; while, from the Bagshot Sands, a *Banksia* whose wood is not distinguishable from that of species now living in Australia had been obtained.

Turning to the animal kingdom, he affirmed the tabulate corals of the Silurian rocks to be wonderfully like those which now exist; while even the families of the Aporosa were all represented in the older Mesozoic rocks.

Among the Mollusca similar facts were adduced. Let it be borne in mind that *Avicula, Mytilus, Chiton, Natica, Patella, Trochus, Discina, Orbicula, Lingula, Rhynchonella,* and *Nautilus,* all of which are existing *genera,* are given without a doubt as Silurian in the last edition of 'Siluria'; while the highest forms of the highest Cephalopods are represented in the Lias by a genus, *Belemnoteuthis,* which presents the closest relation to the existing *Loligo.*

The two highest groups of the Annulosa, Insecta and Arachnida, are represented in the Coal either by existing genera or by forms differing from existing genera in quite minor peculiarities.

Turning to the Vertebrata, the only palæozoic Elasmobranch Fish of which we have any complete knowledge is the Devonian and Carboniferous *Pleuracanthus,* which differs no more from existing Sharks than these do from one another.

Again, vast as is the number of undoubtedly Ganoid fossil Fishes, and great as is their range in time, a large mass of evidence has recently been adduced to show that almost all those respecting which we possess sufficient information are referable to the same subordinal groups as the existing *Lepidosteus, Polypterus,* and Sturgeon; and that a singular relation obtains between the older and the younger Fishes; the former, the Devonian Ganoids, being almost all members

* See the abstract of a Lecture "On the Persistent Types of Animal Life," in the 'Notices of the Meetings of the Royal Institution of Great Britain,' June 3, 1859, vol. iii. p. 151.

of the same suborder as *Polypterus*, while the Mesozoic Ganoids are almost all similarly allied to *Lepidosteus**.

Again, what can be more remarkable than the singular constancy of structure preserved throughout a vast period of time by the family of the Pycnodonts and by that of the true Cœlacanths; the former persisting, with but insignificant modifications, from the Carboniferous to the Tertiary rocks, inclusive; the latter existing, with still less change, from the Carboniferous rocks to the Chalk, inclusive.

Among Reptiles, the highest living group, that of the Crocodilia, is represented at the early part of the Mesozoic epoch by species identical in the essential characters of their organization with those now living, and differing from the latter only in such matters as the form of the articular facets of the vertebral centra, in the extent to which the nasal passages are separated from the cavity of the mouth by bone, and in the proportions of the limbs.

And even as regards the Mammalia, the scanty remains of Triassic and Oolitic species afford no foundation for the supposition that the organization of the oldest forms differed nearly so much from some of those which now live as these differ from one another.

It is needless to multiply these instances; enough has been said to justify the statement that, in view of the immense diversity of known animal and vegetable forms, and the enormous lapse of time indicated by the accumulation of fossiliferous strata, the only circumstance to be wondered at is, not that the changes of life, as exhibited by positive evidence, have been so great, but that they have been so small.

Be they great or small, however, it is desirable to attempt to estimate them. Let us therefore take each great division of the animal world in succession, and whenever an order or a family can be shown to have had a prolonged existence, let us endeavour to ascertain how far the later members of the group differ from the earlier ones. If these later members, in all or in many cases, exhibit a certain amount of modification, the fact is, so far, evidence in favour of a general law of change; and, in a rough way, the rapidity of that change will be measured by the demonstrable amount of modification. On the other hand, it must be recollected that the absence of any modification, while it may leave the doctrine of the existence of a law of change without positive support, cannot possibly disprove all forms of that doctrine, though it may afford a sufficient refutation of many of them.

The *Protozoa*.—The Protozoa are represented throughout the whole range of geological series, from the Lower Silurian formation to the present day. The most ancient forms recently made known by Ehrenberg are excessively like those which now exist: no one has ever pretended that the difference between any ancient and any modern Foraminifera is of more than generic value; nor are the

* 'Memoirs of the Geological Survey of the United Kingdom.—Decade x. Preliminary Essay upon the Systematic Arrangement of the Fishes of the Devonian Epoch.'

oldest Foraminifera either simpler, more embryonic, or less differentiated than the existing forms.

The *Cœlenterata*.—The Tabulate Corals have existed from the Silurian epoch to the present day, but I am not aware that the ancient *Heliolites* possesses a single mark of a more embryonic or less differentiated character, or less high organization, than the existing *Heliopora*. As for the Aporose Corals, in what respect is the Silurian *Palæocyclus* less highly organized or more embryonic than the modern *Fungia*, or the Liassic Aporosa than the existing members of the same families?

The *Mollusca*.—In what sense is the living *Waldheimia* less embryonic, or more specialized, than the palæozoic *Spirifer*; or the existing *Rhynchonellæ*, *Craniæ*, *Discinæ*, *Lingulæ*, than the Silurian species of the same genera? In what sense can *Loligo* or *Spirula* be said to be more specialized or less embryonic than *Belemnites*; the modern species of Lamellibranch and Gasteropod genera than the Silurian species of the same genera?

The *Annulosa*.—The Carboniferous Insecta and Arachnida are neither less specialized nor more embryonic than those that now live, nor are the Liassic Cirripedia and Macrura; while several of the Brachyura which appear in the Chalk belong to existing genera, and none exhibit either an intermediate or an embryonic character.

The *Vertebrata*.—Among fishes I have referred to the Cœlacanthini (comprising the genera *Cœlacanthus*, *Holophagus*, *Undina*, and *Macropoma*) as affording an example of a persistent type; and it is most remarkable to note the smallness of the differences between any of these fishes (affecting at most the proportions of the body and fins, and the character and sculpture of the scales), notwithstanding their enormous range in time. In all the essentials of its very peculiar structure, the *Macropoma* of the Chalk is identical with the *Cœlacanthus* of the Coal. Look at the genus *Lepidotus*, again, persisting without a modification of importance from the Lias to the Eocene formation, inclusive.

Or among the Teleostei—in what respect is the *Beryx* of the Chalk more embryonic or less differentiated than the *Beryx lineatus* of King George's Sound?

Or to turn to the higher Vertebrata—in what sense are the Liassic Chelonia inferior to those which now exist? How are the Cretaceous Ichthyosauria, Plesiosauria, or Pterosauria less embryonic or more differentiated species than those of the Lias?

Or lastly, in what circumstance is the *Phascolotherium* more embryonic, or of a more generalized type, than the modern Opossum; or a *Lophiodon*, or a *Palæotherium*, than a modern *Tapirus* or *Hyrax*?

These examples might be almost indefinitely multiplied, but surely they are sufficient to prove that the only safe and unquestionable testimony we can procure—positive evidence—fails to demonstrate any sort of progressive modification towards a less embryonic or less generalized type in a great many groups of animals of long-continued geological existence. In these groups there is abundant evidence of variation—none of what is ordinarily understood as progression; and, if the known geological record is to be regarded as even any considerable fragment of the whole, it is inconceivable that any theory of a necessarily progressive development can stand, for the numerous orders and families cited afford no trace of such a process.

But it is a most remarkable fact, that, while the groups which have been mentioned, and many besides, exhibit no sign of progressive modification, there are others, coexisting with them, under the same conditions, in which more or less distinct indications of such a process seem to be traceable. Among such indications I may remind you of the predominance of Holostome Gasteropoda in the older rocks as compared with that of Siphonostome Gasteropoda in the later. A case less open to the objection of negative evidence, however, is that afforded by the Tetrabranchiate Cephalopoda, the forms of the shells and of the septal sutures exhibiting a certain increase of complexity in the newer genera. Here, however, one is met at once with the occurrence of *Orthoceras* and *Baculites* at the two ends of the series, and of the fact that one of the simplest genera, *Nautilus*, is that which now exists.

The Crinoidea, in the abundance of stalked forms in the ancient formations as compared with their present rarity, seem to present us with a fair case of modification from a more embryonic towards a less embryonic condition. But then, on careful consideration of the facts, the objection arises that the stalk, calyx, and arms of the palæozoic Crinoid are exceedingly different from the corresponding organs of a larval *Comatula*; and it might with perfect justice be argued that *Actinocrinus* and *Eucalyptocrinus*, for example, depart to the full as widely, in one direction, from the stalked embryo of *Comatula*, as *Comatula* itself does in the other.

The Echinidea, again, are frequently quoted as exhibiting a gradual passage from a more generalized to a more specialized type, seeing that the elongated, or oval, Spatangoids appear after the spheroidal Echinoids. But here it might be argued, on the other hand, that the spheroidal Echinoids, in reality, depart further from the general plan and from the embryonic form than the elongated Spatangoids do; and that the peculiar dental apparatus and the pedicellariæ of the former are marks of at least as great differentiation as the petaloid ambulacra and semitæ of the latter.

Once more, the prevalence of Macrurous before Brachyurous Podophthalmia is apparently a fair piece of evidence in favour of progressive modification in the same order of Crustacea; and yet the case will not stand much sifting, seeing that the Macrurous Podophthalmia depart as far in one direction from the common type of Podophthalmia, or from any embryonic condition of the Brachyura, as the Brachyura do in the other; and that the middle terms between Macrura and Brachyura—the Anomura—are little better represented in the older Mesozoic rocks than the Brachyura are.

None of the cases of progressive modification which are cited from among the Invertebrata appear to me to have a foundation less open to criticism than these; and if this be so, no careful reasoner would, I think, be inclined to lay very great stress upon them. Among the Vertebrata, however, there are a few examples which appear to be far less open to objection.

It is, in fact, true of several groups of Vertebrata which have lived through a considerable range of time, that the endoskeleton (more particularly the spinal column) of the older genera presents a less ossified, and so far less differentiated, condition than that of the younger genera. Thus the Devonian Ganoids, though almost all members of the same suborder as *Polypterus*, and presenting numerous important resemblances to the existing genus, which possesses biconcave vertebræ, are, for the most part, wholly devoid of ossified vertebral centra. The Mesozoic Lepidosteidæ, again, have at most biconcave vertebræ, while the existing *Lepidosteus* has Salamandroid, opisthocœlous, vertebræ. So, none of the Palæozoic Sharks have shown themselves to be possessed of ossified vertebræ, while the majority of modern Sharks possess such vertebræ. Again, the more ancient Crocodilia and Lacertilia have vertebræ with the articular facets of their centra flattened or biconcave, while the modern members of the same group have them procœlous. But the most remarkable examples of progressive modification of the vertebral column, in correspondence with geological age, are those afforded by the Pycnodonts among fish, and the Labyrinthodonts among Amphibia.

The late able ichthyologist Heckel pointed out the fact, that, while the Pycnodonts never possess true vertebral centra, they differ in the degree of expansion and extension of the ends of the bony arches of the vertebræ upon the sheath of the notochord; the Carboniferous forms exhibiting hardly any such expansion, while the Mesozoic genera present a greater and greater development, until, in the Tertiary forms, the expanded ends become suturally united so as to form a sort of false vertebra. Hermann von Meyer, again, to whose luminous researches we are indebted for our present large knowledge of the organization of the older Labyrinthodonts, has proved that the Carboniferous *Archegosaurus* had very imperfectly developed vertebral centra, while the Triassic *Mastodonsaurus* had the same parts completely ossified*.

The regularity and evenness of the dentition of the *Anoplotherium* as contrasted with that of existing Artiodactyles, and the assumed nearer approach of the dentition of certain ancient Carnivores to the typical arrangement, have also been cited as exemplifications of a law of progressive development, but I know of no other cases based on positive evidence which are worthy of particular notice.

What then does an impartial survey of the positively ascertained truths of palæontology testify in relation to the common doctrines of progressive modification, which suppose that modification to have taken place by a necessary progress from more to less embryonic forms, or from more to less generalized types, within the limits of the period represented by the fossiliferous rocks?

* As this Address is passing through the press (March 7, 1862), evidence lies before me of the existence of a new Labyrinthodont (*Pholidogaster*), from the Edinburgh coal-field, with well-ossified vertebral centra.

It negatives those doctrines; for it either shows us no evidence of any such modification, or demonstrates it to have been very slight; and as to the nature of that modification, it yields no evidence whatsoever that the earlier members of any long-continued group were more generalized in structure than the later ones. To a certain extent, indeed, it may be said that imperfect ossification of the vertebral column is an embryonic character; but, on the other hand, it would be extremely incorrect to suppose that the vertebral columns of the older Vertebrata are in any sense embryonic in their whole structure.

Obviously, if the earliest fossiliferous rocks now known are coeval with the commencement of life, and if their contents give us any just conception of the nature and the extent of the earliest fauna and flora, the insignificant amount of modification which can be demonstrated to have taken place in any one group of animals or plants is quite incompatible with the hypothesis that all living forms are the results of a necessary process of progressive development, entirely comprised within the time represented by the fossiliferous rocks.

Contrariwise, any admissible hypothesis of progressive modification must be compatible with persistence without progression through indefinite periods. And should such an hypothesis eventually be proved to be true, in the only way in which it can be demonstrated, viz., by observation and experiment upon the existing forms of life, the conclusion will inevitably present itself, that the Palæozoic, Mesozoic, and Cainozoic faunæ and floræ, taken together, bear somewhat the same proportion to the whole series of living beings which have occupied this globe, as the existing fauna and flora do to them.

Such are the results of palæontology as they appear, and have for some years appeared, to the mind of an inquirer who regards that study simply as one of the applications of the great biological sciences, and who desires to see it placed upon the same sound basis as other branches of physical inquiry. If the arguments which have been brought forward are valid, probably no one, in view of the present state of opinion, will be inclined to think the time wasted which has been spent upon their elaboration.

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THE GEOLOGICAL SOCIETY.

November 6, 1861.

The following communications were read:—

1. *Note on the* Bone-Caves *of* Lunel-Viel, Herault. By Monsieur Marcel de Serres, Professor at the "Faculté des Sciences," Montpellier.

[Abridged.]

The discovery of the bone-caves on the Mazet estate, near Lunel-Viel, already dates back thirty-eight years. Since then I have visited some twenty others, of which the names are solely known by the descriptions given of them by myself and my collaborateurs.

The femur of an Aurochs brought me by Colonel Prost and Captain Rompleur, R.E., led me to presume that it had been transported into the caves of M. Bouquet and belonged to a bone-deposit of late geological date. The partial search that I immediately made justified my predictions, and the government accorded me a sum sufficient for me to collect every specimen. I had the soil containing the bones sifted, and I was thus able to collect a large number of the bones, which are now in the collection of the "Faculté des Sciences."

Unfortunately several of the bones were taken from me by some persons more alive to the marvellous than to the interests of science, I still regret this loss—a loss the more felt as those who permitted themselves the pilfering did so out of mere curiosity, and I found it impossible to recover them. I am ignorant to what species these purloined specimens may have belonged.

The discovery of the large cavern was soon followed by that of several others. I have specified them all in my work under the designation of "fissure" and "gut," in consequence of their small size compared with the first cave*. The fissure was filled with bones of different animals; there were almost as many as in a grave-yard. We do not yet know the opening by which the bones were carried into the principal cave on the Bouquet property; for that by which you now enter is in some degree artificial. The entrance was not, in fact, perceived until a mass of calcareous freestone, 35 metres thick, had been removed. Subsequently enlarged, and closed by a door, it now forms the only way into the principal cavern.

These first points recognized, and the age of the Miocene limestone established, we soon comprehended that there was nothing in common between the formation of these cavities and their filling up. In fact these caves belong to the Tertiary period, whereas the earth (with rolled pebbles) containing the bones and the excrements as clearly belong to the Drift-period (terrains de transport anciens) or to the most recent geological times†.

Later we perceived that these rolled pebbles and the fragments of rock were always accompanied by bone-remains, and after a great number of observations we recognized that the presence of the transported materials was essential to the presence of the bones. In fact, where none of the former exist, none of the latter are met with; so that on entering a subterranean cavity which has not been explored, one can decide beforehand whether or not the remains of animals of geological antiquity exist there. In other caverns, on the contrary, one can feel sure that there is every probability of finding organic remains, especially if a layer of stalagmite covers the pebbly loam. It is, nevertheless, well worth while to observe that the phenomenon of the bone-caves is accompanied by the same circumstances all the world over. The bones are to be referred, some to animals of extinct species, and others to races not to be distinguished from those now living; and these are, notwithstanding, mixed together indiscriminately in the same soil.

Finally, the last question which remains is not the least important. It is, to learn to what cause ought to be attributed the singular assemblage together of so many bones, often accumulated in such large quantities that they are as plentiful as in a cemetery.

What we have already said about the almost constant presence of bones in caves where there occur at the same time *transported* materials, leads to a strong presumption that these remains have been

* "Recherches sur les cavernes à ossements de Lunel-Viel, Montpellier." Boehm éditeur, 1839.

† At the period of the discovery of the bone-caves of Lunel-Viel none had been previously discovered in Tertiary formations; since then we have found several in formations of that age.

carried in, since they are always accompanied by alluvial deposits. If the *Carnivora* alone had been the cause of such phenomena, they ought to be found in all ossiferous caves, whereas it is far from being so. A very great number of them offer, in fact, only herbivorous, without a trace of carnivorous animals.

On the other hand, the condition of the cave-bones proves that they had been deprived of their flesh and integuments before they were carried into the caves. The numerous fissures connected with them, and the red earth with which these are filled, even the narrowest of them, prove in the clearest manner that the bones must have been transported into their present position merely as bare bones, and not otherwise. If, therefore, there are in some caves some bones which have been gnawed, that may have happened before they were swept into the caves.

The excrements of Hyænas are in no wise a proof that these animals lived in the caves where they are discovered. Their solidity and their rounded form would render their transport easily effected. How otherwise can we suppose that carnivorous animals of very unequal strength should live in common, and with a good mutual understanding, as must have happened with the lions, bears, wolves, foxes, otters, beavers, and so many others, which are found in the caverns of Lunel-Viel.

It would be very easy to mention many other caves, even of less size, in which animals of habits not less dissimilar are met with; but the caves of the neighbourhood of Montpellier seem to us to suffice for the demonstration of a fact verified by so many observations.

I will end this note with an observation of the illustrious physicist so recently lost to science. Humboldt observes that, when a phenomenon is general and repeated under the same conditions, as has been the case in the filling of the longitudinal and vertical fissures of calcareous rocks, such a phenomenon must have been produced by a cause as general as the effects which group round it. According to this double condition, which is presented in all caves where remains of animals of geological date are found, it is impossible to attribute it to any other cause than to violent inundations.

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2. *On the* Petroleum-springs *in* North America.

By Abraham Gesner, M.D., F.G.S.

[Abstract.]

The ample information on this subject already published renders it desirable to make use only of the subjoined portion of Dr. Gesner's communication.

The petroleum is obtained by borings, to a depth of from 150 to 500 feet. No reliable record of these borings, or the strata through which they pass, has yet been kept. As a general rule the sections may, however, be represented as—1st. Soil, ferruginous clay, and boulders; 2nd. Sandstone and conglomerates; 3rd. Shale; 4th. Bituminous shale; and 5th. Oil, underlaid by an oil-bearing stratum of fire-clay, containing fragments of *Stigmaria* and other coal-plants. In the deeper sinkings, sandstones and bituminous shales are brought up by the borers; but in every instance the petroleum appears to be underlaid with a tight stratum of fire-clay. As soon as the oil-bearing stratum is reached, there is usually an escape of carburetted hydrogen gas, and it is discharged with such force that the boring-rods are often blown into the air, as if they had been discharged from a piece of ordnance. The gas is followed by a mixture of oil and gas, and finally by the oil itself, which is thrown in a jet upwards, sometimes to the height of 100 feet. The bore of the well is usually about 4 inches in diameter, being an iron tube let down as the boring proceeds. When the oil appears, the workmen, as soon as they can approach the spot, drive a wooden plug into the iron pipe, and thus prevent the flow of oil, until they are prepared to receive it. Finally, when the natural flow ceases, a pump is applied, and the raising of the petroleum proceeds. Some wells at the outset have produced no less than 4000 gallons of oil in twenty-four hours. At some sites the shallow wells have run out or been exhausted; but by sinking them deeper still greater supplies have been obtained, and which at present appear to be inexhaustible. It seems very certain, therefore, that the reservoirs of oil are fissures penetrating certain oil-bearing strata and the intervening deposits.

The specific gravity of the petroleums varies from ·795 to ·881. In general they are of a dark-brown colour. A few wells have produced oils quite clear and transparent; and simple distillation renders them quite pure and suitable for lamps. The inflammability of the vapour of the mineral oil has given rise to accidents. In one case an oil, tapped by a bore at 330 feet, rose in a fountain 100 feet high, was soon afterwards ignited, and burned for two months before the workmen could plug the iron tube.

After some observations on the antiquity of the use of mineral oil in North America and elsewhere, and on the present condition of the oil- and gas-springs and the associated sulphur- and brine-springs in the United States, the author stated that 50,000 gallons of mineral oil are daily raised for home use and for exportation. The oil-region comprises parts of Lower and Upper Canada, Ohio, Pennsylvania, Kentucky, Virginia, Tennessee, Arkansas, Texas, New Mexico, and California. It reaches from the 65th to the 128th degree of longitude west of Greenwich; and there are outlying tracts besides.

The oil is said to be derived from Silurian, Devonian, and Carboniferous rocks. In some cases the oil may have originated during the slow and gradual passage of wood into coal, and in its final transformation into anthracite and graphite,—the hydrogen and some carbon and oxygen being disengaged, probably forming hydrocarbons including the oils. In other cases, animal matter may have been the source of the hydrocarbons.

Other native asphalts and petroleums were referred to by the author, who concluded by observing that these products were most probably being continually produced by slow chemical changes in fossiliferous rocks.

3. *Notice of the* Discovery *of* Additional Remains *of* Land Animals *in the* Coal-Measures *of the* South Joggins, Nova Scotia. By J. W. Dawson, LL.D., F.G.S., Principal of McGill College.

In the long range of rapidly wasting cliffs at the South Joggins, every successive year exposes new examples of erect trees and other fossils; and, as the removal of the fallen débris is equally rapid with the wasting of the cliff, it is only by repeated visits that the geologist can thoroughly appreciate the richness of this remarkable section, while every renewed exploration is certain to be rewarded by new facts and specimens. The present notice is intended to record the gleanings obtained in my last visit, in connexion with the presentation to the Society of a suite of specimens of the fossil Reptiles and other land-animals of the locality, which I desire to deposit in the Museum of the Society, that they may be more fully studied by comparative anatomists, and may remain as types of the species, accessible to British geologists.

In the bed which has hitherto alone afforded reptilian remains in its erect trees, two additional examples of these were exposed. One was on the beach, and in part removed by the sea. The other was in the cliff, but so far disengaged that a miner succeeded in bringing it down for me. In the first comparatively little was found. It afforded only a few shells of *Pupa vetusta*, and scattered bones of a full-grown individual of *Dendrerpeton Acadianum*.

The second tree was more richly stored; and, being *in situ*, was very instructive as to the mode of occurrence of the remains. Like all the other trees in which reptilian bones have been found, it sprang immediately from the surface of the six-inch coal in Group XV. of my section*, which is also Coal No. 15 of Sir W. E. Logan's section†. Its diameter at the base was 2 feet, and its height 6 feet, above which, however, an appearance of additional height was given by the usual funnel-shaped sinking of the overlying beds toward the cavity of the trunk. The bark is well preserved in the state of bituminous coal, and presents externally a longitudinally wrinkled surface without ribs or leaf-scars; but within, on the "ligneous" surface, or that of the inner bark, there are broad flat ribs and transversely elongated scars. The appearances are precisely those which might be expected on an old trunk of my *Sigillaria Brownii*, to which species this tree may have very well belonged‡.

The contents of the trunk correspond with those of others previously found. At the bottom is the usual layer of mineral charcoal, consisting of the fallen wood and bark of the tree itself. Above this, about 2 feet of its height are filled with a confused mass of vegetable fragments, consisting of *Cordaites*, *Lepidodendron*, *Ulodendron*, *Lepidostrobus*, *Calamites*, *Trigonocarpum*, stipes and fronds of Ferns, and mineral charcoal; the whole imbedded in a sandy paste blackened by coaly matter. In and at the top of this mass occur the animal remains. The remainder of the trunk is occupied with

* Quart. Journ. Geol. Soc. vol. ix. p. 58, and vol. x. p. 20.
† Reports of Geol. Survey of Canada, 1845.
‡ Quart. Journ. Geol. Soc. No. 68. p. 523.

grey and buff sandstone, containing a few fragments of plants, but no remains of animals.

Portions of six reptilian skeletons were obtained from this trunk. The most important of these is a large and nearly complete skeleton of *Dendrerpeton Acadianum*—by far the most perfect example, as I suppose, of any carboniferous reptile hitherto found. I shall not attempt to describe this specimen, and the new points of structure which it illustrates; but I send the specimen itself, in the hope that its details may be examined and described by the eminent naturalist by whom the species was originally named and characterized. Another specimen found in this trunk is a jaw of an animal about the size of *Dendrerpeton Acadianum*, but with fewer and larger teeth. I send this specimen, which may possibly indicate a new species. The remaining skeletons were imperfect, and belonged to a small individual of *Dendrerpeton Acadianum*, two of *Hylonomus Lyelli*, and one of *Hylonomus Wymani*. The dislocated condition of these and other skeletons is probably due to the circumstance that, when they were introduced, the matter filling the trunk was a loose mass of fragments, into the crevices of which the bones dropped, on decay of the soft parts. Most of the skeletons lie at the sides of the trunk, as if the animals had before death crept close to the walls of their prison. At the time when the reptiles were introduced, the hollow trunk must have been a pit 4 feet in depth.

A number of specimens of *Pupa vetusta* and *Xylobius Sigillariæ* were found, but nothing throwing further light on these species.

I found in this trunk, for the first time, indications of the presence of *Insects*. The remains observed were disjointed and crushed fragments, and as they did not include wings or elytra, I cannot give any decided opinion as to the orders to which they may have belonged. The most probable conjecture would be that they were *Neuroptera* or *Orthoptera* of large size. The most interesting fragment obtained is a compound eye, imbedded in coprolitic matter, along with obscure portions of limbs and abdominal segments. Its facets are perfectly preserved, and are lined with a brownish bituminous matter, simulating the original pigment. These remains are at least sufficient to prove that in Nova Scotia, as in Europe, Insects inhabited the coal-forests, and that they furnished a portion of the food of *Dendrerpeton* or its allies. I may mention here that in other coprolites quantities of segments of *Xylobius* occur, and that there are some little groups of bones of very small reptiles, which are probably coprolitic.

The beds on a level with the top of this erect tree are arenaceous sandstones, with numerous erect *Calamites*. I searched the surfaces of these beds in vain for bones or footprints of the Reptiles which must have traversed them, and which, but for the hollow erect trees, would apparently have left no trace of their existence. On a surface of similar character, 60 feet higher, and separated by three coals with their accompaniments, and a very thick compact sandstone, I observed a series of footprints which may be those of *Dendrerpeton* or *Hylonomus*. The impressions are too obscure to show the toes distinctly. They are half an inch in length, with a stride of about 2 inches. On neighbouring layers were pits resembling rain-marks, and trails or impressions of a kind which I have not before observed. They consist of rows of transverse depressions, about an inch in length and ¼ of an inch in breadth. Each trail consists of two of these rows running parallel to each other, and about 6 inches apart. Their direction curves abruptly, and they sometimes cross each other. From their position they were probably produced by a land or freshwater animal—possibly a large Crustacean or gigantic Annelide or Myriapod. In size and general appearance they slightly resemble the curious *Climactichnites* of Sir W. E. Logan, from the Potsdam Sandstone of Canada.

I have long looked in vain for remains of land-animals in any other situation than the erect trees of the bed above referred to; but on my last visit I was much gratified by finding shells of *Pupa vetusta* in a bed 1217 feet below the former, in the upper part of No. 8 of my section, or about 15 feet below Coal No. 37 of Logan's section. The bed in question is a grey and greyish-blue under-clay, full of Stigmarian rootlets, though without any coal or erect trees at its surface. It is 7 feet thick, with sandstone above and below. The shells occur very abundantly in a thickness of about two inches. They have been imbedded entire; but most of them have been crushed and flattened by pressure. They occur in all stages of growth; but the most careful examination did not enable me to detect any new species. With them were a few fragments of bone, probably reptilian. This discovery establishes the existence of *Pupa vetusta* in this locality during the deposition of twenty-one coal-seams, and the growth and burial of at least twenty forests; and from the occurrence of numerous specimens at both extremes of this range, without any other species, it would seem as if, for this locality at least, this was the only representative of the shell-bearing Pulmonates.

I append a list of the specimens forwarded to the Museum of the Society, and which, with those formerly sent, constitute a complete collection of the air-breathing animals hitherto recognized in the Coal-measures of Nova Scotia.

List of specimens of Reptiles, &c., from the Coal-formation of Nova Scotia, accompanying this paper.

1. *Hylonomus Lyelli.* A nearly complete skeleton, and the maxillary bone and teeth of another specimen.
2. *H. aciedentatus.* Maxillary bone, vertebræ, ribs, scales, and foot.
3. *H. Wymani.* Lower jaw, vertebræ and other bones, and scales.
4. Jaw of a Reptile, supposed to be new.
5. Skin and dermal plates of *Hylonomus.*
6. *Dendrerpeton Acadianum*, Owen. A nearly complete skeleton.
7. *Pupa vetusta**. From a bed 1217 feet below that in which the species was originally recognized.

* I observe that Professor Owen proposes the name "*Dendropupa*" ('Palæontology,' 1860, p. 79); but I have retained *Pupa* for the present, not being satisfied

4. *On a* Volcanic Phenomenon *witnessed in* Manilla.

By John G. Veitch, Esq.

[Extract of a Letter* to Dr. J. D. Hooker, F.R.S., F.G.S.]

On the 1st ult. a portion of the River Pasig, on the banks of which the city of Manilla is situated, presented an extraordinary appearance, which continued with but slight interruption from 6 to 10 A.M. The oldest inhabitant never remembers having seen or heard of a similar phenomenon.

The river, for the space of a quarter of a mile from east to west, and having at this point a depth of 15 to 18 feet, appeared in a state of violent fermentation, as if some commotion were taking place in parts invisible to the eye.

Quantities of air-bubbles rose to the surface, until the river became covered with foam, and presented the appearance of simmering water. The temperature of the water where this appeared was 100° to 105° Fahr., that of the remainder of the river being 80°.

The most remarkable circumstance was the effect produced on the bed of the river. Mounds of mud were raised several feet above the surface of the water, and appeared as if a huge bank of mud had been permanently thrown up in the midst of the river.

The temperature of the soil thrown up was 60° to 65° only; but it smelt so offensively as to taint the atmosphere for a considerable distance in the immediate neighbourhood.

After having been thus disturbed for the space of four hours, the bed subsided, and the river again resumed its ordinary appearance.

I trust this imperfect description may enable you to judge as to the cause of so curious a commotion. Here it is generally looked upon as being of volcanic origin.

November 20, 1861.

Charles Sanderson, Esq., C.E., Engineer-in-Chief of the Bombay and Baroda Railway, Surat, Bombay; Ralph Tate, Esq., Teacher of Natural Science, Philosophical Institution, Belfast; James Ray Eddy, Esq., C.E., Carleton Grange, Skipton; Henry Worms, Esq., of the Inner Temple, 272 Park Crescent, Portland Place; and Haddock

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that there is any good generic distinction; though I admit that the form of the aperture suggests the possibility of affinity to *Bulimus* as well as to *Pupa*.

Mr. J. G. Jeffreys, F.G.S., who considers the shell to be a true *Pupa*, has kindly directed my attention to traces of ridges observable on the columella of one specimen, and which he regarded as corresponding with the screw-like plates in the young of *Pupa umbilicata* and *P. ringens*. This appearance I have observed in specimens now in my possession; and at one time I supposed that I had made out a distinct tooth; but, not finding this in other and less compressed individuals, I concluded that it was an effect of pressure; in which, however, I may have been mistaken, as Mr. Jeffreys states that these processes have no connection with the teeth in adult specimens, and that even the toothless variety of *P. umbilicata* is furnished with them.

* Dated "Manilla, June 1861."

Dennys, Esq., 3 Percy Terrace, Lower Road, Islington, were elected Fellows.

The following communications were read:—

1. *On the* Bovey Deposit. By J. H. Key, Esq.

(Communicated by Sir C. Lyell, F.G.S.)

[Abridged.]

Introduction.—Singularly enough, as geologists approach our own era the difficulty of determining the relative age of a particular stratum generally increases; and it is in the more modern tertiaries, or deposits succeeding to these, that the greatest amount of difficulty occurs. Among the strata not yet referred to any certain epoch, but broadly designated "tertiary," are the clay-, sand- and lignite-beds, known to geologists as the "Bovey deposit*." Having been for the last ten years engaged in working and boring the various beds of clay, I may have become possessed of facts not generally known to geologists, bearing on the origin and nature of the deposit, and which may assist in some degree to fix its relative age.

The physical features of the basin.—The Bovey basin is a depression beneath the level of the surrounding country; its length, from Bovey-Tracey to about two miles south of Kingskerswell, is about 10 miles; its breadth at the upper end about 2½ miles, becoming much narrower towards its southern extremity. Two rivers, the Teign and the Bovey, both having their sources in the granite of Dartmoor, run into this basin, meet above Stover, and fall into the sea at Teignmouth. The Teign, the larger and more circuitous, for about 13 or 14 miles before entering the Bovey basin, flows through the slate; and the Bovey River, rising near the centre of the moor, crosses for a short distance the slate, and runs into the basin at its upper end. All the drainage of the basin flows to the estuary of the Teign through an opening between Buckland Point and Hackney, about half a mile wide.

The deposit, surrounded by hills forming the margin of the basin, presents to the eye for the most part a level plain; a large portion immediately above the point where the Teign meets the tide being of a very low flat character, subject to floodings at high spring-tides and heavy rains; from this point it rises gradually, on the one hand,

* The clays and lignites of Bovey-Tracey have been more or less fully described by Dr. Jeremiah Milles in the 'Philosophical Transactions' for 1753; by James Parkinson and Robert Scammell ('Organic Remains,' p. 123, &c.) in 1811; C. Hatchett, Trans. Linn. Soc. vol. iv. p. 138, &c.; and Phil. Trans. 1804, p. 390, &c.; J. Macculloch, Geol. Trans. 1814, vol ii. p. 18; Mr. Kingston, 'Mineralogy of Teignmouth'; Conybeare and Phillips, 'Outlines of the Geology of England and Wales,' p. 328, and p. 346.

A *résumé* of the facts and opinions offered by the above-mentioned writers was given by Mr. E. W. Brayley in Moore's 'History of Devonshire,' 1829, vol. i. p. 380, &c. Further notices have been made by Mr. Godwin-Austen in 1834 and subsequently (Geol. Proceed. vol. ii. p. 103, and Geol. Trans. 2nd ser. vol. xi. p. 439, &c.); by Sir H. De la Beche in 1839 (Geol. Report Devon and Cornwall, p. 246, &c.); by Dr. Hooker in 1855 (Quart. Journ. Geol. Soc. vol. xi. p. 566); and by Dr. Croker in 1856 (Quart. Journ. Geol. Soc. vol. xii. p. 354).—Edit. Q. J. G. S.

towards Kingskerswell and Torquay, and on the other, towards the Bovey and Knighton Heaths, where the deposit attains its greatest elevation, 151 feet above the mean level of the sea; farther north it sinks again abruptly, before reaching the slate-hills of Bovey-Tracey, into the valley occupied by the Bovey Pottery. The exceptions to the generally flat appearance of the lower portion of the deposit occur where the hills forming the border-line of the basin are composed of loose material, when it would appear as if portions had been washed into the depression over the deposit, breaking the general level; this is observed at Stover, at Sandy Gate, and below Baker's Hill.

For more than a hundred years the Bovey basin has been worked for pipe and potter's clay, sending off annually large quantities from its shipping port, Teignmouth, to all the principal sea-ports of the United Kingdom. In the northern part of the basin, near Bovey-Tracey, an extensive pottery has been established, excavating the greater part of its fuel for many years from the adjoining beds of brown-coal or lignite; although at present, I believe, from exhaustion of the beds near the surface, sea-borne coal is used to a considerable extent.

In penetrating beneath the soil of this deposit in any part, the borer meets with nothing harder than gravel or beds of lignite, with the exception of an occasional boulder near the surface; the whole basin being filled up with loose material, consisting of various kinds of clay, silt, sand, lignite, and gravel, deposited in beds, with considerable regularity. At one place it has been bored to a depth of 200 feet, and in many places 130 to 150 feet, without meeting rock.

The strata of the Bovey Basin.—Commencing on Knighton Heath, and running down the eastern side of the basin, are three principal parallel beds of clay (used in commerce), resting on, separated, and covered by other parallel beds of muddy clay, silt, sand, and gravel, all having a western inclination or dip*. South of the Newton Railway Station the beds of fine clay thin out to a mere trace, but occur again at the Decoy, as a well-defined and regular deposit; but here the dip is changed from the west to the east, the pipe-clay now being found to the west, and the potter's clay, accompanied by seams of lignite, to the east. Further south, the beds of fine clay thin out again, still keeping their eastern inclination; become again well defined at Aller, especially as regards the potter's clay and lignite (the pipe-clay having here lost its distinctive qualities, being mixed up with sand and stained with ochreous matters); and onwards in the valley leading to Torquay traces of the clay may be found as far as the Atmospheric Engine-house, above the Torr Railway Station.

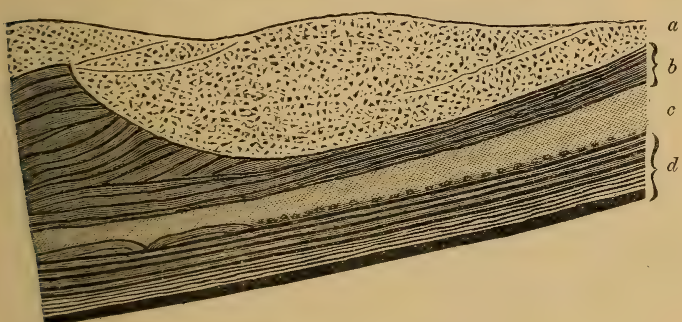
As regards the strike of the strata on the *western* side of the deposit (its central and upper portion), not so much is known; no

* On the plan of the Bovey basin presented to the Society (not published) the bed to the east, marked red, is the pipe-clay (called locally the "white body"), the two western beds, marked green, potter's clay (or the "black body"), and the parallel beds of coarse clay, sand, &c., marked brown. A bed of lignite, in some places well defined, but in others forming merely a trace, accompanies the middle bed of potter's clay—the lignite marked black in the plan.

regular workings have been carried on there, as on the eastern side, the clay found by boring being, for the most part, unsuitable for commerce; it is highly stained with red matter, and gravelly. The little that is known tends to prove that the strike of the beds of clay, sand, and gravel, on the western side, corresponds in direction to an extended outline of the hills on that side, the dip of the beds being the same as at the Decoy, to the east.

The *north-western* part of the basin is better known: here occur large deposits of "Bovey-coal" or lignite,—an accumulation of tangled masses of vegetation, deposited in regular beds, of various thickness, separated by rough clays and sand. At the Bovey Pottery, where they have been worked extensively, the beds dip to the south-east, and the strike of the strata runs about south-west. The dip of the beds is about 11 inches in a fathom; and their vertical thickness is about 100 feet. The lower beds are those worked for fuel; the upper beds being very loose and irregular, and mixed with coarse clay and quartzose gravel. The whole is covered by a deep "head" of gravel, such as would be washed from disintegrated granite.

Fig. 1.—*Section of the Lignite-beds at the Bovey Pottery.* (Taken by Dr. Croker in 1841.) Scale $\frac{1}{8}$th inch to a fathom.



a. "Head" of rough gravel.
b. Imperfect beds of Lignite, separated by thin seams of rough clay and sand.
c. Yellowish sand, 9 feet thick, with bluish clay, sand, and pebbles at the bottom.
d. Ten beds of Lignite, separated by thin seams of clay, mixed with vegetable matter.

The beds dip to the South-east, with an inclination of 1 foot in 11.

The order of deposition observed in this section corresponds with what would be expected to result were a river, bringing various kinds of sediment, to discharge itself into a deep lake. (See further on, page 17.) In the regularity of the ten lower beds of lignite, separated by thin seams of fine clay and vegetable matter, are discerned the characteristics of deposits gradually formed, in deep and comparatively still water, as the lake became filled up with sediment, and the water became shallower, and the current therefore more rapid; the beds of lignite becoming more and more irregular, and separated by coarser and coarser materials. At length, as the sediment approached the surface, the lignite ceased to be deposited; the specific gravity of the trees not being sufficient to withstand the current; and very rough granitic gravel was alone allowed to become fixed.

Fig. 2 is a section across the beds of pipe- and potter's clay, on the eastern side of the basin, near New Cross. It is constructed on data obtained from the inspection of deep and shallow pits from Knighton to Newton-marsh, from reports of the workmen, from borings, and from the superintendence of the Newton-marsh Clay-works. This section will nearly represent the stratification of the continuous clay-deposit from near Knighton, on the north, to the Newton Railway Station; with this difference, that at the commencement of the deposit the seams of fine clay are thin, somewhat irregular, and to some degree mixed with quartz-gravel. The dip is also greater than in the section; and in several places the clay-beds show the action, apparently, of running water, portions of the fine material having been evidently washed away, so that the fine clay runs down to a considerable depth almost perpendicularly.

From Knighton southwards the beds of fine clay increase in thickness, purity, and regularity to below New Cross, where they begin to diminish in thickness, until lost south of the Newton Railway Station. In two or three places narrow bands of coarser clay, generally stained, run across the finer clay; and in several places the pipe-clay forms two beds.

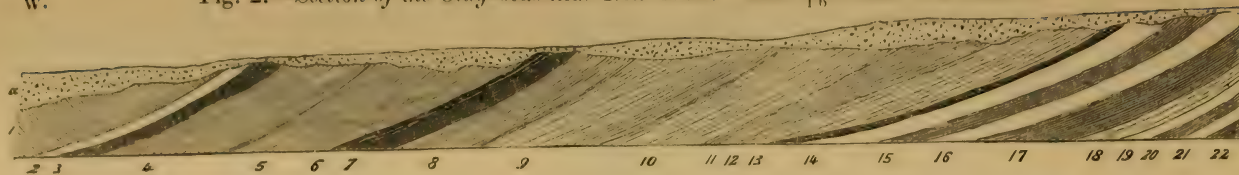
Fig. 3 represents a section of the beds of clay, &c., at the Decoy*, and has been constructed from numerous observations made at the spot and in its vicinity during ten years. All the seams of clay shown in the section have been worked for considerable distances longitudinally, from 60 to 100 feet transversely, and to depths of from 30 to 90 feet. The inclination of the strata here is much greater generally than, and in the opposite direction to, that in the section fig. 2. It will be observed, however, that the superposition of the beds is almost identical with that in the last-mentioned section, taken in the upper part of the basin: the pipe-clay, it is true, is divided into three distinct beds, against two in section fig. 2; but the order of deposition is the same, and the description of one would suit the other. Taking the beds in order upwards, we shall have rough clays, pipe-clay, stiff clay, dark fine clay, rough muddy clays, potter's clay, and lignite. In section fig. 2, there are two beds of potter's clay shown; at the Decoy also there is to the east a small second seam of fine clay resting on the one shown in fig. 3.

Several seams of lignite, almost perpendicular in dip for the first 15 or 18 feet from the surface, and separated by thin divisions of dark clay and vegetable matter, lie immediately below the bed of potter's clay in fig. 3.

The pipe-clay at the Decoy has been worked about 90 feet deep,

* This is the "deep watercourse below Woolborough," in Mr. Godwin-Austen's Memoir, Geol. Trans. 2nd ser. vol. vi. p. 451.

Fig. 2.—*Section of the Clay-beds near New Cross.* Scale $\frac{1}{16}$th inch to a fathom.



a. "Head" of gravel.

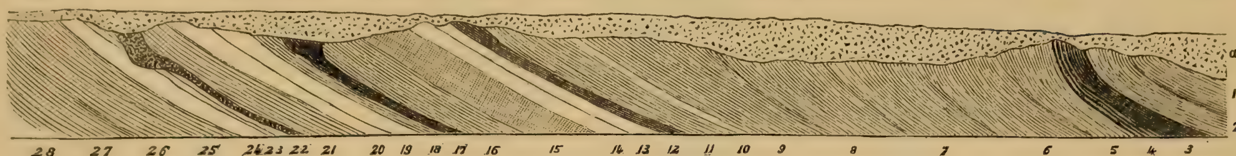
Potter's clay Series.
1. Sand and gravel.
2. Clay.
3. Fine clay.
4. Silt.
5. Muddy clay.
6. Brown clay, with seams of lignite.
7. Fine brown clay.

8–12. Beds of coarse clay, sand, and gravel. (The space occupied by these beds is shortened.)

Pipe-clay Series.
13. Brown clay.
14. Stiff white clay.
15. Pipe-clay.
16. Hard stiff clay.
17 & 18. Muddy clay.
19. Stiff white clay.
20 & 21. Pipe-clay.
22. Muddy clay.

The beds dip to the West.

Fig. 3.—*Section of the Clay-beds at the Decoy.* Scale $\frac{1}{15}$th inch to a fathom.



a. "Head" of gravel.

Potter's clay Series.
1 & 2. Muddy clay.
3. Fine brown clay.
4. Small seams of lignite separated by thin beds of clay.

5–11. Beds of muddy clay and sand.

Pipe-clay Series.
12. Dark clay.
13. Stiff clay.
14. Pipe-clay.
15. Sand, fine and coarse.
16. Muddy clay.
17. Fine dark sand, with Leaves and Seeds.
18. Brown clay.

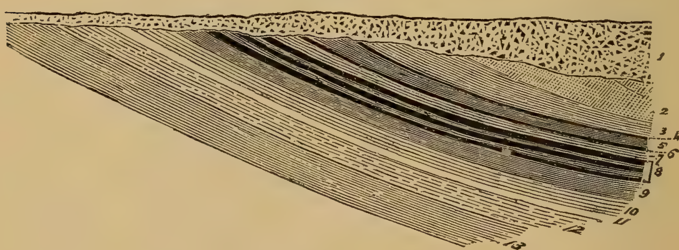
Pipe-clay Series.
19. Stiff white clay.
20. Pipe-clay.
21. Rough muddy clay.
22. Fine dark sand, with Leaves, Seeds, &c.
23. Stiff clay.
24. Pipe-clay.
25–28. Fine clay with pink stains.

and bored to about 120 feet; but the clay-seams gradually thin out, in depth, as shown in fig. 3. The pipe-clay and stiff clay in some places run down almost perpendicularly, as shown in bed 3 in fig. 3, representing the appearance of having been partially washed away by a stronger current than at first deposited the bed; and, wherever this occurs, the deposit lying on the bed so partially washed away is of very much rougher texture—generally fine or coarse sand or gravel.

Here and there a smooth water-worn stone, generally of quartz, but sometimes slate, is found imbedded in the clay. Nodules of iron-pyrites, of all sizes, from that of small shot to that of an egg, are in some places abundant. Detached pieces of lignite, too, are very common—sometimes with the surface changed into mundic.

The clay and accompanying beds at the Decoy rest against the Greensand hills surrounding this portion of the basin; and the strike of the beds forms a segment of a circle, somewhat conformable in direction to the shape of the hills.

Fig. 4.—*Section of Clays and Lignites at Aller.* Scale $\frac{1}{24}$th inch to a fathom.



1. "Head" of gravel.
2. Sand.
3. Muddy clay.
4. Lignite.
5. Clay.
6. Lignite.
7. Clay.
8. Three seams of lignite, separated by fine clay.
9. Fine clay.
10. Rough clay.
11. Fine clay.
12. Rough clay with gravel.
13. Rough sand and muddy clay.

The beds dip to the East.

Fig. 4 shows a section* of the potter's clay and lignite-beds at Aller. Here the lignite, separated by beds of clay, is more developed than at the Decoy. No fine pipe-clay has been found at Aller; but underlying the beds shown in the section, and occupying the position of the pipe-clay, are rough clays, highly stained with ochre, all having an eastern dip.

It will be observed in all the sections here given that the dip of the beds increases from the sides towards the centre of the basin; and this I believe to be generally the case throughout the deposit.

The clay-beds throughout the deposit show no sign of disturbance by slips or faults; they seem perfectly unaffected by any other power than that of water.

* Constructed from numerous observations whilst superintending the works during several years.

Such is the manner in which the clays and other beds filling the basin are arranged; but, to complete the sketch, a description of the "Head" (seen in the various sections), covering the more regularly stratified beds, is necessary.

Lying unconformably on the upturned edges of the clay-beds, and becoming considerably deeper towards the centre of the basin (in some places 30 to 40 ft., in others not more than 3 feet deep), is an accumulation of clay, earthy matter, gravel, rolled stones, and boulders, with but little stratification. This is called the "Head"*. In some places the gravel and boulders, in others the earth and clay, preponderate; and in many places the "Head" partakes of the character of the adjacent hills, particularly if they be of loose material. At the Decoy, for instance, the "Head" is composed of flint-nodules, quartz, boulders, and gravel, mixed with clay and earthy matter, and containing also the fossils proper to the adjoining hills. In the upper portion of the basin, the "Head" is composed of boulders of schorl, quartz, and slate, with sand and gravel.

In the low marshes near Newton, the "Head" over the clay-beds is stratified in the following manner:—From the surface to the depth of 3 to 5 feet, loose silt, without shells; then from 3 inches to 2 feet of dark silt, containing a very few shells of the oyster and cockle, and a great number of the shells now common in the estuary below. Immediately under the silt containing shells, in one place, there is a narrow basin-shaped stratum of peat, from 3 to 18 inches thick, lying on which I found the rib and jaw of a Deer. Below the peat is coarse clay from 6 to 7 feet thick, in which are boulders of granite, slate, and quartz; and then the true stratified beds of clay.

The shelly bed described above is not found in the higher portions of the basin, but only near where the River Teign runs into the salt water; indeed the shells are all found under high-water mark.

Materials and probable mode of formation of the Bovey Deposit.—On submitting the pipe-clay to analysis it is found to contain about† 63 per cent. of silica, 27 to 29 per cent. of alumina, some oxide of iron, and a trace of lime. The stiff clay has considerably more silica, and in larger particles; the potter's clay nearly the same amount of silica and alumina as the pipe-clay, with a little carbon, from the lignite, I suppose, to which it also owes its dark colour.

The sand and silty beds on and under the clay are composed chiefly of minute pieces of quartz, with some schorl and slate; and in the finer beds of silt there are also numerous shining particles of mica.

The greater part of the materials composing the Bovey deposit are, therefore, identical with the component parts of granite, or such

* Some account of the "Head," and of its local differences, is given by Mr. Godwin-Austen at pp. 438 & 440 of his Memoir, Geol. Trans. 2nd ser. vol. vi.—Edit.

† I say that the pipe-clay contains *about* 63 per cent. of silica, because all clays being mechanically, and not chemically, combined, samples of pipe- and potter's clay are found to differ much in their relative proportions of silica and alumina.

as would be expected to be brought to and deposited in a lake * by a river flowing over decomposed granite. A common variety of granite is frequent in Devonshire and Cornwall, containing—

Silica	73·04
Alumina	18·83
Potash	8·51
Magnesia	0·83
Lime	0·44
Oxide of iron	1·73
Fluoric acid	0·18

By looking at the above-mentioned plan of the basin, it will be seen that the clay is continuously deposited in the valley leading to Torquay; therefore, if a lake once existed, in order to deposit the clay, the current must have run in the direction of Kingskerswell and Torquay, and did not, as now, find an exit to the sea by the way of Teignmouth.

In corroboration of this view appears the striking fact, that, were the opening in the chain of hills surrounding the basin between the hills in the rear of Hackney and Buckland Point (now allowing the River Teign and other streams to escape to the sea by the way of Teignmouth) filled up, the water would accumulate until an extensive lake would be formed, having its outline indicated by the dark line around the margin of the basin on the plan, and discharging its surplus water at the point where now stands Lawe's Bridge, taking the road over the railway above the Torr Station; from this point the water of the lake would flow, with a rapid current, through a well-marked channel still existing for some distance, past the Torr Railway-station, and at the foot of the site of Torr Abbey, to the sea in Torbay.

The height of this bridge above the mean level of the sea (as kindly communicated to me by Mr. Appleton, surveyor, of Torquay, and taken by him for the Torquay Water-supply) is 171 feet; but, on examining the nature of the ground around this bridge, it is found to be an accumulation of red brick-earth, evidently washed from the immediate neighbourhood,—no doubt choking up the ancient channel of the river for some considerable depth, certainly for 18 or 20 feet, as seen in the cutting below the bridge. Deducting 20 from 171, we have 151 feet for the height of the surface of the lake above the mean level of the sea. Now this agrees remarkably well with the physical features of the basin. I refer to the fact, that the outline of the lake at that height nearly indicates the outline of the Bovey deposit, no marked member of the deposit being found above that line †; and also that many of the hills forming the margin of

* That the area of Bovey-Heathfield and Bellamarsh was once a lake was argued by Mr. Godwin-Austen in 1834 (Geol. Proceed. vol. ii. p. 103): the upper accumulation ("Head") alone, however, was supposed to be referable to such a condition; the lower sands and clays, which are destitute of chalk-flint detritus, not being included in that lacustrine series, but (at least those near Newton) referred to the Cretaceous series by Mr. Godwin-Austen, Geol. Trans. *loc. cit.* p. 451.—Ed. Q. J. G. S.

† The highest part of the deposit is 151 feet above the mean level of the sea, on Knighton Heath.

the basin present traces of a horizontal ridge at from 130 to 150 feet above the sea, particularly the older and firmer formations,—for instance, Buckland Point, Knowles, the hill over Kingskerswell Church, west of the road, and many others, indicating, it may be supposed, the line of wash near the surface of the lake around its margin.

It is easy to conceive the chain of hills around the basin to have been unbroken at some former period, and the consequent existence of a lake, extending from Bovey-Tracey to near Torr, ramifying far up into the lateral valleys, receiving into it the rivers and streams that now run over its bed. Either by the advance of the sea from without, or, more probably, by the gradual opening of a channel between the hills behind Hackney and Buckland Point from within, by the action of the surface-wash of the lake (the waves of which must have attained considerable power, driven by north or west winds on the point indicated), the lake grew shallower, until it ultimately disappeared.

In order to prove beyond doubt that the surplus water of the lake discharged itself at the point mentioned (Lawe's Bridge), it would have been desirable to find some beds of sand or gravel, indicating the bed of a river between Lawe's Bridge and the sea; but the loose brick-earth forbids. Corroborative evidence, however, of the former channel is found in the bed of peat * on the beach, under Torr Abbey; showing, no doubt, that a small lake had existed here on the course of the river, and which, after the river had ceased to run in this direction, became filled with a growth of peat. On the beach, too, near the peat, are spots of very white sandy clay, resembling that of the Bovey deposit, whiter, I think, than any which could be washed from the Red Sandstone cliff; and these may be small portions of a larger bed, deposited by the river before the sea had penetrated so far inland.

The evidence offered by the strata of the Bovey deposit itself is, perhaps, the most conclusive as to the existence of this lake; the more prominent facts to be gathered from the plan and sections being these:—

1. That the Bovey deposit is composed of various beds almost identical with the component parts of granite.

2. That the strata run, for the most part, parallel with an extended outline of the marginal hills, and dip from the sides towards the centre of the basin,—the nearer the centre, the greater being the dip.

3. That the finer material is deposited towards the sides, and the coarser towards the centre.

4. That where the basin contracts in width, the finer beds contract in thickness, and sometimes disappear; on the contrary, where the basin widens the purest and most regular beds of clay are found.

5. That the northern part of the deposit is at first irregular, and composed of coarser substances than the central and lower portions.

* Bones of Deer have been found in this peat.

6. That on the eastern side of the basin the beds of fine material are more developed than on the western side.

7. And, lastly, that the various beds run in the direction of, and seem to point to, the River Bovey as the source from whence they were derived.

The author then considers the probable conditions of a lake of the size of the Bovey basin, elongate, but contracted in the middle, fed by a rapid river entering the lake at its upper end, and having its tributaries in hills clothed with forest-trees, and consisting of decomposing granite, such as is seen at present on the south-western slopes of Dartmoor, and at the China-clay-works of St. Austell and St. Stephen's, Cornwall, where the felspar of the granite has decomposed into a soft white powder, and the quartz and mica form loose sand and gravel of all degrees of size, for a depth, in some places, of more than 40 fathoms.

The materials brought by the river to the lake would (the author states) mainly consist of—first, clays of different degrees of fineness, derived from the decomposed felspar; secondly, earthy matter, from the vegetable mould; thirdly, siliceous sand and gravel, of all degrees of size; fourthly, vegetable matter, forest-trees and plants of various kinds, from the river, in time of flood or otherwise, undermining its soft banks clothed with vegetation; and, lastly, stones and boulders of various kinds.

The particular plan of deposition, and often redeposition, of these materials is then described by the author, and illustrated by a diagram-plan; and he remarks that the various strata, consequent on the fluctuating quantity of water discharged by the river, would not be deposited horizontally over the bottom of the lake, but would incline more or less from the sides towards the centre, or towards the current, the degree of inclination being regulated chiefly by the strength of the current. Where the lake became very narrow, the beds of sediment would be thin, and the dip great; and where the lake was wide, the dip would be comparatively small; the dip being probably caused by less material being allowed to permanently fix itself at the centre than at the sides; therefore the beds would have a tendency to thicken near the surface, and thin out below, causing the dip to increase towards the centre of the basin. The dip, too, would not be of the same angle throughout, but would be less towards the bottom; the section of such beds assuming a slightly concave form.

Thus the lake would go on filling with sediment, the coarse irregular deposit of the delta advancing downwards, overlying the more regular parallel beds of the fine material beneath: the materials of the delta would be very thickly deposited towards the centre, and more thinly where the beds of fine material approach the surface, and it would thus form a coarse unstratified "Head," overlying the finer stratified deposits.

Mr. Key observes that the strata of the Bovey basin, on comparison, will be found to comply in every material circumstance with what would be expected under the conditions above given; and that though in the Bovey deposit we do not find a uniform arrangement of strata on each side of the basin, but a great development of fine material on one side, attended by a corresponding regularity,—and a paucity of clay and much irregularity on the other, yet, supposing that the rivers and streams of the ancient lake ran into it from similar situations to those now running into its bed, we could not expect the same degree of regularity as in the more simple form of the supposed lake and single river.

Before the lake became drained by the bursting through, or wearing down, of the channel between Buckland Point and Hackney, the "Head" on the clay had probably run out over the greater portion of the higher part of the deposit, every little stream, of course, bringing its own formation from the hills; hence the flint, chert, and fossils from the Greensand. After the waters had retreated, the Teign, the Bovey, and other streams must have channelled out the loose material of the "Head" considerably; and to this cause may be attributed the valley at the upper part of the basin, and others carrying small watercourses.

The author proceeds to state his belief that the Bovey deposits were composed of detritus derived from the surrounding hills, and quietly deposited, with no more disturbance than the occasional flood: that if the relative level of sea and land has been disturbed, it has been over a large area, leaving the physical characters of the country comparatively unaltered; because he does not observe similar deposits on the neighbouring hills; because the basin appears to have been always limited by the existing hills; because there are no slips or faults in the deposit; because the mode of deposition would account for the inclination of the beds, and for their local variations. Some of the beds have a dip of 45° or 50°, and the lignite at the Decoy (fig. 3) is almost perpendicular; but this is only for about 15 or 18 feet; afterwards it takes an angle of 40° or 50°. The perpendicularity of these beds is accounted for by the author, by the supposition that they have been bent outwards by the slipping or forcing out of the lower wedge-shaped beds, when in a soft state, pressed down by the weight of the "Head."

Recurring, says the author, to the opinion I have heard expressed by some geologists, that the Bovey deposit is a portion of more widely spread beds that once existed over a large area, I can only say, it may be so; but up to the present time I have never seen the least sign of the clay and accompanying beds, either in the valley of the Dart, on the one hand, or that of the Exe, on the other. On the northern slope of Dartmoor, it is true, near the village of Merton, there is a deposit much resembling that of the Bovey basin, both in regard to the quality of the clay and the manner in which it lies; but the great similarity in general features of the Merton basin with that of Bovey explains the derivation of the clay-beds, and adds additional proof that my view of the Bovey beds is correct. The Merton clays are deposited in beds sloping at angles similar to those of Bovey; the deposit is entirely surrounded by hills, except at one point, where a chasm of but short width has been worn away, affording a passage to the drainage of the basin into the Torridge. It is plain that a freshwater lake has existed here, in which clays, brought by streams from the northern slopes of Dartmoor, became deposited; and that, by the wearing down of the chasm, the lake has drained itself, and the clays have become exposed in the same manner as are those of Bovey basin.

In conclusion Mr. Key observes—How strange it is that, amid the proofs of teeming vegetation scattered throughout the Bovey deposit, not a fragment of bone or shell should indicate the existence of animal life! Besides *Coniferæ* (of which the mass of the lignite is supposed to be composed), numerous relics of dicotyledonous plants —leaves and seeds—have been collected by Mr. Key, chiefly from the clays at the Decoy; and original sketches of these remains accompanied the paper. Pyritous concretions, probably formed around some vegetable nuclei, occur abundantly, and are also illustrated in Mr. Key's MSS. After some notes on the indications of an abundant flora, so well worth attentive and extended study, and the apparent absence of animal remains, the author remarks, that, with our present amount of knowledge, we can only suppose either that no animals existed around the old lake, or, what is more probable, that the conditions of the strata were inimical to the preservation of animal remains.

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2. *On the* Volcanic Cones *of* Paternó *and* Motta (Sta. Anastasia), Etna. By Signor G. G. Gemmellaro.

[Communicated by Sir C. Lyell, F.R.S., F.G.S.]

The base of that portion of the ancient basin of the Simeto which extends from Catania to the Carca di Paternó is formed of pleistocene clay, which is particularly exposed at the Siete della Motta and in the neighbourhood of the Valley of St. Biagio. The post-pliocene conglomerate, with beds of yellow sand and bands of clay, overlies it, and forms the upper part of the hills of Terre-forti, extending down their southern flanks as far as the broad plain of Catania, whilst the freshwater calcareous tuff, which is above it, completes for the neighbourhood of Paternó the series of sedimentary materials of the said basin.

This fertile district, in addition to having been exposed to the pyroxenic lava-streams from Etna, has been disturbed by the destructive agency of volcanic cones. In the pleistocene period the intrusion of the basalt, coëval with that of Aci-Castello, ravaged the district of Valcorrente; and at a subsequent period two centres of volcanic action existed at Paternó and at Motta (Santa Anastasia), of which the traces only now remain. These, however, offer such interesting phenomena, that I think it desirable to confine my remarks in this notice exclusively to them.

Volcanic Cone of Paternó.—The beautiful city of Paternó, in the Province of Catania, is partly built on a mass of doleritic rock, which, according to Hoffmann, rises to the height of 620 mètres above the level of the sea, and is distant about 12 miles from the existing axis of Etna. After a careful examination of it, the circumference being about a mile, we can make out the central nucleus, the lava, and the broken or fragmentary materials,—all of which are elements concurring to the formation of a volcanic cone.

The central doleritic nucleus rises up directly from below; its hard crests, still rugged and angular, are exhibited at the rock of St. Mark, that of La Scala, and near the old Norman tower, and on the S.W., W., and N.W. sides of the rock, which are entirely exposed and perpendicular, and are denuded of all the fragmentary materials which formed the corresponding flanks of the cone. This consists of a compact dolerite of a dark-ashy colour, tending to black, with conchoidal fracture and porphyritic structure, in which olivine occurs, varying in quantity in different portions of the same rock; nor is it difficult to find augite and labradorite. Some blocks of this rock, broken away from the sides of the cliff, have fallen down on splitting at the surface, which shows itself with an earthy fracture; whilst christianite in small crystals abounds in the vesicular hollows, as well as in the incomplete fractures, together with incrustations of blue phosphate of iron, which I have not found in the rock *in situ* and not decomposed. The character of this dolerite is that of large ovoidal masses laterally depressed, the larger diameter varying from 2 to 4 mètres; they chiefly occur on the S.W. side of the cliff, near the Rock of St. Peter; and here, as well as under the Norman Tower, it assumes a prismatic form, which in the former locality is in large irregular prisms from 1 to 3 mètres, whilst in the latter they are smaller and more regular. On the N.W. side of the cliff the dolerite is impregnated with petroleum.

In a kind of articulated junction between the crests of the nodular dolerite, there is found on the Rock of St. Peter a projecting mass of clay with pebbles of sandstone (grès), and another smaller one on the south side of the Rock, in the same matrix; and these sedimentary rocks, anterior in age to the volcanic, have been metamorphosed and transported, during the very act of the intrusion of the dolerite, at the commencement of this volcanic action.

The lava in this volcanic cone is easily distinguished. It comes out from the upper part of the cone, from the very spot where now stand the Church and Garden of the Capuchines, which is the most elevated portion of the Rock, and in which are found large quantities of scoriæ and volcanic bombs. The lava, when issuing from the crater, flowed in two directions, the one due east, and the other S.W. This latter stream near its mouth of eruption is seen to bifurcate into two branches, one of which forms the Rock of Calacala, and the other flows due south. The eastern stream extends as far as the Chiesa della Consolazione, in the neighbourhood of which it has been cut through by the road also called that of the Consolation. During the whole of this course, which is about 60 mètres, it appears scoriated on the upper surface, to a varying depth of from 3 décimètres to a mètre, while the rest of the mass is compact and of great thickness, and does not occur as one homogeneous mass, like the ordinary lavas of Etna, but in gigantic ovoidal masses, articulating one with another. It rests on the outer flank of the cone, formed principally of volcanic scoriæ which have been altered by the effect of the fumarole of the volcanic current, which, however, it is impossible to describe satisfactorily, or to trace to its termination, in consequence of the ground being in an advanced state of cultivation, and modified by the construction of the more outlying dwelling-houses of Paternó, which extend on that side of the hill to the extreme point.

The other stream extending to the S.W. is different. The branch which forms the Rock of Calacala—so called in Sicilian dialect on account of the great steepness of the lava—extends in length about 55 mètres; it presents a front of about 25 mètres, is very compact in the centre, and slightly scoriform on the lower surface, very much so on the upper; it has an average thickness of about 3 mètres, has an inclination of 36°, and rests on the volcanic conglomerate, containing rounded pebbles of sandstone and clay which have been altered by the action of the fumaroles of the lava itself. This conglomerate forms part of the outer flank of the cone. The other branch, which flows to the south, has not preserved its characteristic features so completely; but neither of these two branches of the volcanic stream reaches the base of the cone, nor can their continuation be traced in the plain below; which proves that the lava did not extend beyond the side of the cone; and the base, which was formed of loose fragmentary materials, having been carried away by the action of water, it has partly fallen down, the upper portion of it still remaining *in situ*.

This volcanic cone, even though it may have been denuded by the action of water, nevertheless still affords a large quantity of fragmentary materials. At the Garden of the Capuchines, in which the crater formerly existed, the scoriæ are of a black colour, with a slight reddish tinge, very cellular and fragile; there also occur metamorphosed preexisting sedimentary rocks. Scoriæ are found in great abundance along the Strada della Consolazione, under one of the ridges of the Rock of St. Peter (and near the Church of St. Mark), which originally belonged to the inner side of the cone, being found in immediate proximity to the doleritic excrescence, and in a state of compact volcanic agglomeration, owing to the pressure of the overlying materials which formed the outer flank; whilst the materials which are seen metamorphosed by an arm of the lava-stream near the Rock of Calacala, those of the Strada della Consolazione to the south of the rock, and those which are seen on the old road leading to the Salinelle, to the north of this same mass of rocks, are a portion of the fragmentary materials which formed the outer flank of the volcanic cone of Paternó, which are still liable to removal, and in great measure have been carried away by the action of rain-water and the River Simeto, which is constantly extending, with the materials which it carries along with it, the plain of Catania.

The rocky elements which constitute the fragmentary portion of this cone are as follows: viz., doleritic scoriæ, more or less altered;

clay in every state of metamorphism, passing even into thermantite; and pebbles of sandstone (grès), some of which have been roasted and fall to pieces with the slightest touch, while others, on the contrary, have passed into the state of quartzite.

The country around Paternó, is, from north to east, entirely covered with the pyroxenic lavas from Etna; whilst the alluvial soil which forms the plain of Catania is exposed to the south and shows a horizontal stratification, as the freshwater calcareous tuff, which overlies it, rests on the west side of the rock. This recent calcareous tuff contains many fossil plants and land-shells, amongst which can be made out *Bulimus decollatus*, Brug., *Helix vermiculata*, L., *Helix aspersa*, Müll., &c.,—species which are still living and abundant in the neighbourhood.

Volcanic Cone of Motta (*Sta. Anastasia*).—The village of Motta (Sta. Anastasia) is also built on the remains of a volcanic cone. It is elevated about 813 Paris feet (Hoffmann) above the level of the sea, distant about thirteen miles from the present axis of Etna, and offers on a smaller scale the same phenomena as we have observed at Paternó.

The sides of the Rock of Motta (Sta. Anastasia), from west to north, are in connection with the pre-existing sedimentary formations; but the village being almost entirely built on it, it is impossible to describe it satisfactorily. The doleritic nucleus is almost perpendicular on the south side, the lower portion of which consists of large and irregular prisms, which from below upwards, for about 25 mètres, converge to the centre, whilst in the upper portion the dolerite loses this character and becomes amorphous. To the S.E. it is connected with great masses of conglomerate, of volcanic scoriæ, clay, and pebbles of sandstone (grès), altered like those of Paternó. On the east side, this nucleus is cut through by a road, which has exposed between the articulated joints of one of its outer ridges a great mass of clay, with sand and pebbles of grit, altered and contorted by the pressure of the doleritic nucleus, and which at the time of its intrusion were also carried up. On the S.W. side the same amorphous nucleus is also seen, and in connection with great masses of volcanic conglomerate which overlie it from the base up to the rugged crests.

In this eruption the lava-stream also issued from the upper part of the cone. It issued from the side to the west of the Norman Tower, and flowed towards the S.W., and can be traced as far as the Church *della Immacolata*. This lava, however, is less clearly made out than that of Paternó, being cut through and broken away in many places for the construction of the houses and roads of the upper part of the village; it is nevertheless easily made out at the commencement, and its course can be traced, being very cellular on its upper surface, compact in the centre, and about 3 mètres thick in some places.

The fragmentary materials consist of scoriæ, clay, sand, and pebbles of sandstone (grès), altered by the igneous action of the volcanic rock, and which, being here and there in contact with the doleritic nucleus, constitute the foundations of the internal sides of the cone. The volcanic scoriæ near the *Chiesa Madre* and the Norman Tower, which are close to the source of the lava-stream, are further proofs to enable us to fix accurately the site of the crater, while the moveable materials which form its outer sides have been carried away by the action of waters.

There can be no doubt that this doleritic rock offers a smaller number of phenomena than that of Paternó, in consequence of its smaller diameter and the ground being more changed; but it is more interesting on account of the clear connection which the volcanic products show with the pre-existing sedimentary formation which has not been invaded by lavas from Etna. The pleistocene clay and the post-pliocene conglomerate are closely connected together on the west and north-west sides, where no kind of alternation can be seen between these two rocks—either the volcanic or the sedimentary—as occurs in many other cases of extinct volcanos in the Val di Noto and in the Vallone della Pulicera, in which the stratification of the sedimentary deposit can be distinctly seen for a great distance; the clay and the conglomerate are perfectly horizontal.

Conclusion.—From these observations we may conclude,—1st. That at Paternó and Motta (Sta. Anastasia) are the remains of two doleritic volcanic cones, because we there find the essential elements of volcanos, viz., a central nucleus, lava, and fragmentary materials. 2nd. That these volcanic phenomena were contemporaneous, and occurred during the post-pliocene period, previous to the deposit of the freshwater calcareous tuff of the neighbourhood of Paternó, because in the fragmentary materials of the two cones we find clay and pebbles of sandstone (grès)—pre-existing rocks, and no calcareous tuff. 3rd. These are cones of eruption and not of elevation, as some persons have lately endeavoured to prove, because the pre-existing sedimentary deposits of the neighbourhood do not show any modification in the direction of their strata. 4th. These eruptive cones are independent of Etna, because the doleritic nuclei have been brought up at once from below, and the lavas have issued from their terminal portions; whereas in all the parasitical cones of Etna the streams follow the direction of the longitudinal fractures, which extend from the volcanic axis to the periphery; and the lavas do not issue from the upper portion of the parasitical cones, but from their bases, or at some greater distance. The bursting forth of lava from the throat or crater is a peculiarity of central eruptions, but not of those which are lateral or parasitic.

3. *On some* Carboniferous Brachiopoda *collected in* India *by* A. Fleming, M.D., *and* W. Purdon, Esq., F.G.S. By T. Davidson, Esq., F.R.S., F.G.S.

[Plates I. & II.]

I. *Brachiopoda of the Carboniferous Period, collected in the Punjab by A. Fleming, M.D., during the years* 1848 *and* 1852.

During his geological survey of the Salt-range in the Punjab, Dr. A. Fleming had opportunities of collecting a considerable number of fossils, which he sent to England in 1849 and 1852, and of which a portion were at the time cursorily examined by M. De Verneuil, myself, and one or two other palæontologists. Some few of these fossils have been already recorded in a paper by Dr. Fleming, published in the 9th volume of the Quarterly Journal of the Geological Society (1853), also in the Journal of the Asiatic Society of Bengal for 1853, as well as in the same author's excellent 'Report of the Geological Structure and Mineral Wealth of the Salt-range in the Punjab,' printed at Lahore in 1854; and at the author's request I have recently re-examined all the species of *Brachiopoda* of the Carboniferous age which he had collected, with the view of completing in this respect the imperfect list published in 1853 *.

It will not be necessary to dwell upon the geological features of the Carboniferous rocks of the district, as I could only repeat those details that have been made known in the report and papers above referred to. It will suffice for my present purpose to mention that the fossils occur in several beds differing mineralogically, some being crystalline and very hard, and others argillaceous: a few of the fossils occur in a magnesian limestone; but the same bed may be magnesian in one locality, and at a few miles distance be purely calcareous. Thus Dr. Fleming separates the Carboniferous rocks of the Salt-range into three divisions:—

c. Upper Limestone. *Brachiopoda* and other fossils occur throughout the formation.

b. Grey sandstone and shales, in which but few fossils have been found.

a. Lower Limestone, with calcareous sandstone. This limestone generally abounds in large *Brachiopoda* and other fossils.

It is also necessary to mention that the richest localities for Carboniferous fossils were Moosakhail, in the Salt-range proper, and Kafir Kote on the east bank of the Indus at about twenty-five miles below Kalabag, where the western prolongation of the Salt-range stretches down to the very bank of the Indus; and Dr. Fleming informs me, moreover, that from these two localities the larger number of his fossils were procured, though of course they may also be found at intervening localities, such as Chederoo, Vurcha, Nulle, &c. Dr. Fleming assures me, likewise, that he is quite convinced that all the species about to be enumerated were derived from rocks of the Car-

* The following are the species identified by M. De Verneuil and myself in 1853:—*Athyris Royssii*, a *Spirifera* nearly related to *S. lineata*, *Streptorhynchus Crenistria*, *Productus Cora*, *P. Flemingii*, *P. costatus*, and *P. Humboldtii*.

boniferous period; and this I hasten to announce, because two of the species of *Terebratula* have puzzled me much, and raised some doubts in my mind as to their age; for they remind me more of what we should expect to find in the Jurassic or even Cretaceous, than in Carboniferous strata.

Carboniferous Brachiopoda collected by Dr. Fleming in the Punjab.

Terebratula (*vel* Waldheimia) Flemingii, *Dav.*
—— biplicata, *Brocchi* (?). *Var.* problematica, *Dav.*
—— Himalayensis, *Dav.*
—— subvesicularis, *Dav.*
Athyris Royssii, *L'Eveillé, sp.*
—— subtilita, *Hall, sp.* *Var.* grandis, *Dav.*
Retzia radialis, *Phillips, sp.* *Var.* Grandicosta, *Dav.*
Spirifera striata, *Martin, sp.*
—— Moosakhailensis, *Dav.*
—— lineata, *Martin, sp.* *Var.*
Spiriferina octoplicata, *Sow., sp.*
Rhynchonella Pleurodon, *Phillips, sp.*
Camarophoria Purdoni, *Dav.*
Streptorhynchus Crenistria, *Phillips, sp.*
—— ——. *Var.* robustus, *Hall.*
—— pectiniformis, *Dav.*
Orthis resupinata, *Martin, sp.*
Productus striatus, *Fischer, sp.*
—— longispinus, *Sow.*
—— Cora, *D'Orbigny.*
—— semireticulatus, *Sow.*
—— costatus, *Sow.*
—— Purdoni, *Dav.*
—— Humboldtii, *D'Orbigny.*
Strophalosia Morrisiana, *King*(?). *Var.*

1. Terebratula (vel Waldheimia) Flemingii, Dav. Pl. I. figs. 1, 2.

Shell variable in shape—ovate, longitudinally oval, or slightly pentagonal; valves almost equally deep and convex, but usually much depressed; surface evenly smooth, without sinus or fold. Beak and foramen small and slightly separated from the hinge-line by a deltidium in two pieces; lateral ridges of the beak continued along the sides. Margin of the valves straight. Interior unknown.

Of this species I have examined a number of specimens, which were all derived from a bed which first appears in the Nilawan ravine, and which Dr. Fleming considered to mark the commencement of the Carboniferous formation, which gradually increases in thickness as we proceed westwards towards the Indus. The shell could not, however, be identified with any *Terebratula* of the Carboniferous age from any other part of the world, with which I am at present acquainted, while its affinities would on the contrary recall to our mind certain forms of the Jurassic period and more particularly those of the *T. numismalis* group. The largest example measured 13 lines in length, 11 in width, and 8 in depth, and was proportionally much more convex than the other specimens.

2. Terebratula biplicata, Brocchi (?), var. problematica, Dav. Pl. I. fig. 3.

Shell oblong, obscurely pentagonal; dorsal valve convex, rather deeper than the opposite one, and prominently biplicated; ventral valve flattened along the middle to a certain distance from the beak, where a median rounded rib with a sulcus on either side is produced and extends to the front. Beak small, and truncated by a foramen of moderate size. Margins of the valves sinuous. Interior unknown. Length 20, width 8 lines.

Of this species I am acquainted with but a single example, stated by Dr. Fleming to have been found by himself in the Carboniferous

Limestone of Moosakhail; and although the shell is silicified, like many of the other fossils from the Carboniferous Limestone in the Punjab, I cannot help repeating what I said with reference to the preceding species, viz. that it has much more the appearance of a Jurassic or Cretaceous form, *e. g.* of *T. biplicata*, Brocchi, than of any shell of the Carboniferous period with which I am acquainted.

I would therefore call the attention of geologists and palæontologists who may visit the district, to the two last-described shells, so as to ascertain whether they do really belong to the Carboniferous age as stated by Dr. Fleming, or whether they might not have been derived from some less ancient formation.

3. Terebratula Himalayensis, Dav. Pl. II. fig. 1.

Shell ovate or ovato-pentagonal, longer than wide; valves almost equally and moderately convex, without sinus or fold; beak rather small, gently incurved, and truncated by a circular foramen, which slightly overlies the umbone of the opposite valve and thus conceals the deltidium to a greater or lesser extent. The surface of both valves is smooth up to within two or three lines of the margin, where a small number of rounded ribs are developed, of which four or five occupy the front, while two or three ornament each of the lateral portions of the valves; so that eleven of these short rounded ribs may be counted round the margin of each of the valves. The largest specimen I have seen measured in length 11, width 9, depth 6 lines.

This appears to be a common and characteristic species of the Carboniferous Limestone of the Punjab. All the specimens from Moosakhail are silicified.

4. Terebratula subvesicularis, Dav. Pl. I. fig. 4.

Shell small, ovato-pentagonal, longer than wide; valves unequally convex, the ventral one being the deepest; beak incurved, and truncated by a small oval-shaped foramen, which overlies the umbone of the opposite valve. Surface smooth to about half the length of the valves from the beak, while seven small ribs are developed near the margin: in the dorsal valve one or two of these occupy a slight mesial depression; so that the frontal margin of the valve is usually triundate, from one or two of the central ribs being on a lower level than the lateral ones: in the ventral valve the ribs are somewhat similarly arranged. Dimensions generally small; an average-sized specimen measured 7 lines in length by $6\frac{1}{2}$ in breadth.

This form does not appear rare in a darkish limestone in the neighbourhood of Moosakhail, and differs from *T. vesicularis* and *T. Himalayensis* by the arrangement of its marginal ribs.

5. Athyris Royssii, L'Eveillé, sp. Pl. I. fig. 6.

This characteristic and well-known species is very abundant at Moosakhail, and in several other localities in the Salt-range. It is identical in shape with our European specimens, and has been also ound in the black shales in the Chor Holi Pass by Capt. Strachey.

6. Athyris subtilita (Hall, sp.), var. grandis, Dav. Pl. I. figs. 7, 8.

Terebratula subtilita, Hall (?) in Howard Stansbury's Exploration of the Valley of the Great Salt Lake of Utah, p. 409, pl. 2. figs. 1, 2; 1852.

This appears to be a common species in the Punjab, having been found in several localities, but more abundantly at Moosakhail. It varies also considerably in shape and size; so that (as justly observed by Dr. Shumard while describing this shell from the Carboniferous strata of the Red River of Louisiana) we are very liable to multiply species from its varieties, unless a large number of specimens are under examination. Some of our Indian examples are exactly similar to those from Iowa, or from Pecos Village in New Mexico, whence the type of the species was obtained; while others are larger and more inflated or globose than any I have hitherto seen from either Europe or America, although these last would agree very well with certain specimens described by Dr. Shumard from Washington county, Arkansas. The largest Punjab specimen which has come under my observation measured in length 21, width 18, depth 17 lines.

7. Retzia radialis (Phillips, sp.), var. Grandicosta, Dav. Pl. I. fig. 5.

Shell longitudinally oval or ovate, with almost equally deep or convex valves; the beak is produced, and truncated by a small circular foramen, which is slightly separated from the hinge-line by a small hinge-area; each valve is ornamented with about thirteen or more angular ribs, of which the central one is somewhat the largest, and corresponds to a groove of greater depth in the ventral valve.

Our British specimens of *R. radialis* are extremely variable in size and plication. In the typical form the ribs are smaller and more numerous than in the Punjab variety; while identical specimens of this last have been found in England, as well as in the Carboniferous rocks of Bolivia. Dr. Fleming states that he has found this shell rather abundantly near Moosakhail.

8. Spirifera striata, Martin, sp. Pl. I. figs. 9, 10.

Of this shell Dr. Fleming was able to procure but three or four fragmentary specimens, which could not be distinguished from similar British examples of Martin's species. It occurs at Nulle, Chederoo, and several other localities.

9. Spirifera Moosakhailensis, Dav. Pl. II. fig. 2.

Shell transversally subrhomboidal; valves almost equally deep or convex; hinge-line variable in length, sometimes not half as long as the breadth of the shell, while at times it is as long. Ventral area of moderate width; fissure wide and partially arched over by a pseudo-deltidium. Dorsal valve sublinear; beak small and moderately incurved. In the dorsal valve there exists a wide, elevated angular fold, and in the ventral one a corresponding sinus. The whole surface of the shell is covered with numerous small ribs, which cluster into fasciculi, seven or eight being collected into groups, which give to the valves the appearance of a double plication, many of the smaller ribs being due to interpolation; while the whole surface and ribs are closely intersected by numerous sharp, projecting, concentric, undulating laminæ, of which four or more may be counted in the breadth of a line. Dimensions very variable: a large example measured 26 lines in length by 39 in width and 18 or 19 in depth.

It was not until after much hesitation that I have ventured to propose a new name for the *Spirifera* under description. In external shape as well as by the grouping of its ribs, it bears much resemblance to several known species of *Spirifera*, and especially to that figured in Owen's 'Geological Survey of Wisconsin and Minnesota' (pl. 5. fig. 4) under the name of *Spirifer fasciger*, Keyserling?; but I partake of that author's doubts while referring the shell in question to De Keyserling's Russian species. It approaches also by its shape to certain examples of D'Orbigny's *Sp. Condor*, *Sp. cameratus*, Hall, as well as to some exceptional British specimens of *Spirifera striata*; but in none of these do we perceive, nor does any author describe, the peculiar and beautifully regular, closely disposed, sharp, projecting, concentric, undulating laminæ, which resemble so closely those of *Sp. laminosa*, and which give to the shell its beautiful sculptured appearance. *Sp. Moosakhailensis* is common in the Punjab, at Moosakhail, Chederoo, Kafir Kote, &c.

10. Spirifera lineata, Martin, sp., var. Pl. II. fig. 3.

Martin's shell varies considerably in shape, but has nowhere, to my knowledge, attained the large proportions of certain Punjab specimens; and indeed I was for some time uncertain whether these last did really belong to our well-known European species; but, after the attentive examination of some smaller Indian examples, I found these last to be undistinguishable from many specimens of Martin's type. The peculiar arrangement of spinules, so well displayed in some Scottish examples of *Sp. lineata*, could also be observed here and there upon the Punjab silicified specimens. The largest Indian example I have seen measured 3 inches 2 lines in length, by $3\frac{1}{2}$ in width and 1 inch 7 lines in depth. Another, identical with one from Derbyshire, measured in length 22, and in width 23 lines. It occurs at Chederoo and Moosakhail. This is the shell which in 1853 M. De Verneuil and myself considered to be nearly related to *Sp. lineata*.

11. Spiriferina octoplicata, Sow., sp. Pl. I. figs. 12, 13.

The Moosakhail specimens exactly resemble our British Carboniferous examples; they show the same variations in shape and number of ribs.

12. Rhynchonella Pleurodon, Phillips, sp.

One or two examples, which appear to agree with our British type, have been found by Dr. Fleming at Moosakhail.

13. Camarophoria Purdoni, Dav. Pl. II. fig. 4.

Shell somewhat obscurely subrhomboidal or deltoid, wider than long. Valves almost equally convex, with a wide mesial fold of moderate elevation in the dorsal valve, and a corresponding sinus in the ventral one. The surface of each valve is ornamented with from eighteen to twenty-two angular ribs, of which from seven to eight occupy the fold, and from six to seven the sinus. The beak is small and much incurved; so that the foramen, which is situated under the angular extremity of the beak, is but slightly seen. No marginal expansions could be perceived.

This species does not appear to be rare in the Punjab; it occurs at Moosakhail, Vurcha, &c.

14. Streptorhynchus Crenistria, Phillips, sp.

Some very large examples, which entirely agree with our British specimens, have been found at Moosakhail, at Vurcha, and in other localities; one in particular measured nearly 4 inches in length by about 5 in width and $1\frac{1}{2}$ in depth. The specimens are usually very irregular in their shape, from contortion and malformation, but agree in all their characters with Phillips's type.

15. Streptorhynchus Crenistria (Phillips), var. robustus, Hall. Pl. I. fig. 16.

Orthis robusta, Hall, Report of the Geological Survey of the State of Iowa, p. 713, pl. 28. fig. 3; 1858.

Shell somewhat marginally pentagonal and plano-convex; hinge-line nearly as long as the width of the shell. Dorsal valve semi-circular and gibbous: ventral valve pentagonal and nearly flat; area triangular and wide, with a narrow pseudo-deltidium. Surface marked by small radiating striæ with interspaces of almost equal width, while at variable distances from the beak finer interpolated striæ occur between the larger ones. The valves are also crossed by numerous concentric lines or striæ. A specimen from the Carboniferous Limestone of Vurcha measured 21 lines in length by 23 in breadth and 14 in depth.

The Punjab examples of this variety of *S. Crenistria* so closely resemble a specimen of *Orthis robusta*, Hall, from the Lower Coal-measures of St. Clair County, Illinois, in North America, that I am induced to consider them identical.

16. Streptorhynchus pectiniformis, Dav. Pl. I. fig. 17.

Shell scallop-shaped; valves equally convex; hinge-line sometimes less, rarely longer, than half the width of the shell, with projecting angular extremities. Ventral area triangular, usually higher than wide, and longitudinally divided by a narrow convex pseudo-deltidium. The beak is pointed and tapering at its extremity, which is generally bent or twisted more to one than the other side. Dorsal valve pecten-shaped, very convex at the umbone, with small eared expansions, this valve being also slightly depressed along the middle.

The valves are ornamented with from twelve to fourteen angular ribs; while the entire surface (area excepted) is covered with a great number of minute crenulated striæ, which increase in number by the interpolation of smaller striæ, especially close to the margin. The largest example I have seen measured 20 lines in length, by about the same in width and 14 in depth.

This beautiful shell is not rare in the Carboniferous Limestone of Moosakhail, Chederoo, Nulle, and Kafir Kote; and appears to me to be quite distinct from any of its congeners.

17. Orthis resupinata, Martin, sp. Pl. I. fig. 15.

Of this well-known species one or two examples have been collected by Dr. Fleming in the Punjab.

18. Productus striatus, Fischer, sp. Pl. I. fig. 18.

This European Carboniferous shell does not appear rare in a light-yellow limestone at Khond in the Punjab.

19. Productus longispinus, Sow. (=P. Flemingii ejusd.). Pl. I. fig. 19.

Two specimens exactly agreeing with Sowerby's type have been found by Dr. Fleming, at Moosakhail in the Punjab, and at Srinuggur in Kashmir; the specimen figured in my plate is the one identified by M. De Verneuil and myself in 1853.

20. Productus Cora, D'Orbigny.

Specimens identical with those of America and Europe have been found at Kafir Kote, Moosakhail, &c.

21. Productus semireticulatus, Sow.

Of this species two or three specimens have been found in the Punjab by Dr. Fleming.

22. Productus costatus, Sow. Pl. I. figs. 20, 21.

This appears to be one of the most common species in the Carboniferous Limestones of the Punjab. It occurs at Moosakhail, Kafir Kote, &c., where it has sometimes attained large proportions, as may be seen from the specimen figured in my plate. The Indian examples are exactly similar to those we find in Europe.

23. Productus Purdoni, Dav. Pl. II. fig. 5.

Shell longitudinally oval, broadest at two-thirds the length from the beak; ventral valve moderately convex, flattened along the middle and longitudinally divided into two lobes by a deep sinus, which commences at the extremity of the beak and extends to the front. Beak and ears small; hinge-line very short, and generally not exceeding half the breadth of the shell. The dorsal valve is very much flattened until within a short distance from the margin, where it becomes concave, and is divided by a mesial elevation, which commences close to the hinge-line and extends to the front. Exteriorly the surface of the ventral valve is entirely covered with minute, narrow, elongated tubercles, from which rise numerous small tubular spines, both the tubercles and spines becoming smaller and shorter as they approach the margin. The dorsal valve is covered with small pits and tubercles, from which also rise slender spines, but apparently less abundantly than on the ventral one. A large specimen measures 2 inches 5 lines in length, by 2 inches 2 lines in breadth and 1 inch in depth.

Of this interesting species I have seen several specimens from Chederoo and Moosakhail.

24. Productus Humboldtii, D'Orbigny. Pl. II. fig. 6.

Productus Humboldtii, D'Orb., Paléont. du Voyage dans l'Amérique Méridionale, pl. 5. figs. 4, 7; 1842.

Shell marginally transverse, rotundate, quadrate; ventral valve moderately convex, with a wide shallow longitudinal sinus commencing at a short distance from the extremity of the beak and extending to the front. Beak small and incurved; hinge-line rather shorter than the greatest width of the shell. Dorsal valve almost flat for some distance, becoming slightly concave close to the margin, and with a small mesial fold or elevation perceptible only close to the front. The surface of the ventral valve is covered with numerous small elongated tubercles arranged somewhat in quincunx, and from which rise short tubular spines.

The largest of Dr. Fleming's specimens measured 13½ lines in length by 16 in width and 6½ in depth. Dr. Fleming found his specimens at Kafir Kote on the west bank of the Indus. D'Orbigny's examples were obtained from Yarbichambi, on the Bolivian table-land of the Andes. I must, however, observe that several of the Indian examples bear so close a resemblance to some of our British specimens of *P. scabriculus*, that they could be with difficulty distinguished.

25. Strophalosia Morrisiana, King (?), var. Pl. II. fig. 8.

Among the fossils stated to have been procured at Moosakhail, I found two specimens of a shell which so closely resembled certain examples of the Permian *Strophalosia Morrisiana*, that neither Messrs. Kirkby, Howse, nor myself were able to distinguish it. In shape it is nearly circular, with the same convexity of the ventral, and concavity of the dorsal valve, the same relative proportions of the dorsal and ventral areas, and, lastly, the presence of the same elongated adpressed spines which adorn the surface of the ventral valve in the Permian specimens; while the only difference consists in the apparent absence of those minute radiating raised striæ observable in the perfect shell of King's species: but it must also be remembered that this point of difference is only a negative one, and of slight value; for some specimens of the species from Tunstall Hill do not show the character. The material at my command is not, however, sufficient to enable me to positively affirm the identity; so that the safest plan will be for the present to consider the Punjab shell as a variety of *S. Morrisiana* *.

II. *Brachiopoda of the Carboniferous Period, collected in India by W. Purdon, Esq., F.G.S.*

At Mr. Purdon's request I have examined the *Brachiopoda* collected by himself during his survey of the Punjab and N.E. Himalayan districts of India.

Mr. Purdon's collection contained many interesting and fine examples of the following species †:—

1. *Terebratula Himalayensis*, Dav.; 2. *Athyris Royssii*, L'Eveillé; 3. *Athyris subtilita*, Hall (?), var.; 4. *Spirifera Moosakhailensis*, Dav.; 5. *Sp. lineata*, Martin, var.; 6. *Rhynchonella Pleurodon*, Phillips, var.; 7. *Camarophoria Purdoni*, Dav.; 8. *Streptorhynchus Crenistria*, Phillips; 9. *Strept. pectiniformis*, Dav.; 10. *Productus striatus*, Fischer; 11. *P. Cora*, D'Orb.; 12. *P. Purdoni*, Dav.; 13. *P. costatus*, Sow.; 14. *P. Humboldtii*, D'Orb.; 15. *P. semireticulatus*, Sow.; 16. *Strophalosia Morrisiana*, King (?), var.; 17. *Aulosteges Dalhousii*, Dav.; 18. *Crania* (sp. undeterminable).

Having already described the sixteen first-named species in my preceding communication, all that remains for me to do, in order to complete the notice of what has been up to the present time discovered, is to describe the *Aulosteges Dalhousii* from the very interesting specimen found by Mr. Purdon in the Carboniferous (?) rocks of the Punjab.

AULOSTEGES DALHOUSII, Dav. Pl. II. fig. 7.

Subtrigonal marginally, wider than long; anterior angles rounded; moderately indented in front; hinge-line slightly exceeding half the width of the shell. Ventral valve convex, divided by a wide and deep mesial sulcus or sinus; beak nearly straight, but inclining more to the one than the other side; area flat, irregularly triangular, forming an obtuse angle with the plane of the dorsal valve, and divided along the middle by a narrow convex pseudo-deltidium, the entire surface (area excepted) being closely covered with slender

* In 1857 Messrs. Howse, Kirkby, and myself entertained the opinion that the British Permian *S. Morrisiana* should be considered identical with the *S. lamellosa* of Geinitz, or as nothing more than a variety of it; but although we are not yet prepared to abandon that view, it must be mentioned that Dr. Geinitz has expressed a contrary opinion in his recently published work, 'Dyas oder Zechst.,' etc., wherein he asserts that *S. lamellosa* and *S. Morrisiana* are entirely distinct species. It must not, however, be forgotten that *S. lamellosa* appears to have been a very variable species, and to have suffered great modifications of general form, mode of growth, and of spine-arrangement, such as changes in physical condition would necessarily induce, and which should never be overlooked in taking philosophical views of species.

† It was not my intention to have alluded to the species collected in the Punjab by Mr. Purdon until the publication of that gentleman's memoir upon the geology of the district; but, as I had also promised Dr. Fleming to describe those he had found in the same localities, I thought it desirable to delay no longer the mention of those collected by Mr. Purdon, and to give him full credit for his discoveries.

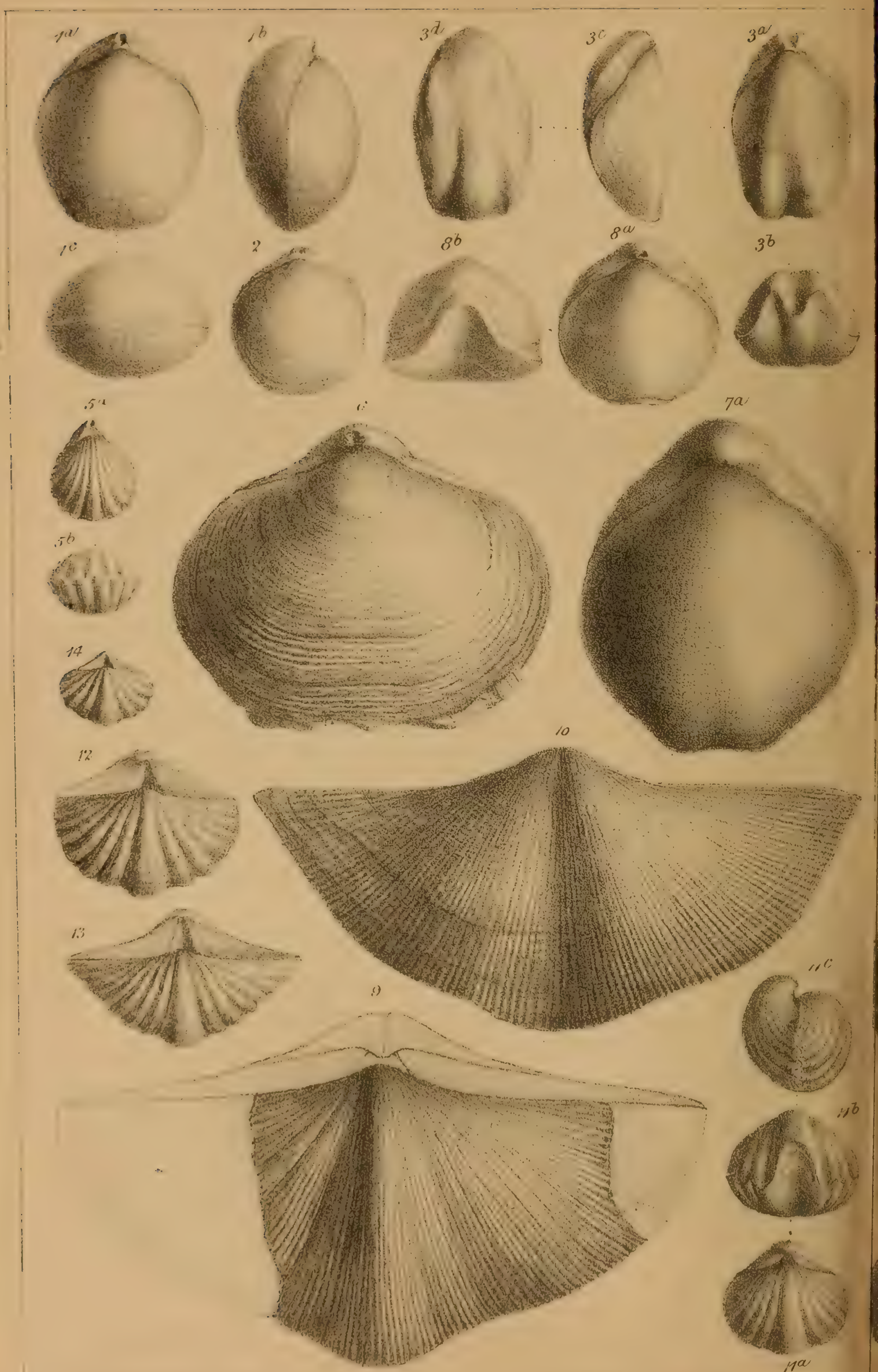
tubular spines, which appear to have exceeded in certain places 4 or 5 lines in length. The spines lie rather close to the surface of the valves, with their extremities directed towards the margins of the shell. The dorsal valve is convexo-concave, that is to say, gently convex until within a short distance of the margin, where the valve becomes concave or bent. The dorsal area is narrow and linear; and the entire surface of the valve appears to have been covered with slender spines. In the interior of the dorsal valve the cardinal process is trilobed; and on either side may be seen some slight indications of dental sockets: a small longitudinal ridge, which first appears under the cardinal process, extends to rather more than half the length of the valve; and on either side are situated two elongated-oval-shaped dendritic muscular scars, which are no doubt referable to the adductor or occlusor muscle. From the inner extremities of these depart the so-called reniform impressions, which extend by an outward oblique curve to near the margin, and, turning abruptly backwards and inwards, terminate at some short distance from their first point of departure. The interior of the ventral valve could not be observed.

An attentive examination of this interesting species has led me to consider that its affinities lie more with Helmersen's subgenus *Aulosteges* than with King's *Strophalosia*. Specifically speaking, it bears some resemblance to *A. Wangenheimi* (=*A. variabilis*, Helmersen); but it may, I think, be distinguished by its shape, larger dimensions, and internal details.

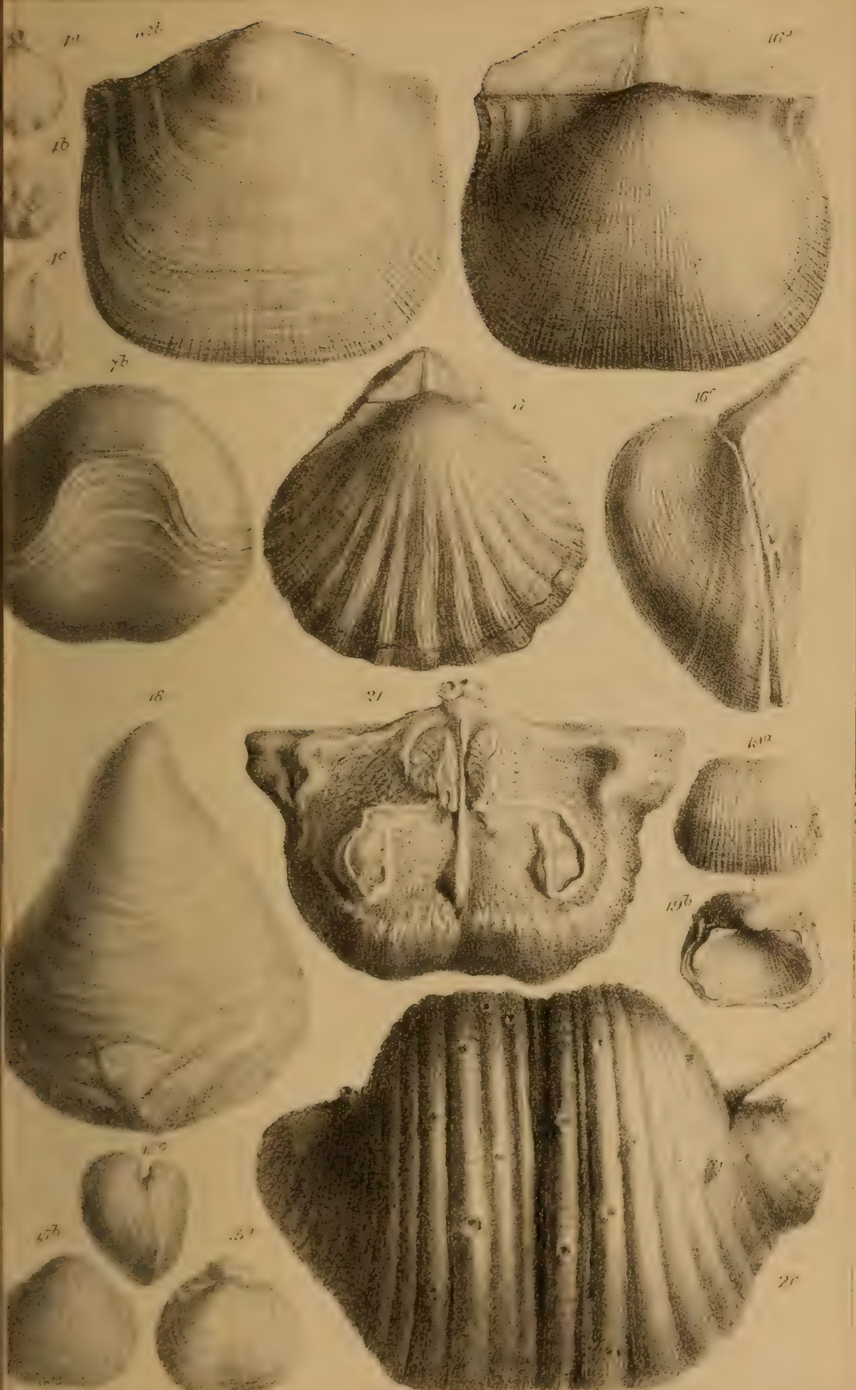
The species composing the subgenera *Aulosteges* and *Strophalosia*, though represented in the Carboniferous period, appear in Europe to be more specially characteristic of the Permian epoch; and it may therefore remain a question whether in the Punjab there does not exist, above all well-authenticated Carboniferous strata, some small bed representing the Permian age, and from which *A. Dalhousii* and the variety of *Stroph. Morrisiana* we have described might have dropped and become mixed with shells of the Carboniferous period. We may also here remind the reader that another species of *Strophalosia* (*S. Gerardi*, King) was some years ago discovered by Dr. Gerard in the Himalayan range at 17,000 feet above the sea.

Of *Aulosteges Dalhousii* a single example has been hitherto procured from the Carboniferous Limestone (?) of Moosakhail.

In conclusion, we may observe that the total number of Carboniferous *Brachiopoda* hitherto discovered by Dr. Fleming and Mr. Purdon in the Salt-range of the Punjab amounts to about twenty-eight species, of which thirteen at least are common to European rocks of the same period, although several of these have in India attained larger proportions. It is also very probable that further research among the Carboniferous deposits of the Punjab would bring to light several more species in addition to those here enumerated.



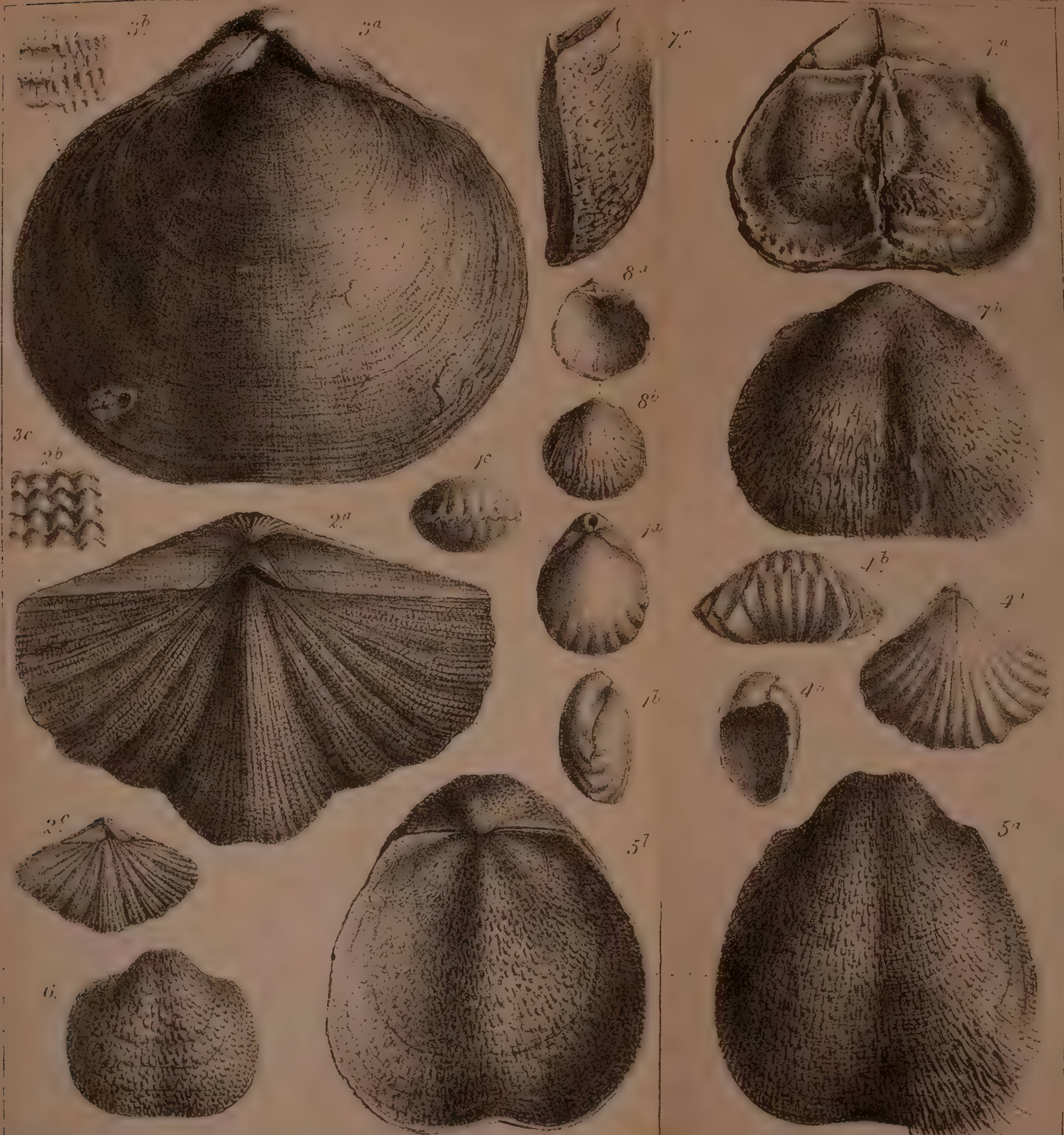
FOSSIL BRACHIO



...A FROM INDIA.

FOSSIL BRACHIOPODA FROM INDIA.

Thos. Davidson del. &



Thos Davidson del. & lith.

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FOSSIL BRACHIOPODA FROM INDIA.

EXPLANATION OF PLATES I. & II.

Plate I.

Specimens in Dr. Fleming's collection, and in the Geological Society's Museum.

Fig. 1, 2. *Terebratula* (vel *Waldheimia*) *Flemingii*, Dav.
3. *T. biplicata*, Brocchi (?), var. *problematica*, Dav.
4. *T. subvesicularis*, Dav.
5. *Retzia radialis*, Phil., var. *Grandicosta*, Dav.
6. *Athyris Royssii*, L'Eveillé.
7, 8. *A. subtilita*, Hall, var. *grandis*, Dav.
9, 10. *Spirifera striata*, Martin.
11–14. *Spiriferina octoplicata*, Sow.
15. *Orthis resupinata*, Martin.
16. *Streptorhynchus Crenistria*, Phil., var. *robustus*, Hall.
17. *S. pectiniformis*, Dav.
18. *Productus striatus*, Fischer.
19. *P. longispinus*, Sow.
20, 21. *P. costatus*, Sow.

Plate II.

Specimens collected by W. Purdon, Esq., and now forming part of Mr. Davidson's collection.

Fig. 1. *Terebratula Himalayensis*, Dav.
2. *Spirifera Moosakhailensis*, Dav.: 2*c*, a young example.
3. *S. lineata*, Martin, var. :3*c*, *Crania* (?).
4. *Camarophoria Purdoni*, Dav.
5. *Productus Purdoni*, Dav.
6. *P. Humboldtii*, D'Orb.
7. *Aulosteges Dalhousii*, Dav.
8. *Strophalosia Morrisiana*, King (?), var.

Supplemental Note on the Plant-bearing Sandstones *of* Central India *. By the Rev. Stephen Hislop.

(In a Letter to the Assistant-Secretary, dated Nagpur, July 19, 1861).

[Read at the Evening-meeting, January 8, 1862; and, by Permission of the Council, printed in the February Number of the Journal.]

"Recently I have obtained more Insect-remains † from Kotá, with a morsel of *Sphenopteris* in the limestone; also an *Ichthyolite*, probably *Æchmodus Egertoni*.

"I think there are strong reasons for believing that the ichthyolitic beds of Kotá are superior to our plant-sandstone and coal ‡; and hence, if the former be Lower Jurassic, the latter must be older.

"In the sandstone at Sironcha, six miles further down the River Pranhita, there is an abundance of compressed stems identical with those at Silewa*da*; so that there can be no doubt that the argillaceous sandstone there is of the 'Damúda group.' This sandstone of Sironcha is stated by Mr. Wall to underlie almost immediately the Kotá limestone."

After remarking that the genus *Tæniopteris* occurs both in the Rajmahal Beds of Bengal and in the "Damúda Beds" of Nagpur, Mr. Hislop proceeds to state that the largest *Tæniopteris* from Kampti (near Nagpur) is exceedingly like *T. lata* and *T. multinervis* of the Rajmahal Beds. The *Tæniopterides*, thus closely approaching in form, prove, in his opinion, that the Damúda and the Rajmahal Beds cannot be widely separated.

* See Quart. Journ. Geol. Soc. vol. xvii. p. 346 *et seq.*

† The associated *Estheria* (*loc. cit.* p. 356) has been carefully examined, and appears to be different from that found at Mangali: both are new species; the latter, however, is very similar to an *Estheria* found living in Palestine.—T. R. J.

‡ An opinion coincident with Dr. Oldham's: see Mem. Geol. Surv. India, iii. p. 202.—T. R. J.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the Lines *of* Deepest Water *around the* British Isles.
By the Rev. R. Everest, F.G.S.

(Read June 19, 1861*.)

[Abridged.]

From two papers by Mr. Godwin-Austen† we learn that the English Channel was, in all probability, a valley of depression. If, by the light thus afforded us, we examine the locality as laid down in a good chart, we shall see that as there is a valley of depression, so is there also an axis of depression, if the term may be used. We have in common use the term "axis of elevation" to signify the line of greatest elevation in a mountain-range; and in a similar way we would employ the phrase "axis of depression" to mean the line of deepest water in a narrow sea.

If we take a point (see Map) nearly south of Dungeness in Kent, or in north lat. about 50° 30′, and east long. rather less than 1°, and from this draw a straight line a little to the south of west, passing through the middle of the deep water, and meeting about north lat. 48° 20′, and west long. 8° 20′, and another line of a similar kind passing through the deepest water of the St. George's Channel between Ireland and England, we find, tracing the course of our line, that it first passes between the two pits, called "North Deep" and "South Deep," in the same longitudinal or axial direction as both of them; it cuts the "West Deep" in its deepest part, and nearly in the same longitudinal direction; it passes through the "Hurds Dyke" from end to end, and meets successively the projecting easternmost points of the lines of 40 to 50, 50 to 60, and 60 to 70 fathoms. Beyond this last, the lines of equal depth are but triflingly affected by the entrance to the Channel. See the Admiralty Charts.

We would now wish to draw attention to the above-mentioned longitudinal pits, remarkable as they are for their great length, and for lying, all of them, nearly in the same direction.

It has, I think, been suggested that a large river once passed

* For the other papers read at the Evening-meeting, see Quart. Journ. Geol. Soc. vol. xvii. p. 533, &c.

† Quart. Journ. Geol. Soc. 1850–51; vol. vi. p. 69; vol. viii. p. 118.

through the bed of the Channel, when it was above the level of the sea; but the action of running water cannot be considered sufficient to have hollowed out troughs of this kind, with no exit or open passage at either end. We should rather wonder that they have not yet been filled up by the deposits that must have been poured into them. Here we have a long narrow cavity ("Hurds Dyke") surrounded by water of the depth of about 30 fathoms up to its sides, and having in its centre a depth of 72 fathoms, or about 240 feet more than its edges. It therefore seems probable, from what we know on the subject, that the remark of Sir Henry De la Beche respecting a similar pit (the "Silver Pit" off the coast of Lincolnshire) would apply to these, viz. that they were the remains of ancient cracks or fissures in the earth.

The chemical theory of volcanos, the subterranean solution of felspathic, calcareous, and other rocks by water, and the crumpling of strata* appear to account for the origin of cavities beneath the crust of the earth, and its consequent fissuring.

From the point first taken, nearly to the south of Dungeness, the line of deepest water takes a north-easterly course to a little above lat. 52° N.; a winding course, like that of the English Channel, if observed only for a short distance, but in long distances deviating not much from a straight one. From the point last mentioned, in lat. 52° N., the line appears to turn in a direction somewhat to the west of the north; but beyond this it rapidly becomes shallower, indeed below 30 fathoms. It may be traced, however, with a depth of between 20 and 30 fathoms to a little north of lat. 53° N., and there ceases as a continuous line, though there are detached pits, such as the "Silver Pit" above alluded to, with a depth of from 40 to 50 fathoms. But, generally speaking, a bank here runs across the Channel all the way from England to Holland, so that a rise of 20 fathoms (120 feet) in the bed of the sea would enable us to walk across to Holland dryshod, all the way from the Wash to the Elbe.

As the line of deepest water has now terminated in this locality, we must turn to another, and endeavour to recover it. To the north-east of the Shetland Isles we meet with the 100-fathom line, which passes round the western coasts of Scotland and Ireland. North of the Shetlands it takes a bend to the east, and runs in a direction nearly west to east; then sweeps round to the north, until it terminates its course in that direction almost in a point, and then runs away in a south-east direction, following the line of the coast of Norway. But during the short distance that it has run from west to east, it gives off a deep channel to the south; so that in an easterly direction from the north point of the Shetlands there is, after passing over the shoal water near the land, a channel of from 80 to 100 fathoms in depth, then a bank of from 60 to 70 fathoms, and beyond that the deep channel which runs conformably to the coast of Norway, to the depth of 200 fathoms or more. There is a deficiency of deep-sea soundings from about lat. 60° 30′ to 59° 30′; but the channel we have mentioned, divided from the deep water on the coast of Norway,

* See De la Beche, Mem. Geol. Surv. vol. i. p. 237.

may be traced all the way, nearly in a southerly direction, at a depth of 70 to 80 fathoms, having on its eastern side the bank of 60 to 70 fathoms, which separates it from the Norway Sea. At about lat. 58° 40′, where the soundings are more regularly given on the charts, we find again the deep channel of from 80 to 100 fathoms, running in a direction nearly south, with a slight inclination to the east, having on either side a depth of 70 to 80 fathoms, and outside of that again a depth of 60 to 70 fathoms. Here we observe that it must have divided into two, after passing the northern point of the Shetlands, though the soundings are too imperfect to enable us to say where the division took place. We find, however, two channels of 70 to 80 fathoms in depth, with a bank between them. The easternmost or principal channel is continued to below lat. 58° at the depth of above 80 fathoms, and a little farther at the depth of above 70 fathoms. It continues at a depth of 50 to 60 fathoms to below 56° 30′, and there merges into a broad expanse of 40 fathoms depth. The westernmost or side channel appears to conform more to the line of the coast than the other. It gives off a branch into the Moray Firth, and another into the Firth of Forth. Lower down it runs conformably to the line of coast, and ends in about 54° 10′ lat. in a rounded point at the depth of 30 fathoms,—unless indeed we suppose the detached pits, the "Silver Pit," the "Sole Pit," the "Cole Pit," and the "Outer Silver Pit," to be continuations of it, which is probable. The first appears to branch aside in the direction of the "Wash;" the second and third to continue in the direction of the channel which, as we saw, ends in lat. 54° 10′; and the last runs in a direction west to east, whence it may be traced in the chart all the way to the mouth of the Elbe.

Now, take a central point, at the end of the principal or eastern channel, which we saw was in about lat. 56° 26′, and draw a straight line from that to the point which we have before taken in lat. 52°; then produce the straight line so formed until it meets the line drawn from the projecting angle of the 100-fathom line, west of the Hebrides, towards the projecting angle of the same line which lies to the north-east of the Shetlands; from the first point draw a straight line to the next projecting point of the 100-fathom line in a S.W. direction, which lies between lat. 53° and 54° N., off the west coast of Ireland; from this last point draw a straight line to the point we have before taken at the entrance of the British Channel, in lat. 48° 20′ N. and long. 8° 30′ W.: we have now completed an unequal-sided hexagonal figure, which may be said very nearly to represent the lines of deepest water round the British Isles. It is obvious, on referring to the Map, that, starting from the last-named point, in lat. 48° 20′ N., a similar process may be repeated for Ireland; and we then get a pentagonal figure, the third side of which, running between the coasts of Ireland and Scotland, passes along a remarkable pit, 30 to 40 miles long, 3 to 4 miles broad, and 100 to 150 fathoms deep, or as much as 70 to 80 fathoms (420 to 480 feet) deeper than the water at its edges. See the Admiralty Charts.

It may be objected, that in these two figures we have taken, on the western or oceanic faces, the 100-fathom line of equal depth, which is a different thing from a line or lines of greatest depth. To which we can only answer, that the 100-fathom line is the greatest depth for which the necessary soundings have been given to enable us to construct a continuous line for the whole distance. There are indications of a line of greatest depth outside of this, and which may be distinctly traced in the channel between the Ferroe Islands and the Orkneys, and between Rockall and the Hebrides; but, as the necessary soundings are not given for the southern part of its course, we do not insist on it.

This form of an irregular polygon, usually the pentagonal or the hexagonal, is the form that bodies approximate to, more or less, in shrinking, either when cooling down from a great heat or when drying. Of the former process basaltic columns afford familiar examples; and the same kind of thing may be seen in large surfaces of river-mud drying under the influence of a hot sun; and from what we know otherwise, the probable inference is that the contraction or shrinking in question (from whence these large polygonal areas appear to have had their origin) has arisen from cooling, and the falling in of cavities occasioned by upheaval.

The difference between the deep isolated pits and simple lines of depression appears to be this, that in the one case the strata are more unyielding than in the other. The area of the English Channel has been shown to be a valley of depression, from the terrestrial remains fished up in it, and the sunken forests on its edges. The same thing is known of that part of the German Ocean which is south of lat. 53°. There can then be no improbability in assigning a similar origin to the northern part of it. We have, therefore, two antagonistic forces in operation—the one an elevating and expanding force, the other depressing and contracting, both acting, if not in lines exactly straight, at least nearly so. If the bed of the English Channel, east of the Start Point, were upheaved 30 fathoms or 180 feet perpendicular, it would present the appearance of a chain of lakes, similar to what is seen in the inland valley (the Great Glen) through which runs the Caledonian Canal. Does it not then appear probable that the latter valley has also had a similar origin, lying as it does between two lofty mountain-chains? The furrow has run parallel to the ridges on either side of it. That it has been upheaved above the level of the sea by an after-process may be inferred from this, that the narrow trough at the western end of it (the Linnhe Loch), and the Moray Firth at its eastern entrance, have both the same maximum depth of water, viz. 100 to 120 fathoms.

The line of 100 fathoms on the western face of the islands is the greatest depth at which numerous soundings are given, and thus yields better data for a continuous line.

We will commence at its north-eastern end, to the north-east of the Shetland Isles, where it forms a remarkable projection into the deep water beyond. (1) From this point, it keeps a westerly direction until north of the Shetlands, and then bends somewhat to the south in a line nearly straight, until off the Hebrides, (2) when it again makes a bend to the south. It continues in this direction until about lat. 53° 20′, (3) when it again bends to the south, and continues nearly as a north and south line to a little above 49° 20′, (4) when it takes a sudden bend to the south-east, and runs in that direction all the way across the Bay of Biscay to the western foot of the Pyrenees. It will be observed that between these projecting points (see Map) the line bends inwards, like a slackened rope between

Map of the British Isles, showing the 100-*fathom line and the Hexagonal Area.*

its points of support, and the cracks or rents we have been discussing begin between the points of support at the deepest point of the curve. It will be observed also, that this 100-fathom line partakes but little of the irregular shape of the coast; but that the shallower the water becomes, the more does the line of equal depth conform to the outline of the dry land opposite to it. May we not then explain these appearances by saying, that as the mass was upheaved from the bed of the ocean, the sides opened, in a degree, with the strain and shrank inwards or towards the land, so as to produce (in the case of the channel to the north-east of the Shetlands, the northern entrance of the Irish Channel, and the entrance of the English Channel) a great crack or rent, which opened more and more as the mass rose into shallower water? This appearance in the last case, at the entrance of the English Channel, can be best studied in Maury's small Chart of the North Atlantic.

The relations of the strong projections or angles, and the weaker sides, of the half-hexagonal figure thus described are then treated of by the author;—the analogous irregularly hexagonal outline of the Isle of Arran and of the Spanish Peninsula, and its 100-fathom line,—the absence of such a line of angles on the eastern side of England, where the strata are softer,—and the bearings that certain lines drawn across the British Isles from the projecting angles of the polygon appear to have on the strike, and other conditions of the strata—were described. After some remarks on the probable effect that shrinkage of the earth's crust must have on the ejection of molten rock, the author observed that, in his opinion, the action of shrinking is the only one we know of that will afford any solution of the phenomena treated of in this paper, namely, long lines of depression accompanied by long lines of elevation, often, as in the case of the British Isles, Spain and Portugal, and elsewhere, belonging to parts of huge polygons broken up into small ones, as if the surface of the earth had once formed part of a basaltic causeway.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 4, 1861.

Samuel Harradan, Esq., 6, Westbourne Terrace, Barnsbury, London; Frederick Merryweather Burton, Esq., Gainsborough; Jonathan Sparrow Crowley, Esq., Lavender Hill, London, S.W.; William Henry Paine, Esq., Stroud, Gloucestershire; Edwin Witchell, Esq., Stroud, Gloucestershire; Henry Tibbats Stainton, Esq., F.L.S., Mountsfield, Lewisham, Kent; Captain Auguste Frederic Lendy, F.L.S., Sunbury House, Sunbury; Isaiah Booth, Esq., Mining Engineer, Oaks Colliery, Oldham; and Don Ramon da Silva, Consul for Chile, 43, Moorgate Street, were elected Fellows.

The following communication was read:—

On the Bracklesham Beds *of the* Isle of Wight Basin.

By the Rev. Osmond Fisher, M.A., F.G.S.

Contents.

Introduction.—We are indebted to Mr. Prestwich for a clear conception of the age of the Bracklesham series, and of its place among the Eocene Tertiaries; while the late Mr. Dixon has described the fossils of Bracklesham and Selsea, and given a very interesting account of the coast of that part of Sussex. In the course, however, of collecting specimens from these beds during the last eight years, I have been led to think that there are many points of interest on which a more minute description of the succession of their subordinate divisions, and of the fossiliferous localities, might be acceptable.

The term "Bracklesham Beds" is applied to the group of strata, many of them rich in organic remains, the greater part of which are seen displayed at low water upon the shore of Bracklesham Bay in Sussex. But I shall include under that name beds that are above any seen at Bracklesham Bay, because, when the deposits of Stubbington and of the New Forest come to be described, it will appear that many of the fossil forms peculiar to the Bracklesham Beds range higher than the highest stratum seen at the Bay. In other words, I shall group certain strata, which appear to intervene between the base of the Barton series and the highest beds of Bracklesham Bay, among the Bracklesham Beds, on account of their containing an assemblage of fossils more akin to the fauna of the latter than of the former.

As regards the inferior limit, I have not seen anywhere any marine fossiliferous beds below the lowest at Bracklesham Bay until we reach the Bognor Rock or the London Clay, except it be in a thin stratum of clay at the very base of the Bracklesham series at White Cliff Bay.

Many species, as is well known, range uninterruptedly from the Bracklesham Beds into the "High Cliff Sand" (by which term I do not intend the sands at the base of High Cliff, but those about its middle portion, so long known for the richness of their fossil-beds), and a considerable proportion into the still higher beds of Barton Cliff. (See fig. 2, p. 87.) For the purposes of this paper I shall follow Mr. Prestwich in considering the High Cliff Sand as a part of the Barton series *.

The *Cardita planicosta*, *Pecten corneus*, *Sanguinolaria Hollowaysii*, *Solen obliquus*, *Cytherea suberycinoides*, *Voluta cithara*, and *Turritella sulcifera* range throughout the group, and seem to be confined to it, with the single exception that *Pecten corneus* is rarely met with in the High Cliff beds. There are certain species which have a much more confined range †; and by means of these I have divided

* Quart. Journ. Geol. Soc. vol. v. p. 44.

† The genus *Pleurotoma* affords great help in subdividing the beds, as Dr. Wright and others have remarked of the *Ammonites* in the Mesozoic rocks. With a few exceptions, the range of the various species seems very confined. *Pleurotoma plebeia* has a very extended range, even throughout the Eocene period. *Pleurotoma prisca* ranges throughout a great portion of the Bracklesham and Barton beds. These are the chief exceptions. The great abundance of the individuals generally adds to the value of this genus in correlating beds; while the complete Monograph of Mr. Edwards renders their determination comparatively easy.

the whole series into four principal groups of strata distinguished by the letters A, B, C, D.

A is the upper group, generally abounding in *Gasteropoda*, and has one of its fossil-beds, in the eastern part of its range, full of *Nummulina variolaria*. It contains four *principal* fossil-beds, distinguished by the letters *a, b, c, d*.

B is the next member of the group, more sandy in its general condition than the last, and marked by the presence of *Cerithium giganteum*. It contains two fossil-beds, *e, f*, of which *f* is the most noteworthy. *Nummulina variolaria* is found in this member of the group at White Cliff Bay.

C, the next division, is sandy, like the last, but rendered remarkable by the profusion of *Nummulinæ lævigatæ* which crowd its principal fossil-bearing bed, *g* *.

D embraces the lowest fossiliferous sands of Bracklesham Bay. The distinctive shells are *Cardita acuticosta* and *Cypræa tuberculosa*.

The whole group consists of alternations of beds of sand and sandy clay,—the clays being more prevalent in the highest member, and the sands in the lower. Green grains abound in all the beds. Many of the beds are laminated, being formed by alternations of very thin bands of clay, separated by sandy layers. Such are generally devoid of shells, but contain much vegetable matter. They appear to have been caused by the deposit of sediment, in a quiet estuary, from a great river, the changes to the coarser sediment being caused by the state of flood.

The beds of sand point to a shallower condition of the sea-bottom, subject to drifting water. The shells in such beds are often drifted into patches, and are sometimes exceedingly abundant at one spot, while a few yards off scarcely a specimen will be found. The beds of clay were deposited in a deeper sea, and the species found in them agree with such a supposition.

Bracklesham Beds at White Cliff Bay.—The Bracklesham Beds are unquestionably better exhibited, in respect conjointly of development and display, at Bracklesham Bay than at any other place. But, because many parts of the series are there covered up by more modern deposits, while the relation of the whole to overlying and underlying deposits is indifferently shown, the section at White Cliff Bay becomes of much value; for there we have an unbroken sequence throughout, from the Chalk to the Bembridge Marls †. Mr. Prestwich has given a detailed account of this section in the

* Sir C. Lyell found the same change in the species of the Nummulites at the *Cerithium giganteum* bed at Cassel. Quart. Journ. Geol. Soc. vol. viii. p. 328.

† When examining the White Cliff Bay section, I was much interested in finding the equivalent to, and so fixing the position of, the very remarkable fossiliferous bed of Brockenhurst. It occurs in the upper part of bed No. 21 of Mr. Prestwich's section, Quart. Journ. Geol. Soc. vol. ii. pl. 9. p. 253. In plate 10 (by E. Forbes and W. H. Bristow) of the Memoir on the Isle of Wight (Geol. Surv. 1856), it is described as "brown clay, with irregular fracture, shaly in places, often with clayey nodules, containing fish and marine shells—*Cardita acuticosta*" (*deltoidea*, Edw. MS.).

2nd volume of the Society's Journal, in his paper on the Isle of Wight Tertiaries. I have compared his section with the beds on the spot, and found it very correct. But, inasmuch as some parts of the series seem better exposed at the present time, and since my object in this paper is more especially *to distinguish the fossiliferous beds*, I shall give a part of his section somewhat more in detail (fig. 1), together with lists of fossils made from my own observation.

The Bracklesham Beds resting on the Lower Bagshot Sands may be considered to commence in ascending order with No. 6 of Mr. Prestwich's section, where their base is a bed of rolled flint-pebbles, from 10 inches to a foot in thickness *, incomparably the most marked bed of pebbles in the section. *Immediately* above the pebbles impressions of bivalve shells occur in clay; they are scarce, and difficult of determination. One looks like a *Cytherea*, and another like a *Tellina*. But their presence is interesting, because the next 200 feet of sands and finely laminated clays and sands contain apparently no organic remains except vegetable impressions and lignite. A thin band of impure pipe-clay may be made out in this part of the series, with vegetable impressions very inferior to, but possibly corresponding with, the leaf-bed of Alum Bay.

There is much difficulty in fixing here a superior limit to the Bracklesham Beds. It is true that the series is complete; but the highest fossiliferous bed which can be satisfactorily made out undoubtedly belongs to the Bracklesham series.

Above this we do not know our whereabouts for certain, until we reach the Headon Sands. The intervening beds are badly displayed, and appear to contain very few fossils, and those not very typical. Provisionally, No. 18 of Mr. Prestwich's section † may be taken to represent that stratum of the Barton series usually known as the "High Cliff Sand;" and then No. 19, and possibly part of the Sand-bed No. 20, which Prof. Forbes found to contain "abundant impressions of marine shells, apparently of Barton species" ‡, will represent the upper part of the Barton series §. It will be seen that the strata of No. 17 of Mr. Prestwich's section are much obscured by the condition of the cliff. If we give the whole of this portion to the Barton series, we shall not be able to allow as much thickness to the superior part of the Bracklesham Beds as the Stubbington section and the New Forest beds would lead us to attribute to them. It therefore seems most probable that the line of separation at this place is to be sought somewhere in the concealed portion of No. 17 (No. XIX. of the following section). The upper part is probably the equivalent of a bed near the base of the Barton series, which is 52 feet thick at Alum Bay, and at that place very fossiliferous, having been formed under a less deep-water condition. The next portion

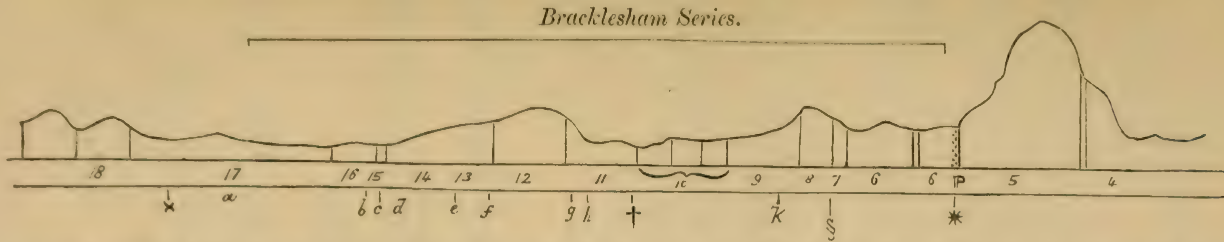
* A pebble-bed, forming the base of the Bracklesham series, is very fully developed at Bishopstoke. See Geol. Survey Map, sheet No. xi.

† See Quart. Journ. Geol. Soc. vol. ii. p. 254.

‡ Memoirs of the Geol. Survey, Isle of Wight, 1856.

§ Even at Alum Bay the dark clays of the central portion of the Barton series are replaced by sands.

Fig. 1.—*Diagram showing a portion of Mr. Prestwich's Section of Whitecliff Bay, Isle of Wight, and indicating the position of the principal Fossil-beds.* Scale 150 feet to 1 inch. (See Quart. Journ. Geol. Soc. vol. ii. pl. 9.)



a (XIX.) Probable horizon of the Coral-bed of Stubbington and of Hunting Bridge in the New Forest, and upper limit of the Bracklesham Beds.
b (XVII.) *Nummulina variolaria* bed=the "Clibs" of Selsea, and the Shepherd's Gutter bed of the New Forest.
c (XVI.) Sand-rock with *Tellinæ*=the "hard bed" of Selsea.
d (XIV.) *Corbula pisum* bed=the "*Cypræa Bowerbankii* bed" of Selsea, and the "Brook bed" of the New Forest.
e (XI.) *Sanguinolaria Hollowaysii* bed.
f (IX.) Bed of shells and pebbles: the lowest observed range of *Nummulina variolaria*. Probably=the "*Cerithium giganteum* bed" of Bracklesham and Hill Head.
g (VII.) *Nummulina lævigata* bed=the "Park bed" of Selsea.
h (VI.) Bed of shells with fish-remains (Prestwich), probably=the "Palate-bed" of Bracklesham.
k (IV.) *Cardita planicosta* bed=the lowest fossil-bed of Bracklesham, "Barn-bed" of Dixon.
* Bed of shells imperfectly exhibited.
† Spring at the base of the Cliff.
§ Impressions of vegetables.
* Casts of bivalves, immediately above the Pebble-bed.

will be the equivalent of the green bands which form the base of the Barton beds at High Cliff and Alum Bay, and there contain the *Nummulina planulata*, var. *Prestwichiana*, while the lower part will represent the upper beds of the Bracklesham group as seen at Stubbington and Hunting Bridge. No. 16 of Mr. Prestwich (Nos. XVIII. & XVII. of the following section) undoubtedly belongs to the Bracklesham group, as I shall prove when speaking of the New Forest beds. It is on the horizon of the highest bed seen at Bracklesham Bay, and locally known as the "Clibs" *.

In the following section the numerals within brackets agree with those in Mr. Prestwich's section, where the numbers run throughout all the Eocene beds seen at the Bay. The Roman numerals refer to the Bracklesham Beds alone, which I have subdivided somewhat more minutely. It is well to premise that the colours of the strata at this locality are, for the most part, much altered by recent weathering, and their lithological characters a good deal changed from the same cause.

Descending Section of the Bracklesham Beds at White Cliff Bay, Isle of Wight.

[NOTE.—*a*, *b*, *c*, &c., denote the more important fossil-beds, which, by means of these letters, may be identified at the various localities †.]

Somewhere in this portion commences the—

BRACKLESHAM SERIES.

[**Group A.**]

Nos. in Mr. Prestwich's Section.

XIX.

Feet.

(17) *a* Greenish and blue clays 162

At 24 feet from the top is a band of small shells imperfectly exhibited.

Ostrea flabellula.	Cardita, a small species like *C. oblonga*.
Mytilus, a small species.	

XVIII.

(16) Dark-blue clay, weathering brown 22

XVII.

b *Nummulina variolaria* in blue clay. The clay is crowded with Nummulites, which are often black 10

Turbinolia sulcata.	Cassidaria nodosa.
Nummulina variolaria.	Pleurotoma inflexa.
Quinqueloculina Hauerina.	—— plebeia.
Alveolina sabulosa.	—— scalarata.
Rotalia obscura.	—— Fisheri.
Fusus longævus.	Voluta nodosa.
—— pyrus.	Mitra labratula.

* Dixon's Foss. and Geol. Sussex, p. 25.

† Many of the species were, on account of their fragile and weakened condition, necessarily determined and noted on the spot. It is possible that a few errors may thus have arisen; but the author hopes they are but few.

Mitra parva.
—— ——, var.
Turritella sulcifera.
Dentalium politum.
—— ? striatum.
Rissoa cochlearella.
Pecten corneus.
Cardium ? parile.
? Lucina.
Cardita planicosta.
Crassatella (the species found also at Brook).
Corbula pisum.
—— cuspidata.

XVI. Feet.

(15) *c* Light-coloured sand, with two beds of sand-rock. *Tellina* and small Univalves in the bottom of the lower rock 6

Natica. Tellina donacialis. T. plagia.

XV.

(14) Sandy clay, passing into lead-coloured compact clay 10

Echinoderm in sand. Ancillaria canalifera in clay.

XIV.

d Dark sandy clay, with grains of black sand, full of *Corbula pisum* in the upper part, and with numerous shells below; passes into dark clayey sand with *Pecten corneus* 3

Nummulina variolaria (common).
Rostellaria sublucida.
Murex asper.
Fusus pyrus.
Strepsidura turgida.
Cassidaria nodosa.
Pleurotoma plebeia.
Voluta nodosa.
—— Selseiensis.
Cerithium tritropis, *Edw. MS.*
Calyptræa trochiformis.
Turritella imbricataria.
—— sulcata.
Ditrupa plana.
Pecten corneus.
Pinna margaritacea.
Nucula Dixoni, *Edw. MS.*
Leda.
Crassatella (the Brook species).
Corbula pisum (abundant).
—— costata.
Cytherea lucida.
Cultellus.

XIII.

Beds not exposed; apparently clays 39

[**Group B.**]

XII.

Streaked, whitish-yellow, and foxy sands 10

XI.

e Sandy clays, weathering grey and yellow. There is a layer of casts of shells where it passes into the next bed, *Sanguinolaria Hollowaysii* being extremely abundant 4

Turritella sulcifera.
Pecten corneus.
Pectunculus pulvinatus.
Cytherea lucida.
Sanguinolaria Hollowaysii.
Solen obliquus.

X.

Sand, weathering yellow and grey 7

IX. Feet.

(13) *f* Brownish sandy clay, with shells and pebbles at the bottom. The shelly layer appears to be a lenticular mass, and not to be persistent 6

Nummulina variolaria.
Murex minax.
Voluta nodosa.
Turritella imbricataria.
—— sulcifera.
Natica ? labellata.
Nucula ? subtransversa.
Tellina ? plagia.
Pecten 30-radiatus
Ostrea ? zonulata.
Arca.
Pectunculus pulvinatus.
Chama gigantea.
Crassatella compressa.
Cardita planicosta.
Corbula pisum.
Sanguinolaria Hollowaysii.

[Group C.]

VIII.

(12) Foliated, dark, sandy clays, weathering brown; with vegetable matter interspersed. There is a layer of casts of shells at the junction with the next bed 46

VII.

g Green sand, in which *Sanguinolaria Hollowaysii* is very abundant 15
(*Nummulina lævigata* occurs in a mass four feet from the bottom.)

Nummulina lævigata.
Sanguinolaria Hollowaysii.

VI.

(11) *h* Light- and dark-coloured green sands, with many shells in the upper part. (A spring at the base of the cliff.) 62

Nummulina lævigata.
Fusus longævus.
—— pyrus.
Voluta nodosa.
—— spinosa.
Pleurotoma dentata.
Natica (small).
Turritella sulcata.
—— sulcifera.
—— terebellata.
Calyptræa trochiformis.
Pecten corneus.
Mytilus.
Nucula.
Leda.
Lucina.
Cardita planicosta.
Tellina plagia.
Sanguinolaria Hollowaysii.
Solen obliquus.
Corbula (? Gallica).
—— pisum.

[Group D.]

V.

(10) Laminated grey clay, with some beds of calcareous green-sand, and a few beds of lignite 76

IV.

(9) *k* Calcareous, clayey, green, and iron sand, with numerous shells in seams. The base seems washed into the next bed 52

Nummulina lævigata (rare).	Ostrea flabellula.
Fusus pyrus.	Cardita planicosta.
Metula (Buccinum) juncea.	Cytherea lucida.
Pleurotoma (small).	C. suberycinoides.
Voluta nodosa.	Tellina.
Natica.	Panopæa.
Turritella? imbricataria.	Corbula pisum.
Calyptræa trochiformis.	

III. Feet.

(8) Alternating beds of green sand and finely laminated clay, weathering grey and brown; with thin seams of lignite 18

II.

(7) Yellow sand 10

1.

(6) Sandy clay, weathering grey and brown, finely laminated with yellow sand. There are casts of bivalve shells in a band of clay at the bottom. It is based on from 10 to 18 inches of black rounded flint pebbles, often as large as swans' eggs 95

653

This section will be used as a typical section, the beds being referred to by means of the Roman numerals.

Bracklesham Bay.—I will now shortly describe the principal localities where the Bracklesham Beds yield a harvest to the collector.

Among these, Bracklesham Bay, both for interest and display of the beds, undoubtedly holds the highest place, although it is extremely difficult to preserve the fossils found there, on account of their perishable condition *.

The beds are exposed on the shore of a shallow bay; their strike is about W. by S. and E. by N., and they dip slightly S. by E. There is no opportunity given to measure the dip or the thickness of the beds with accuracy. In the following section the order of the beds is correctly noted; and the distances between the outcrops on the shore may be taken to give the proportions of the thicknesses of the lower beds approximately; but towards Selsea Bill, where the upper beds are exposed, their strike is nearly tangential to the coast, and consequently we continue upon the same outcrop for a considerable distance. Here, as at White Cliff Bay, the chief difficulty in determining the relation of the beds occurs at the upper part of the section. At the extreme southern point, at low water at spring-tides, a few septaria crop out, resting on a very sandy clay, weathered greenish, and containing the remains of fossils. Among these I distinguished *Cassidaria coronata* and *Metula (Buccinum) juncea*; but the relation of this bed to the rest of the section

* I have used isinglass dissolved in gin for this purpose. Mr. Dixon recommended a mixture of diamond-cement and water.

was, when I saw it, very obscure; whether above or below the *Nummulina variolaria* bed, I could not satisfy myself. The dip of the strata would appear to make it the Cypræa-bed of Dixon (*d*, below); but its lithological character is different. I will give the sequence of the beds round Selsey Bill as I observed them, merely as a guide to those who may visit the spot.

Commencing at a spit of gravel seen at low water, brought together by the meeting of the tides from the Park and Bracklesham Bay, and going westward, we have this apparently ascending section:—

	Paces.
Beds covered with sea-sand	600
Outcrop of septaria, resting on sandy clay, weathered green, with remains of shells; just seen.	
Beds covered with sea-sand	127
Hard, dark-grey, sandy bed, Nummulitic in the upper part. Nummulites abundant at 216 paces. Concretions at 226 paces	420
Nummulites and other Foraminifera in clay	324

The Nummulite of these beds is *Nummulina variolaria*.

Taking up the last-named bed again, as being the highest certainly distinguishable at this place, we have the general descending series along nearly 3 miles of the shore as follows:—

*Descending Series at Bracklesham Bay**.

				Paces.
A.	22	(*b*)	Clay, weathered grey, crowded with *Nummulina variolaria*, *Alveolina sabulosa*, *Quinqueloculina Hauerina*, *Biloculina ringens*, *Rotalia obscura*, *Turbinolia sulcata*, &c. ("Clibs")	324
			Beds covered with sea-sand	185
	21	(*c*)	Hard calcareous sand, with comminuted shelly matter and numerous *Tellinæ* and other fossils ("Hard Bed"†). Many of the *Foraminifera* of No. 22 are common in this bed	140
			Concretionary lumps at the bottom of the above	105
	20		Greyish clay, with *Corbulæ* and *Nummulinæ* at 38 paces	120
	19	(*d*)	The clay becomes darker and more sandy, and fossils increase in number. They are most abundant towards the middle of the bed (Cypræa-bed of Dixon)	460
	18		Sandy clay, firmer than the last, containing many of the same shells, but not so abundantly; seldom seen: it was exposed in Aug. 1857	66
	17		Sandy clay, weathered green (Pleistocene weathering‡); remains of fossils in the upper part	194
			Pleistocene mud	112
			Green sandy clay	300

* This list of beds was made in May 1861. The beds were then, on the whole, very favourably exposed; but occasions sometimes occur when they are still better seen. I saw them better than I have ever seen them before or since, in June 1856.

The fossils of the different beds of Bracklesham Bay, and of the other most celebrated localities, will be given in a catalogue which is in preparation.

† The local names are those used by W. Woodland, of Medmery Farm, who collects for sale.

‡ Not the least interesting phenomena at Bracklesham Bay are those connected with the Pleistocene beds. The greater part of that area has been occupied with forest-ground; and during the period that it was dry land the Eocene beds formed the subsoil, and that weathering took place which is so fre-

Group	No.	Bed	Paces.
B.	16 (*e*)	Sand full of casts of bivalves, weathered yellow and reddish, partly covered by sea-sand	218
		Pleistocene mud	80
	15	Hard sand, weathered verdigris-green	70
	14	Shelly sand, weathered greenish brown, full of fossils; small *Cerithia* and *Cytherea striatula* common. ("Little Bed.")	29
	13	Dark sandy clay, with numerous *Turritellæ imbricatariæ*	240
		Pleistocene sandy clay, laminated, with a bed of *Ostrea edulis* and other shells at the bottom	124
	12 (*f*)	Dark clayey sand with numerous specimens of *Cerithium giganteum*, *Pectunculus pulvinatus*, and other shells	163
	11	Septaria, resting on a bed of shelly sand, with black flint pebbles*	150
C.	10	Laminated liver-coloured clays; more sandy towards the bottom	246
	9	*Ostrea tenera* bed: a congeries of Oysters, about 18 inches thick	52
	8	Dark-green sand, full of broken shells—*Pectunculus pulvinatus*, *Lucina* (unnamed), *Bulla Edwardsii*, &c., towards upper part (79 paces); less shelly in the middle (48); abounding in *Turritella terebellata* at the base (48): in all	175
	7	Soft laminated dark-coloured clay	177
		Pleistocene mud, out of which in places protrudes a clay, weathered green	288
	6 (*g*)	*Nummulina lævigata* bed, with numerous fossils ("Little Park Bed")†	40
	5	Sandy clay, weathered green	107
		Beds covered partly with sea-sand and partly with Pleistocene mud	105
	4 (*h*)	Dark, mottled, sandy clay, with perished shells and scattered Nummulites, fish-, and serpent-remains. ("Palate-bed" of Dixon)	134
		Covered with sea-sand	96
	3	Dark sandy clay	53
		Dark sandy clay, with soft broken shells	111
		Covered	30
D.	2	Turritella-bed; *Turritella imbricataria*, and *T. sulcifera*	92
	1 (*k*)	Septaria; containing shells and occasionally *Rostellaria ampla* (68 paces), resting on a mass of *Cardita planicosta* and *C. acuticosta*. The lower part of the bed is green sand, crowded with shells, among which, immediately	

quently referred to in the text. It will be observed that, wherever a tract of Pleistocene forest is approached, the bordering Eocene deposit is "weathered;" but if the Pleistocene be subaqueous at that spot, the bordering Eocene retains its original colour. Weathering is caused by the atmospheric air which the rain carries down with it as it percolates the soil. Another interesting phenomenon here is the furrowed condition of the surface of the Eocene beds, caused by the coursing of drifting gravel over them. The furrows are filled with large flints and boulders from the older rocks, in many places undisturbed, but sometimes washed out by the present waves and redeposited in the furrows along with shingle from the present beach.

* Fossil shells, in a beautiful state of preservation, are frequently washed up by the sea in the neighbourhood of the Cerithium-bed. They probably are derived from lenticular patches of shells on the horizon of No. 11, and correspond with the fossil-bed of Hill Head, near Stubbington.

† Concretions containing this Nummulite are often washed up by the sea. They are probably derived from No. 4. The Nummulite-bed No. 6 is green in Bracklesham Bay, but yellow at the Park, where it has suffered Pleistocene weathering.

		Paces.
D.	beneath the *Carditæ*, the *Cypræa tuberculosa* * may be found. The bed then becomes less fossiliferous, and passes into a dark-grey laminated clay, broken up and rearranged, mixed with dark sand and black pebbles. "Barn-bed" of Dixon	330
		5016

Below this the beds are covered up, and no fossils are to be found. I believe it is the lowest fossiliferous bed of the series; for it is a fortunate circumstance to the collector that the presence of fossils, and the calcareous matter derived from them, impart a hardness to the matrix, which causes the fossiliferous beds to resist the action of the water, so as to be always more exposed to view than unfossiliferous beds.

The Park, on the east side of Selsea, and the Mixen Rocks.—On the eastern side of the Selsea peninsula there is also a display of a part of the same series. The highest bed seen is on the horizon of VII.,—the *Nummulina lævigata* bed being better developed there than elsewhere, and abounding in fossils. All the succeeding beds, down to the *Cardita planicosta* bed, No. 1, are usually exposed upon that part of the coast which is called "The Park."

There is a ledge of rocks off at sea, about a mile south of Selsea Bill, called the Mixen Rocks: they consist of a sandy limestone, made up almost entirely of *Foraminifera*, principally of a *Miliola* and an *Alveolina*. I believe the rock to be nothing more than a continuation of No. 22 (*b*) under a more calcareous condition †.

Bury Cross.—In following the course of the Bracklesham Beds westward, the next section is that at the Gosport Water-works at Bury Cross, of which Mr. Pilbrow has supplied a section in vol. xvi. of the Journal, at p. 447.

I have examined the series of specimens preserved at the office of the Water-works at Gosport, and was much interested by their striking resemblance to the lower part of the Bracklesham Bay beds. The following abstract of the section is made from these specimens, which were taken at the depths noted:—

			ft.	in.
C.		Laminated clay (weathered)	11	9
		Laminated clay and dark sand	37	3
	(*g*)	*Nummulina lævigata* bed	67	3
	(*h*)	Very *green* sand, with a few specimens of *Nummulina lævigata*	75	0
D.		Turritella-bed, a conglomerate of shells, as at Bracklesham, here containing *Cardita planicosta*	95	0
	(*k*)	Cardita-bed; shells rather smaller	104	0
		Shaly and peaty clays	109	0

In Mr. Pilbrow's section he has given sandy clay and black pebbles, 1 foot 3 inches thick, at 329 feet; and the boring was carried

* This is not an extremely rare shell, though very difficult to obtain perfect; but it is seldom that the bed is sufficiently exposed to afford a fair opportunity of observing them.

† For a description of this part of the coast of Sussex, see Dixon's 'Fossils and Geology of Sussex,' chap. ii.

only 2 feet 3 inches further in hard clay. If I were to hazard an opinion, I should say that the water was obtained in the London Clay series, and that the Bracklesham Beds ended at a depth of 201 feet 9 inches. The green sand (with water), 20 feet 6 inches thick, would then belong to the Lower Bagshot Sands. There is a remarkable thinning-out of the lower fossiliferous beds here, as compared with the section at White Cliff Bay; while beneath them the unfossiliferous laminated clays and sands continue of nearly the same thickness. We have an interval from VII. to IV. at White Cliff Bay, 198 feet; at Bury Cross, 47 feet: interval from IV. to I. at White Cliff Bay, 119 feet; at Bury Cross, 118 feet *.

Fort Gomer.—At the new works at Fort Gomer, south of Bury Cross, are to be seen the beds on the horizon of XVII. near the upper part of the series. *Nummulina variolaria* and *Pecten corneus* occur in blue sandy clay.

Rowner Fort.—At Rowner Fort, now in process of construction, some sand from a shallow well contained comminuted shells, among which *Turritella imbricataria* was distinguishable, but no traces of Nummulites. There was not sufficient evidence to identify the bed.

Stubbington.—The next locality to which I refer is Stubbington. This is a place of some interest, having long been known for its Eocene fossils; but they were, I believe, formerly collected from only one or two beds in the upper part of the series. I was myself the fortunate finder, in March 1856, of the very rich deposit of fossils on the horizon of IX. *f*.

The beds here, as at Bracklesham, do not admit of convenient measurement. They are seen, at intervals, beneath gravel at the base of the low cliffs west of Brown Down. But a more complete section may be obtained by noticing their outcrop at low water. The dip of the beds is nearly S. by W.; their dip in the direction of the shore is but slight, and consequently we continue a long distance upon the same bed. The proportion of the thickness to this distance is nearly uniform for all the beds, because the shore is very nearly straight.

Commencing from a point in a line with two large boulders on the shore, and opposite a hut upon the cliff, near the eastern end of Stokes Bay, and going westward, we have the following descending section †.

			Paces.	Thickness. ft.	in.
A.		Shingle and sand (beds not exposed)	130		
		Sunk forest (Pleistocene)	60		
		Beds not seen..	46		
	21	Light-greenish-blue sandy clay, laminated	219	14	6
		Bracklesham Beds:—			
	20 (*a*)	Light-greenish sandy clay, containing rather abun-			

* Quart. Journ. Geol. Soc. vol. xvi. p. 448.

† By measuring the dip of the nodules in the cliff, I obtained a dip of about 3½ feet in 64 paces; and by comparing the thickness of the Nummulitic bed with its extension on the shore, we get a dip of 4½ feet in 74 paces; taking the mean of these, we find the factor which, multiplied by the extension in paces, will give the thickness of the beds in feet, to be approximately ·066.

			Paces.	ft.	in.
		dantly a Coral like *Paracyathus caryophyllus* (see Palæont. Soc. Monogr. vol. for 1850, pt. 1) and crushed *Dentalia*, with a few Bivalves, species undistinguishable. (The equivalent bed is found at Hunting Bridge, in the New Forest.) It ends not far east of some rails on the cliff	8	0	6
	19	Greenish-blue sandy clay; no fossils seen	339	22	4
	18	The same, rather more laminated	114	7	6
	17	The same, with Pleistocene weathering and roots of trees, opposite the mouth of a valley	43	2	9
	16 (*b*)	*Nummulina variolaria* bed; with *Pecten corneus* at the top, and *Cardita planicosta* at the bottom. (This bed was proved to be 4½ feet thick by digging through it)	74	4	6
	15	Liver-coloured stiff clay	49	3	3
A.	14	Dark-greenish-blue clay, crowded with *Corbula pisum*	62	4	0
	13 (*d*)	Very dark clayey sand, with many fossils and a layer of large *Carditæ planicostæ* at the bottom	97	6	4
	12	Clay greyer and less sandy, fewer fossils, but *Corbula* common	15	0	11
	11	Clay darker and more sandy; flat septaria, usually formed on drift-wood bored by *Teredines*. There is sometimes coarse drift-sand on the eastern side of the logs. *Pinna margaritacea* abundant	100	6	7
	10	Strata not seen; presumed, from what appears in the cliff, to be soft sand, with small shells...	152	10	0
	9	Dark sand; very few shells	105	6	11
	8	Bed of great septaria in dark sand, which weathers of a greenish yellow in the cliff	57	3	8
	7	Dark sandy clay	39	2	6
	6 (*e*?)	Dark sandy clay, with broken fossils. (This is seen as the most westerly fossiliferous bed in the cliff.) *Dentalium* and *Cytherea lucida* common	66	4	3
	5	Dark-green sand: *Cardium? Edwardsi*, var., very common	24	1	6
	4	The same: *Pecten corneus* very common	48	3	1
	3	Darker and coarser sand	26	1	8
		Total..........		106	9

From this point the section is nearly obscured for about half a mile; but sufficient is exposed to show that it consists almost wholly of sands belonging to Group B.

Then, in the old cliff, at Hill Head, at the point where the word "fossils" is engraved in the map of the Geological Survey, there is a bed of large septaria in sand, resting upon laminated clay. Here I found, in 1856, a lenticular mass of fossil shells with *Cerithium giganteum*, washed together, partly concreted into septaria, and partly free.

The position in the section, as well as the assemblage of shells, prove it to be on the horizon of IX.* Beyond this point the beds consist of sands, weathered yellowish and bluish green, and rather micaceous. Further east, near Meon, are greenish sands, with

* An extension of this bed, with similar fossils, seems to occur beneath low-water mark, at the furthest extremity of the spit of shingle opposite Stubbington Lane-end, where specimens may be found washed in by the sea.

casts of *Turritella*, but with no distinct indication of their place in the series.

Netley.—Following the shore of the Southampton Water, we find the strata unfavourably exposed. At Netley Hospital, *Pecten corneus* occurs in clay; and other common Bracklesham fossils, in dark sand, were brought up from a well. At Netley Cliff, casts of univalves may be seen in bluish-green sand; while at Southampton Docks, *Nummulina lævigata* occurred. This fixes the horizon of the beds at group C.

The New Forest.—Within the last few years the cabinets of collectors of Eocene fossils have been enriched with specimens from Bramshaw and Brook, in the New Forest. The first intelligence which I received of the occurrence of fossils in this neighbourhood was from Mr. Bristow, of the Geological Survey, who discovered them here in the year 1854. I believe H. Keeping had become acquainted with the spot about the same time. In the course of my own working in that neighbourhood, I found other places which yielded many specimens. The strata where these beds occur are coloured as belonging to the Barton series in the Geological Survey Map, the line of demarcation being drawn at the commencement of the sands which characterize the 2nd fossiliferous horizon B of the Brackleshams on the *Cerithium giganteum* division. The richness of the deposits in this neighbourhood exceeds that of the relative beds at any of the places I have mentioned.

Hunting Bridge.—The highest fossil-bearing bed belonging to the Bracklesham series which has been met with in the New Forest is near a place called Hunting Bridge, in an artificial watercourse in an enclosure near the letter "*d*" in "Lynwood Coppice" on the Ordnance Map. This fossil-bed was discovered only within the last month, by Henry Keeping, of Freshwater, who collected for me the specimens from which the following list is taken, and to whom I am indebted for the stratigraphical particulars of this locality. His section gives—

	ft.	in.
(*a*) Bluish-green clay, full of large *Dentalia* (sp. nov.) and Corals...	0	6
Dark-green sandy clay, with fossils scattered throughout, about perhaps	20	0

I have not yet had an opportunity of visiting Hunting Bridge. The specimens which I have received therefrom are—

Rostellaria ampla (fine).
—— rimosa.
—— arcuata.
—— minax.
Murex asper (common)
Fasciolaria uniplicata.
Fusus Noæ.
—— pyrus.
—— carinella (common).
—— interruptus.
—— ? n. s., found also at Alum Bay and Hill Head.
Strepsidura turgida.
Pseudoliva ovalis.
Cassidaria nodosa.
—— coronata.
Pleurotoma prisca.
—— plebeia.
—— planetica.
—— crassicosta.
—— ligata.
Voluta labrella.
—— nodosa.
—— maga.
Natica Willemetii.
—— ? ambulacrum.

Turritella sulcifera.
Turritella ? nov. sp.
Phorus agglutinans.
—— ? excavatus, *Edw. MS.*
Calyptræa trochiformis.
Bulla (?) Edwardsii.
Dentalium (large and very common), nov. sp.
Serpulorbis ornatus ? (rather common).
Niso terebellatus.
Pecten corneus (not common).
Arca barbatula.
—— *prope* aviculina. (? n. s.)
Spondylus rarispina.
Limopsis (nov. sp.)
Cytherea lucida.
—— ? sp.
Cardium parile.
—— porulosum (*teste* Keeping).
Cardita elegans.
Crassatella (found also at Brook).
Pectunculus pulvinatus (common).
Tellina (?) Branderi, var. (rather common).
Corbula Gallica (*teste* Keeping).
Pinna margaritacea.
Nummulina (apparently *N. variolaria*) on *Phorus agglutinans.*

The upper layer of bluish-green clay at this place seems undoubtedly to be the equivalent of the bed No. 20 (p. 77), with Corals and *Dentalia*, at Stubbington, which I have taken as the highest of the Bracklesham series at that place. The lower portion, which has afforded, with very little working, the above list of species, does not appear to have an equivalent fossil-bed there; or, if it has, I have overlooked it. The species are so decidedly of a Bracklesham type, that I have no hesitation in classing the deposit as a part of that series; and, as I have premised when speaking of its limits, I am obliged to extend the classification under that head to beds above any seen at Bracklesham Bay, where the section terminates with the "Clibs." Those "Clibs" are the equivalent of the *Nummulina variolaria* bed, No. 16, of Stubbington, which is more than 30 feet lower than the coral-bed corresponding with the upper part of the Hunting Bridge Bed. Nevertheless the character of the matrix at Hunting Bridge approaches more nearly to some of the Barton deposits than to any of the Bracklesham strata.

Bramshaw; Shepherd's Gutter.—The nature of the surface does not admit of giving complete sections in the forest; but the general stratification of the district leaves no doubt of the last-mentioned fossil-bed being followed in descending order by the Shepherd's Gutter Bed, which is to be met with at Three-water Gutter, about half a mile to the south-east of Hunting Bridge. The spot where this bed was originally found on Shepherd's Gutter, and which is indicated in Mr. Edwards's monographs as the "Bramshaw" locality, may be found by drawing, on the Ordnance Map, a straight line from the first "B" in "Burntford Bridge" to the "*ll*" in "Bramble Hill Lodge."

Passing through some soft blue clay, the first part of the fossiliferous bed reached, about a foot thick, is crowded with *Turritella carinifera* in clay. Then we have a few inches of stiff blue clay, in which occur *Triton nodulosus*, Edw. MS., and *Pleurotoma ligata*, and then from three to four feet of very dark clayey sand, with abundant shells. The larger shells are at the bottom of the bed. At the base is a layer full of *Pecten corneus* and many specimens of *Conus deperditus.* The whole rests on a dark-grey sand, with fragments of *Pecten corneus*, which have lost their fresh brown tint. The *Nummulina variolaria* is by no means uncommon in this bed, and is usually to be found attached to the specimens of *Phorus agglutinans*. Beneath this bed are clays, perhaps 10 feet thick; and then a thin fossil-bed, with *Pecten corneus* abundant, and many of the smaller shells of the bed just described. This is succeeded by dark and very sandy clay, with scarcely any traces of fossils. *Cardita planicosta* is rare at this locality. On following the brook a few hundred yards downwards, through the length of two fields, the Corbula-clays, belonging to the next succeeding fossil-bed (*d*), may be made out in a weathered condition in the bank of the stream. A very few feet beneath this stratum, coarser sands with grains of silicate of iron come in. I place the Bramshaw or Shepherd's Gutter Bed on the horizon of XVII. (*b*).

The argument for the position of the Shepherd's Gutter Bed is of this kind. It is succeeded at the interval of a few feet (there is no opportunity of taking a measurement, but it may be 20 or 30 feet*) by the "Brook" Bed, a deposit of a marked character (see p. 83). The extraordinary abundance of *Corbula pisum* in the upper portion of this bed, the abundance of *Pleurotoma attenuata*, elsewhere rare, and the presence of *Voluta horrida* render it peculiar. There is also an individuality about a fossil-bed which cannot be fully appreciated except by one who has personally worked it. The characters of the "Brook Bed," belong also to bed No. 13 at Stubbington and to the Cypræa-bed, No. 19, of Selsea, in Bracklesham Bay; there is therefore a presumption that the three are equivalent. Now there is, at a short interval above the beds 13 of Stubbington and 19 of Selsea, a remarkable deposit of *Nummulina variolaria*: at Selsea that Nummulite is accompanied by *Alveolinæ* in abundance, and by other Foraminifera. Thus we have two beds at Stubbington and Selsea similar in their general character, and also similar in sequence. Passing to White Cliff Bay, we find a *Nummulina variolaria* bed, No. XVII., intermediate in character between those of Stubbington and Selsea, containing a larger proportion of Nummulites than at Selsea, but with *Alveolinæ* and other Foraminifera of Selsea which are not found at Stubbington. The bed is based on a sandy deposit, as is that at Selsea, containing in both places numerous *Tellinæ*. The sand-rock is soon succeeded by a bed (XIV.) full of *Corbula pisum*, which, as far as I was able to examine it, appeared to agree with the Cypræa or "Brook" Bed (*d*) of the New Forest, Stubbington, and Selsea. Thus it seems to admit of little doubt that the *Nummulina variolaria* bed (the "Clibs") of Selsea, the Nummulina-bed of Stubbington, and *Nummulina variolaria* bed of White Cliff Bay are equivalent.

Now, the *Nummulina variolaria* bed of White Cliff Bay contains rather a peculiar assemblage of *Pleurotomæ* as well as the *Rissoa cochlearella*, which are found at Shepherd's Gutter, as are also all its fossils, except the *Alveolina*, absent also at Stubbington; and it is shown to occupy a position with regard to bed *d* similar to that occupied by the Shepherd's Gutter Bed; therefore the argument

* All the beds in this part of the series appear thicker in the New Forest than to the south-east.

from fossil contents and sequence renders it most probable that the two are equivalent, and therefore that the Shepherd's Gutter Bed is equivalent also to the *Nummulina variolaria* beds of Stubbington and (the "Clibs") of Selsea.

But the argument is still further strengthened thus. Let it be granted that the Shepherd's Gutter Bed is equivalent to No. XVII. of White Cliff Bay; it is therefore equivalent to the *Nummulina variolaria* bed of Stubbington. Now, there is at Stubbington, about thirty feet higher up, a very remarkable bed, No. 20, containing *Paracyathus caryophyllus* and *Dentalia*; whilst a bed with similar contents is also found in the New Forest, at Hunting Bridge, not many feet above the Shepherd's Gutter Bed. It will be seen that the above contains also the data upon which I have ventured to differ from former observers* respecting the line of separation between the Bracklesham and Barton Beds at White Cliff Bay, and to place it slightly higher up.

At about a mile and a quarter S. by W. of Shepherd's Gutter, near the letter "*k*" in "Brook Common" on the Ordnance Map, at the corner of Prior's Acre, is a fossil-bed, in its leading features very similar to that at Shepherd's Gutter. The stratum covering the fossil-bed is soft blue clay. To this succeeds a bed of clay crowded with *Turritella imbricataria* and *T. carinifera*, and then a bed of dark sand with many shells. This last is not so thick as at Shepherd's Gutter, averaging about $1\frac{1}{2}$ foot. There are not so many broken shells; but the percentage of tolerably perfect shells is perhaps larger. Beneath it we find decayed *Pectines cornei* in a sandy clay. *Cardita planicosta* is very rare. This bed is, I believe, a continuation of the Shepherd's Gutter Bed, and is on the horizon of XVII.

A section, by digging and boring, gave—

	ft.	in.
Superficial soil	2	0
Soft, weathered, blue clay, with selenite † and *Turritellæ*	7	0
Fossil-bed (*b*)	1	0
Stiff slate-coloured clay	3	6
A thin fossil-bed, with *Pecten corneus* ‡ ....say	0	3
Purplish, very sandy clay (not pierced), probably *c* of Bracklesham	2	0

Brook.—About a quarter of a mile down the brook or "gutter" called King's Garden Gutter, in which the last-mentioned bed was reached, occurs a second rich fossil-bed, which lies beneath it. It is that cited by Mr. Edwards § as the "Brook" locality. After passing through a covering of clay, a thin bed of dark-green sand

* Prestwich on Bagshot Sands, Quart. Journ. Geol. Soc. vol. iii. p. 388.

† A collector should keep a look-out for selenite, because it is often the only indication, seen on the surface, of the neighbourhood of fossil shells. When clay contains fossil shells and sulphuret of iron, the change which takes place in the course of weathering is this:—The sulphur combines with the oxygen of the atmosphere to form sulphuric acid; this combines slowly, as it is formed, with the carbonate of lime of the shells, and crystallizes into selenite, the shell being ultimately entirely removed.

‡ Corresponding probably with the thin fossil-bed, containing *Pecten corneus*, mentioned as occurring at Shepherd's Gutter.

§ Palæontographical Society's Monographs, 1858, p. 270.

is reached, full of shells. Single valves of *Cardita planicosta* are common. There are numerous small *Cerithia* in this bed, of several species. *Fusus polygonus* is also not uncommon, as also *Pseudoliva ovalis*. The bed is about 8 or 10 inches thick. Beneath it we come upon very stiff lead-coloured clay, in which *Corbula pisum* soon begins to make its appearance ; and, after passing through about 4 feet of this clay, we reach a sandy layer, of a somewhat greenish tint. In this many good specimens are to be found, especially of *Pleurotoma attenuata*. The clay then becomes less sandy, and is crowded with *Corbula pisum*, other fossils occurring sparingly for about 2½ feet. We then reach a bed of dark sand with shells, chiefly (but by no means all) broken. There are a large number of single valves of *Cardita planicosta* at this level ; and, when these are passed, another layer of shells, mostly broken, is usually found, containing several rare species, and among them many specimens of *Voluta horrida*, a species known only by a single broken specimen from Bracklesham before I found it at this place. Hard grey clay, with intermittent layers of *Corbulæ*, and but few other species, succeed this bed.

I consider the Brook Bed to be on the horizon of XIV. (*d*). It is the bed most constant in its character of any, and differs so little at White Cliff Bay (where, however, it is difficult to find, as it lies in a vertical position at the bottom of a small streamlet), Bracklesham Bay, Stubbington, and Brook, that it affords a very satisfactory presumption of its being quite possible to divide the Bracklesham series into successive beds, each recognizable by its lithological characters, position, and fossil contents.

The "Brook Bed" crops out in the ditch by the side of Sir F. Pollock's Wood, in Canterton Lane; and it may be seen there, as well as in Shepherd's Gutter, that it is soon succeeded by sands, which are no doubt the sands belonging to the horizon of IX.

Western Range of the Bracklesham Beds. Poole and Corfe.—I have thus described the character and sequence of the Bracklesham Beds as they occur at intervals throughout the eastern and northern parts of the Isle of Wight Basin. I have now to speak of their western development near Poole, at Alum Bay, and at High Cliff. There is a specimen in the Museum at Dorchester, which I have been credibly informed came from a sand-pit at Lytchett, near Poole. It is a concretion of ferruginous sand, formed upon a mass of *Carditæ planicostæ* and *Turritellæ* (probably *T. imbricatariæ*), the casts only remaining. This is an interesting specimen, because it shows that the sea of the Bracklesham period was tenanted by such forms very near the district of Poole and Bournemouth, where the only remains hitherto observed have been those of vegetables and insects. I have, however, seen a small round Oyster from Furzeybrook claypit, near Corfe,—the only instance on record, as I believe, of a marine shell from these Corfe Beds*.

* Large palm-leaves are not uncommon at Furzeybrook, which seems to show that a subtropical climate was shared in by the land as well as by the ocean, during the Bracklesham period. A specimen of these palms was exhibited when the paper was read.

These facts seem to point to the coast-line of the sea of the period having passed near the area in which these pipeclay-beds occur. The prevailing character of the Corfe deposits is such as would indicate them to have been derived from land consisting of granitoid rocks, while the clays and sands of the beds which lie to the north and east have been partly derived from rocks of the Secondary and Older Tertiary Periods, supplying the dark clays and the flint-pebbles which abound in them.

There remain but two localities of which I shall speak, namely, Alum Bay and High Cliff near Christchurch.

Alum Bay.—At Alum Bay, the greater part of the fossiliferous beds included in No. 29 of Mr. Prestwich's section * may be satisfactorily correlated with those usually known as the Barton and High Cliff series. There is a well-known and marked seam of dark-green sandy clay, containing abundance of *Nummulina Prestwichiana* †. It contains Barton forms; and therefore we may safely carry the Barton series down so far, though it is lower in the series than any bed from which fossils have hitherto been collected at High Cliff. The same Nummulite-bed occurs there also. Commencing with this bed, a descending section brings us, in about 15 feet, into beds of Bracklesham age.

	ft.	in.
10. Dark-greenish, coarse, sandy clay	3	0

(Crowded with *Nummulina Prestwichiana.*)

Rostellaria ampla.
—— rimosa.
Murex asper.
Typhis pungens.
Cancellaria.
Pyrula nexilis.
Fusus bulbus.
—— carinella.
—— errans.
—— interruptus.
—— longævus.
—— Noæ.
—— regularis.
—— unicarinatus.
—— n. sp., as at Hunting Br. and Hill Head.
Strepsidura turgida.
Cassidaria ambigua.
Ancillaria.
Pleurotoma turbida.
—— conoides.
—— plebeia.
Pleurotoma? sp.
Voluta athleta.
—— depauperata.
—— maga.
—— nodosa.
Mitra parva.
Marginella.
Natica labellata.
Turritella imbricataria.
Phorus agglutinans.
Calyptræa obliqua.
Dentalium.
Ostrea flabellula.
—— ? dorsata.
Pecten corneus.
Cardium (small species, like that of High Cliff).
Corbula pisum.
Pholadomya.
Echinoderm.
Operculina.
Nummulina Prestwichiana.

	ft.	in.
9 (*b*). Lead-coloured clay, with few fossils	3	0

Rostellaria macroptera.
Corbula pisum.

* Quart. Journ. Geol. Soc. vol. ii. pl. 9. See also the elaborate section at p. 136, and pl. 9, Mem. Geol. Surv., Isle of Wight, 1856.

† See note, on the determination of this Nummulite by Mr. T. R. Jones, to the paper by Sir C. Lyell on the Belgian Tertiaries, Quart. Journ. Geol. Soc. vol. viii. p. 334. See also Appendix B, p. 93.

	ft.	in.
8 (*a*). Dark sandy clay, with fossils (principally small bivalves)	9	0

Rostellaria ampla.
Fusus (? regularis).
Pleurotoma exorta.
Voluta nodosa.
Turritella imbricataria.
? Melania.
Calyptræa.
Solarium plicatum.
Arca aviculina.
Leda (common).
Nucula.
Cardium parile.
Cardita globosa.
Cultellus.
Corbula pisum.

Bracklesham Series.

	ft.	in.
7. Dark sandy clay	15	6
6. Indurated, dark-greenish, sandy clay, with impressions of fossils	1	0

Fusus ? undosus.
Murex asper.
Pyrula nexilis.
Turritella imbricataria.
Natica ambulacrum.
Dentalium, probably the species found at Hunting Bridge.
Cardium parile.
Cardita ? sp. (abundant); ribs acute and numerous, rather small.
Cytherea lucida.
—— suberycinoides.
Sanguinolaria Hollowaysii.
Modiola.
Tellina plagia.
—— ? filosa.
—— ? Branderi (common at Hunting Bridge).
—— ? sp.
Arca aviculina.

	ft.	in.
5. Dark sandy clay, containing a bed of septaria, like those beneath Rothsay Castle, High Cliff	11	0
4. Indurated, greyish, sandy clay, with impressions of fossils	0	7

Fusus ? undosus.
Voluta nodosa.
Natica.
Phorus agglutinans.
Turritella sulcifera.
Dentalium.
Teredo (in wood).
Pecten corneus.
Cardium parile.
—— (rather small and broad species, unknown).
Cardita (rather small, with numerous acute ribs; very abundant, the same as in the last bed).
Cardita (with fewer ribs; rare).
Cytherea obliqua.
—— suberycinoides.
—— lucida.
Tellina ? tumescens.
—— ? sp.
—— ? sp.
Sanguinolaria Hollowaysii.
Panopæa corrugata.
Leda.
Modiola (or *Mytilus*), n. sp.

	ft.	in.
3. Dark sandy clay, weathering greenish-grey, containing carbonaceous matter	16	0
2. Conglomerate of large flint-pebbles	0	10
1. Sands of various shades of yellow, white, and crimson.		

The lower 43 feet of this section appear to belong to the Bracklesham Beds.

Mr. Prestwich has remarked on the change of character in the organic remains towards the lower part of his stratum No. 29 (Journ. vol. ii. p. 242). The species, as he observes, are those of a shallow sea. But if I have determined them aright, several of them belong to the Bracklesham series, and, as I shall show hereafter, are in a part of the series which Mr. Prestwich has placed among the Bracklesham Sands at High Cliff.

Here, then, we have a proof that the Bracklesham Beds have not all become unfossiliferous at Alum Bay *, but the same shelving of the sea-bottom towards the coast-line †, which has here given an estuarine condition ‡ to the shallower seas of the lower and middle beds of the northern and eastern area, has converted the deep sea of the upper part into a shallow sea, represented by beds 6 and 4 of the section.

This shallower condition may account also for the disappearance at Alum Bay of the *Nummulina variolaria*. The water, already converted from an estuary into a shallow sea, seems to have continued to deepen §; and at No. 10 Nummulites come in abundantly. But the variety is not identical with that found in the upper beds of the Bracklesham series ‖; and the list of fossils from that bed contains species of a Barton type, viz. *Pleurotoma turbida* (*colon*), *P. conoides*, and *Cassidaria ambigua*.

High Cliff.—The well-known series of fossiliferous sands and sandy clays of Barton Cliff and High Cliff terminate downwards in a series of dark-green sandy clays ¶, which are based upon light-coloured sands **. These Mr. Prestwich considers to belong to the Bracklesham series.

There is an advantage in studying these beds at High Cliff, from the fact that the same strata are visible for a considerable distance in the cliff (fig. 2); so that the changes, due to horizontal range, which took place in them can be observed,—an advantage which is not offered by the vertical strata at Alum Bay and White Cliff Bay.

* Quart. Journ. Geol. Soc. vol. iii. p. 394.

† "Physical Geography of the Tertiary Estuary of the Isle of Wight," by H. C. Sorby, Esq., Edin. New Phil. Journ., Apr. 1857.

‡ Memoir of Geol. Survey on Isle of Wight, p. 34.

§ Edin. New Phil. Journ. *ibid.*

‖ See Sir C. Lyell's paper on the Belgian Tertiaries (Geol. Soc. Journ. vol. viii. p. 334, *note*). Mr. T. R. Jones informs me that this Nummulite is a variety of *N. planulata*, as also is *N. variolaria*. The common Nummulite of the High Cliff Sands is *N. variolaria*. The Alum Bay variety is here called *N. Prestwichiana*. See Appendix B, page 93.

¶ The green colouring-matter which is so common in the Middle Eocene beds is remarkably abundant here. It occurs in grains, which, when separated from the matrix, have the size and form of grains of fine gunpowder.

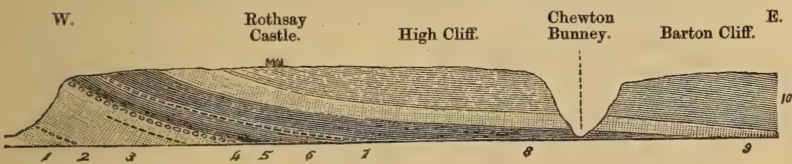
Professor Liveing has kindly furnished me with the following analysis of this substance, and informs me that it does not differ materially from the colouring-matter of the Greensand bed at the base of the Lower Chalk of Cambridgeshire:—

Water	10·02
Silica	50·11
Iron, protoxide	25·04
Alumina	6·12
Magnesia	3·14
Potash	5·17
	99·60

** See Mr. Prestwich's paper "On the Strata of Christchurch Harbour," Quart. Journ Geol. Soc. vol. v. p. 44.

It has been seen, in the lists of fossils from the Alum Bay beds, that the *Nummulina Prestwichiana* bed contains Barton forms, viz. *Pleurotoma turbida, P. conoides,* and *Cassidaria ambigua,* while the superior beds at that place afford assemblages of fossils exactly analogous to the well-known High Cliff and Barton types. I have therefore assumed the *Nummulina Prestwichiana* bed at Alum Bay to belong to the Barton series.

Fig. 2.—*Section of High Cliff and Barton Cliff.* Length 2 miles.



1. White siliceous sand.
2. Band of flint-pebbles.
3. Sands, with a band of iron-stone septaria.
4. Pebble-bed and fossils.

} Brackle-sham beds.

5. Dark-green sandy clay.
6. Slightly indurated marly clay.
7. *Nummulina Prestwichiana* bed.
8. Grey clays.
9. "High Cliff Sands."
10. "Barton Clays."

} Barton beds.

I find a bed containing *Nummulina Prestwichiana,* at High Cliff, analogous to that at Alum Bay. I believe it has hitherto been overlooked, but it may easily be recognized by the following indication: —There will be observed extending along all the central portion of High Cliff, not far overhead, as you walk upon the beach, a narrow band of hard marly clay *, not quite a foot thick, weathering of a reddish foxy tint, and projecting slightly beyond the general face of the cliff. Immediately above this, in marked contrast of colour, is a narrow green band of coarse sandy clay, about 8 in. thick. This is the *Nummulina Prestwichiana* bed. It is much thinner than at Alum Bay, and the Nummulites are less profusely scattered in it. At this place they are pyritized. They are entirely distinct in appearance from the *N. variolaria* of the sands in the beds above. Now, here this bed is thin, and poor in fossils; but, judging from the equivalent bed at Alum Bay, it belongs to the Barton series; and I have seen nothing above it which would lead me to place it otherwise. I therefore commence my High Cliff section with this bed, as has been done already in the Alum Bay section †.

* This is the band of tabular soft septaria, mixed with green sand, of Mr. Prestwich's section (Quart. Journ. Geol. Soc. vol. v. p. 44).

† The upper part of this section was made more to the east than Mr. Prestwich's, as may be seen by the position of the flint gravel which caps his section. The slight differences in the measurements are thus accounted for. It is also carried rather further down. The lower part is often obscured by talus, but was better exposed than usual when I last saw it.

The fossils of this locality, having lost all their shelly matter, are the less easy of determination. On that account the lists here given must not be looked upon as beyond question. Nevertheless the characters of the species are better preserved than in ordinary casts.

Section at High Cliff.

	ft.	in.
7. *Nummulina Prestwichiana* bed, in coarse, green, sandy clay with grains of quartz. The tool gives a bright-green streak. This bed passes beneath the beach at about 750 yards west of Chewton Bunny	0	8

Nummulina Prestwichiana.
Natica (small).
Cardium parile.
Cardita (small, ribbed).
Cytherea.

	ft.	in.
6. Slightly indurated marly clay, mottled green and brownish grey. It weathers of a foxy-red. "Tabular soft Septaria"	0	7

Nummulina Prestwichiana.
Ancillaria canalifera.
Voluta (small, with distant ribs).
—— (? nodosa).
Turritella imbricataria
Cardium parile.
Cardita (small, ribbed).
Modiola.
Corbula pisum.
Thracia.
Echinoderm.

	ft.	in.
5. Dark-green, coarse, sandy clay, giving a bright-green streak with the tool. "Clayey green sand"	9	0

Fusus pyrus.
Pyrula nexilis.
Voluta ? nodosa.
Dentalium.
Cardium semistriatum.
Cardita (small, ribbed).
Cytherea (a Barton species).
Crassatella costata.
Corbula pisum.

(*Bracklesham Series.*)

	ft.	in.
4. Pebble-bed towards the west, changing towards the east into a soft, dark, sandy clay, with scattered pebbles, and full of impressions of fossils. "Rounded flint-pebbles"	1	6

Murex minax.
Fusus carinella (common).
Voluta nodosa.
Serpula.
Dentalium (large species).
Arca duplicata.
Cardium parile.
—— porulosum.
Cardita (ribbed).
Cytherea (? lucida).
—— suberycinoides (common).
—— ? trigonula.
Crassatella sulcata.
—— ? compressa.
Sanguinolaria Hollowaysii.
Corbula Gallica.
—— pisum.
Panopæa.

	ft.	in.
3. Sands, clayey at the bottom. Towards the west these are clearly stratified in three beds; but soon the middle division suddenly thins out, and the upper and lower divisions come into contact, with very confused bedding. The colour also changes from white to a brownish hue. Vegetable matter is abundant throughout; and impressions of fossils abound towards the east. There is a band of ironstone-septaria in these sands which is not persistent	33	0

Turritella imbricataria.
Arca aviculina.
Pecten corneus.
Pecten ? 30-costatus.
Tellina dis-stria.
Cardium parile.

Cytherea suberycinoides (common).
—— lucida.
—— ? trigonula.
Solen (long and narrow).
Panopæa.
Modiola.

	ft.	in.
2. Band of flint-pebbles, engaged in the base of the last bed. They have become white and friable	0	6
1. White siliceous sand; the bottom is not seen	6	0

The list of fossils from No. 4 agrees well with its assigned position in the Bracklesham series; while I have seen no species in No. 5 to bring it within that category. Moreover there is every indication of No. 4 having formed the bottom of the sea for a long period, during which the sediment, small in quantity, differed from that which afterwards constituted bed No. 5. From these two considerations, it may appear admissible to place the line of division where nature seems to have placed it, viz. above the pebble-bed; and I have endeavoured to place it in the corresponding point at Alum Bay. This pebble-bed, which is strictly a fossil-bed, seems to be contemporary with No. 6 at Alum Bay, and is probably a shallower condition of the Hunting Bridge Bed. There are two species, not usually at all abundant in the other beds of the series, which appear rather common at Hunting Bridge and in these highest Bracklesham beds at Alum Bay and High Cliff; they are *Fusus carinella* and *Tellina Branderi*, var.

Figs. 3 and 4.—*Comparative Sections of the Strata at Alum Bay and High Cliff.* Scale $\frac{1}{8}$th of an inch to a foot.

Fig. 3.—*Alum Bay.*

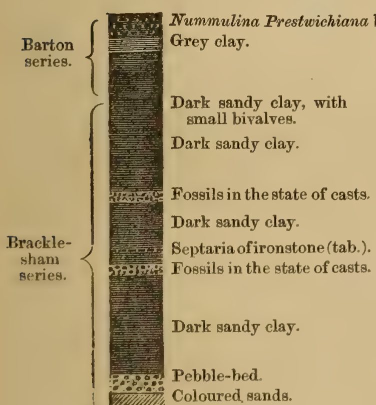


Fig. 4.—*High Cliff.*

A comparison of the sections near the junctions at Alum Bay and High Cliff will render the correlation of the beds at those places clear. It appears that all the strata in this part of the series are thicker at Alum Bay than at High Cliff. The *Nummulina Prestwichiana* Bed may be taken as a safe horizon at the two localities. Seeing that the upper pebble-bed of High Cliff changes into a fossil-bed, with scarcely any pebbles, in the range of about a mile, it is not surprising to find no pebble-bed in its place at Alum Bay. The tabular iron-stone septaria hold a similar place in each section, and are identical in appearance. The great pebble-bed of Alum Bay appears to be equivalent to the lower and less important one of High Cliff, and the coloured sands of Alum Bay to represent the white sand at the base of the High Cliff section. (See figs. 3 & 4.)

The casts of fossils at both these localities are in a rather peculiar condition. They are not casts of the inner, but of the outer surfaces of the shells. After the shell had been dissolved away, the matrix which filled it appears to have been pressed into the mould left by the outer surface; and in some cases traces of the epidermis seem to have remained. Thus it will be seen that these casts are more suited to the determination of species than is usually the case.

It may also be noticed that High Cliff is the only locality referred to where there appears to be a natural physical break and distinct change in the character of the deposit between the Bracklesham and Barton beds. The division is probably, in reality, one of convenience only, the two groups forming a continuous series changing *gradually* throughout in its lithological character and fauna. And if we take a comprehensive view of these two portions of the Eocene series in Hampshire, it will appear that the amount of depression of the sea-bottom*, on the whole, exceeded the depth of sediment deposited during the Bracklesham period, while the reverse was the case during the Barton period; so that the tendency in the former case was from an estuarine to a deep-sea condition, while towards the close of the Barton period an estuarine condition again prevailed. This, however, again gave way to a marine condition during the deposition of the Hempstead series; and we have no means of carrying the record further in our district.

Pebble-beds.—At White Cliff Bay, Alum Bay, and High Cliff, and in a less degree at Bracklesham, we meet with several pebble-beds; and the sequence in which they occur seems usually be this:—The character of the deposits in ascending order, that is, in the order of events, changes gradually from clay to sand; and when a sandy condition has obtained for some time, we meet with a bed of pebbles; these are again followed by clay, and a like sequence recommences. It is also very evident that the pebble-beds at localities not far distant from each other occur on different horizons.

Now the pebble-bed at High Cliff affords an opportunity for studying one of these deposits for about a mile; and the changes in it in that short distance are very remarkable. At the western part, where a fallen block fortunately gave me an opportunity of studying it, it is a conglomerate of rolled pebbles of flint, with a few of quartz and other rocks, imbedded in a clayey matrix, which contains impressions of fragments of shells and of vegetable matter. But as it is followed towards the west the pebbles become gradually less numerous, until, at the point where it sinks beneath the beach,

* Prestwich, Quart. Journ. Geol. Soc. vol. ii. p. 251.

there are few to be met with, while the shells are much less broken. This shows that the pebble-bed was a very local condition of the sea-bottom of that period, either caused by the spot being subject to stronger currents, or to its being a littoral zone. The matrix, however, in which the pebbles are imbedded is of a different character from the bed beneath, being finer and more argillaceous. There must, therefore, have been a change in the conditions of deposition accompanying, or immediately succeeding, the dispersion of the pebbles. And one new condition seems to have been, that the amount of deposit for a long period of time was comparatively very small, so that the exuviæ of many generations of mollusks were accumulated in a small vertical range. Afterwards the amount of deposit increased, and simultaneously the Bracklesham types disappeared from the locality. There is another pebble-bed at High Cliff, lower in the series; and a similar change in the deposit occurs there also. From a sharp sand we pass upwards into a sandy clay, and the pebbles are imbedded in the base of the bed of clay.

In short, it appears as if a pebble-bed usually accompanied a change from a shallow to a deeper condition of the sea. Can the dispersion of these pebbles have been owing to sudden subsidence of the sea-bottom? This is a question which has much interest; and, when we consider the local condition of the area, it does not appear to suggest an improbable solution of the phenomena. Such movements would have distributed pebbles to a certain distance from the marginal zone, or from such other accumulations as may have been subject to their influence.

Sir Charles Lyell has brought together proofs that the Weald had begun to be elevated before the Eocene period*. The elevation of the Chalk of the Isle of Wight is undoubtedly a part of the same system of disturbances; and the present contorted form which it has assumed is merely an intensified condition of a form that it had begun to assume before the Eocene period. Anticlinals were then probably forming where anticlinals exist now; and the synclinals occupy the same positions that they did of old.

Moreover the whole effect was produced by lateral pressure. When, then, at any period the pressure had accumulated to such an extent that the beds gave way, the anticlinals would be raised and the synclinals be depressed relatively, if not absolutely; and thus (the curves occupying but moderate intervals) areas not far distant would be raised and depressed simultaneously. Nor does it appear necessary that an equal amount of disturbance should take place *along* the axis of the country at the same period; but a portion towards the east might be more affected at one time, and towards the west at another.

Movements are still going on in the island. Mr. Godwin-Austen, amongst other evidences of change of level, refers to an old well, near Brading, which is now rendered useless, being covered by the sea at high tide†. The opposite coast of Sussex has been not unfre-

* Manual of Geology, 5th ed. p. 282.
† Quart. Journ. Geol. Soc. vol. xiii. p. 66.

quently visited by earthquakes: such are recorded as having occurred in recent times, and, of late years, in December 1824 (Portsmouth, Chichester, and the neighbourhood), in 1833 (Horsham, Sussex), and in January, August, and October of 1834 (Chichester, &c.)*.

Conclusion.—Before concluding this paper, there is one point to which I would refer. It seems that in a series of deposits like that of the Bracklesham and Barton beds we have the best field for the investigation of the great problem of the succession of species. We have in these an extended series of beds in which the record seems nearly perfect. It is true that we have occasionally physical breaks in the sequence; but still we have long intervals in which the species change and no physical breaks can be detected. I would suggest that a genus should be taken in hand, such as *Voluta* or *Pleurotoma*, and that intermediate forms between species succeeding each other in time should be sought out, not necessarily on the same spot, but in beds of the same or intermediate age in other parts of the area occupied by eocene deposits.

I should ill repay the kindness of Mr. F. E. Edwards did I omit to acknowledge the invaluable assistance I have received from him towards naming the specimens in my collection, by the aid of which I have been enabled to give the lists of fossils from the various localities. Mr. T. R. Jones has also helped me most materially with respect to the Foraminifera, and likewise by pointing out many references to the works of other geologists, who have preceded me in this most interesting field of research.

APPENDIX A.

On the Correlation of the Fossiliferous Localities of the Bracklesham Beds (descending).

a.
- Some portion of No. XIX., White Cliff Bay.
- Coral-bed (No. 20) of Stokes Bay, Stubbington.
- Coral-bed and Shell-bed of Hunting Bridge, New Forest.
- Pebble-bed (No. 4), with casts of shells, at High Cliff.
- Bed (No. 6), with casts of shells, Alum Bay.

b.
- *Nummulina variolaria* bed (No. XVII.), White Cliff Bay.
- *N. variolaria* bed (No. 22) (the "Clibs") and Mixen rocks of Selsea.
- *N. variolaria* bed (No. 16) of Stubbington.
- Shepherd's Gutter Bed of Bramshaw, New Forest.
- Threewater Gutter Bed of Brook, New Forest.

c.
- Sand-rock (No. XVI.), White Cliff Bay.
- Hard bed (No. 21), opposite Medmery Farm, Selsea.
- Liver-coloured clay (No. 15), Stubbington.
- Purplish sandy clay, beneath the Shepherd's Gutter Bed, New Forest.

* See Mallet's 'Earthquake Catalogue.'

d. { Dark sandy clay (No. xiv.), White Cliff Bay.
Clay bed (No. 19), west of Medmery Farm-house, Selsea. It is the *Cypræa* (*Bowerbankii*) bed of Dixon, from which most of the Selsea fossils have been collected.
Cardita-bed (No. 13), Stubbington. It is the oldest known collecting-ground of that place.
King's Garden Gutter Bed, New Forest, cited by Mr. Edwards as the "Brook" locality.

e. { Sandy clay (No. xi.), White Cliff Bay.
Sand (No. 16), Bracklesham Bay.
Sandy clay (No. 6), Stubbington.

f. { Shell- and pebble-bed (No. ix.), White Cliff Bay.
Cerithium giganteum bed (No. 12), half a mile west of Thorney Station, Bracklesham Bay.
Hill Head, Stubbington.

g. { *Nummulina lævigata* bed (No. vii.), White Cliff Bay.
"Park Bed," on the west of the Selsea Peninsula, near the "Barracks."
"Little Park Bed" (No. 6), Bracklesham Bay.
In the well at Bury Cross, Gosport Waterworks.
At the Southampton Docks.

h. { Bed No. vi., White Cliff Bay.
"Palate-bed" of Dixon: No. 4, Bracklesham Bay, nearly half a mile east of the spot where the Bracklesham Homestead formerly stood.
It is also to be found at "The Park," Selsea.

k. { Bed No. iv., White Cliff Bay.
"*Venericardia* (*Cardita*) bed" of Dixon: No. 1, Bracklesham Bay, opposite where Bracklesham formerly stood.
It also occurs at "The Park."

APPENDIX B. (See pages 86 and 87.)

Note on Nummulina planulata, *Lamarck*, sp., *var.* Prestwichiana, *Jones*. By T. Rupert Jones, F.G.S.

This little Nummulite is discoidal, smooth, and flat, rarely in any degree biconvex, even in the young state, unless the outer whorl has been flattened by pressure; about $\frac{1}{10}$th inch in diameter, and $\frac{1}{75}$th in thickness. The gently sigmoid and semitranslucent edges of the septa appear at the surface, and but seldom rise above it (except when the specimens are mechanically compressed, which is a common condition). The whorls (three in large specimens) are all visible in empty shells made transparent by water or Canada-balsam; they are proportionally wide for *Nummulina* (the outer whorl making half the width of the disk). The chambers are about half as long as wide, neatly curved, but subject to irregularity of growth. The lateral portions of the chambers, though very shallow, are continued over the surface towards the centre on each face, and are rather straighter in old specimens than in the young.

This neat and delicate variety of *Nummulina planulata*, Lamarck, sp., has long been known in a clay containing much green sand, at Alum Bay, Isle of Wight (lower part of the bed 'No. 29' of Mr. Prestwich's Section, Quart. Journ. Geol. Soc. vol. ii. p. 257, pl. 9. fig. 1.); but it has not hitherto been described *. It is near to MM. d'Archiac and Haime's '*Nummulites planulata*, var. *a*,' from Jette, Belgium †; but the latter has a biconvex centre (opake when mounted in balsam), has narrower whorls (in the proportion of 1 to 4, instead of 1½ to 4), and grows to a somewhat larger size. To distinguish our variety (which characterizes a well-marked geological zone), I propose to give it the name of *Prestwichiana*; and, as the small biconvex variety of *Nummulina planulata* passes binomially as *N. variolaria*, so this small depressed variety of the same species may be allowed to stand on a similar footing, and be known as *N. Prestwichiana.*

In the sandy clay-bed at Alum Bay the shells of this little Nummulite are very numerous, and often well preserved, but not unfrequently much crushed by pressure. In many specimens, especially large ones, the chambers are occupied by iron-pyrites; and neat casts may be obtained by carefully dissolving the shell in weak dilute acid. In the clay at High Cliff the shells are not so numerous, are very much compressed, and so highly pyritized that they are readily destroyed by the atmosphere.

January 8, 1862.

Charles Sturtirant Wood, Esq., Geological Survey of Otago, New Zealand; Robert Harris Valpy, Esq., Enborne, near Newbury; and William Shepherd Horton, Esq., 10 Church Street, Liverpool, were elected Fellows.

The following communications were read:—

1. *On the* Carboniferous Limestone *of* Oreton *and* Farlow, Clee Hills, Shropshire. By Prof. John Morris, V.P.G.S., and Mr. George E. Roberts. *With a Description of a New* Pterichthys; by Sir Philip de M. G. Egerton, Bart., M.P., F.R.S., F.G.S.

[Plate III.]

Contents.

§ 1. The general physical and palæontological features of the small district referred to in these notes having been carefully and clearly

* "*Nummulites lævigatus* and *N. elegans*" are incorrectly referred to as occurring in this bed, No. 29, *op. cit.* p. 257.

† See 'Foss. de l'Inde,' pp. 143, 144; and also Quart. Journ. Geol. Soc. vol. viii. p. 333, *note*.

described by Sir Roderick Murchison in his classic work 'The Silurian System,' the additional facts which a visit paid to it during the past autumn enables us to record may be considered simply as a continuation of those previously observed.

The thin beds of limestone which form the basement of the Titterstone Clee Coal-field are well exposed in a marginal flexure of the strata north-eastward of the hill, at Oreton and Farlow, and also, at a somewhat higher level, around its southern abutments. Our observations upon the character of the beds and their fossil contents have been confined to the exposures in the first-named localities.

The geographical relations of this limestone ridge with the nearlying millstone-grit and coal-measures, in their turn covered up by the sheets of erupted basalt which form the high summits of the Clee, are well seen from the igneous knoll of Kinlet, three miles to the eastward.

§ 2. Immediately below the summit of the ridge at Farlow, and on the northern side, is a quarry of yellow sandstone, from which recently a large quantity of stone has been obtained for the rebuilding of the church.

It is a thick-bedded, fine-grained sandstone, having ripple-marked surfaces, and occasionally containing disseminated pebbles of quartz. The colour of the stone is a pale yellow, in places slightly stained by ferruginous oxidation. Remains of fossil Fishes were first detected in this quarry in 1856; these consisted of dermal plates of *Pterichthys*, or an allied genus; and from it was subsequently obtained by Mr. T. Baxter, F.G.S., the anterior portion of a *Pterichthys*, of a new species, which is now in the collection of Sir Philip Egerton. It is described by Sir Philip at the end of this paper. Several other specimens (one nearly perfect) of this new species have lately been obtained by us from some large slabs of this yellow sandstone, as well as fragments of a larger *Pterichthys*, and detached scales of a small *Holoptychius*, probably of an undescribed species. A single plate of the well-known *Holoptychius giganteus* also rewarded our search. No remains of Testacea (with the exception of fragments of *Conulariæ*) nor of Plants have yet been detected in these beds.

The measures lying between this Pterichthys-bearing sandstone, and the Old Red rocks which form a wide surface to the northward, are the following, given in descending order:—coarse yellow sand, without pebbles; yellow sand with loosely laid pebbles of quartz; a thin bed of similar pebbles, compacted into a conglomerate; and fissile yellowish sandstones. The precise junction of this lowest bed with the red rocks having cornstone-bands is not at present to be seen, but a roadway now in progress of cutting will probably expose it.

Above the Pterichthys-bed, a nearly similar series of alternating sands, with and without pebbles, lead up to compact pebbly sandstones and coarse grits; and these are capped near the summit of the ridge by fissile yellow sandstones. About thirty feet of unknown ground lies between this and the beginning of the limestone series.

Passing southward over the ridge, and at a point immediately below its summit, the upper beds of this sandstone series are observed, underlying and passing into the Carboniferous Limestone series above.

This junction with the superincumbent limestone beds is clearly to be seen in a quarry S. of the road, in a line with the one we have been describing. The general relations of the series are seen in the following section. The strata dipping to the S.E. at an angle of 60°.

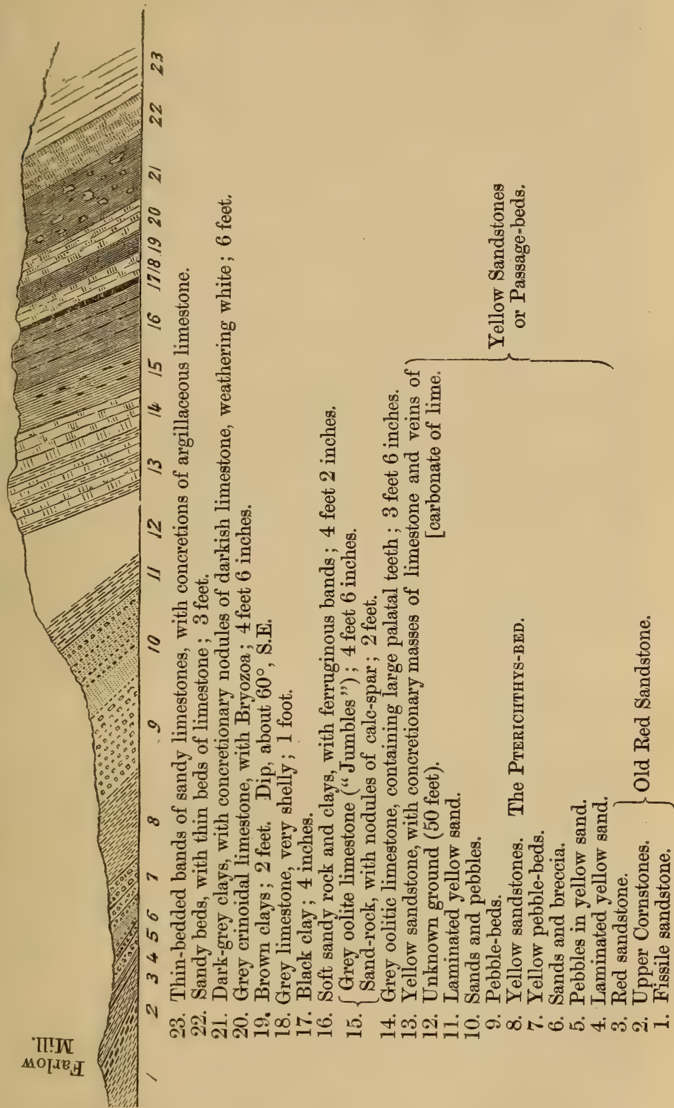
All the beds in this section, and more especially the oolitic limestone, are seen to increase in thickness as we trace them eastward from Farlow to Oreton.

Many Cestraciont palatal teeth and Brachiopodous shells have been obtained from this opening into the limestone ridge, so graphically described by Murchison. Half-a-mile eastward of it are the greater quarries of Oreton. There is evidence in the intermediate space of the limestone having been formerly worked; for numerous hollows, from which stone has been got, make the irregularly undulating ground still more uneven.

We are indebted to the Rev. J. Williams, of Farlow, for some valuable information relating to a recent exposure, in one of the deepest of the Oreton quarries, of the subterranean stream which has long been known as flowing parallel with the axis of the ridge. This "mole river" loses itself in a hollow called the Foxholes, at the western extremity of the limestone, and, taking an N.N.E. course, reappears at the distance of a mile, about 300 yards from its confluence with the River Rea. Two of the quarrymen, who had struck upon it at the depth of about fifty feet from the surface, described it as a constant stream, occasionally greatly swollen by floods. An interesting account of an accidental stoppage at its inlet during one of the great floods of last year was furnished us by Mr. Williams. He stated, from his own observation, that two and a half acres of the hollow were covered to an average depth of fifteen feet by the damming up of its course. Forty-eight hours sufficed to drain away this accumulation of water through its underground passage. From the data supplied by the careful observations of Mr. Williams, whose residence is above the stream, the lake thus formed must have contained one million six hundred and thirty-five thousand cubic feet of water; and the rate of its subsidence was not less than thirty-four thousand cubic feet per hour. It appears from this that the fissure through which the stream flows is of no insignificant dimensions.

§ 3. The quarries at Oreton are very extensively worked, and afford a good section of the general thickness and character of this limestone in its northern area. In the order of the beds, the deposits are a repetition, in greater thickness, of those exposed at Farlow. The variable character of this limestone, and its thinning out at each extremity, have been alluded to in 'The Silurian System,' and are interesting as showing the different conditions, within a limited area, which obtained during its deposition. As a rule, the middle and lower parts of the limestone series are more fossiliferous than the upper; and these indicate a deep-sea condition, by the abundance

Section through the Yellow Sandstones at Farlow, Shropshire, showing also the Lower Carboniferous Limestones.



of Brachiopodous shells, and the absence of large Lamellibranchiate bivalves. The most important physical feature of the series are the bands of oolitic limestone, which indicate by their structure similar agencies of formation to those which have produced like beds in the

Carboniferous Limestones of Bristol and along the margins of the South-Wales Coal-field.

Most of the larger palatal teeth lie in the specular limestone, and in this the oolitic grains are associated with fragments of Brachiopods, Bryozoa, and Crinoids.

As the limestone-bands differ in character, some being more shelly than others, some oolitic, and a third group slightly argillaceous and sandy, they necessarily vary in commercial value, and are used for sundry purposes, among which lime-making and building-stone appear to be chief. The thickest of the oolitic beds has been worked to a considerable extent for decorative purposes; this is locally called "jumbles," but is elsewhere known as "Clee Hill marble."

§ 4. But, besides its economic value, this quarry is particularly interesting and important to the palæontologist, with regard to the fossil fauna of the period, in the comparative abundance of well-preserved ichthyic remains, chiefly Cestraciont teeth and fin-spines. We are indebted to Mr. Weaver Jones, of Cleobury Mortimer, for the preservation of some of the finer and more remarkable of these, especially the great *Deltodi*, which probably belong to an undescribed species. The attention of another gentleman, Mr. E. Baugh, of Bewdley, has been directed of late years to the fossil contents of these limestones; and with much assiduity he has collected every fragment of organism which could add to our knowledge.

The following genera are represented by palatal teeth:—*Orodus* (specimens of *O. ramosus* of unusual size are occasionally met with, —one of those we exhibit exceeds the largest figured by Agassiz), *Helodus, Cochliodus, Cladodus, Psammodus, Deltodus* (examples of a new species of this form of tooth, of great dimensions, which have been found several times of late, are here figured), and, more rarely, the cusped *Pristicladodus Goughii*.

With these, fin-spines of great size are occasionally found associated. The form most commonly met with is that of a *Ctenacanthus*; but the series of tubercles, more or less compressed, which are arranged perpendicular to its length, do not agree with any published figure. Specimens, however, less ornamented, and which appear to be *Ctenacanthus brevis*, are also met with.

No other ichthyic remains, save a few undeterminable fragments, probably of dermal plates, have come under our notice.

Zones of shells also occur in these limestones, both above and below the beds which contain the fish-fossils, but very rarely associated with them. These are principally Brachiopods, of which *Spiriferæ* and *Rhynchonellæ* are the most abundant. The species are but few in number; but an instructive series of intermediate forms —as, for example, those which appear to link together *Spirifer cuspidatus* and *Sp. distans*—may be collected.

Among the *Rhynchonellæ*, *R. pleurodon* is found in great abundance at the bottom of the series, though we have met with no instance of its occurrence in the previously laid sandstones.

Terebratulæ are nearly, if not quite, absent; and *Discinæ* are only represented by one species—*D. nitida*.

Of *Gasteropoda* we have only seen *Euomphalus pentangulatus*.

The *Crustacea* are as poorly represented; one imperfect specimen of *Phillipsia mucronata*, from the lower beds, being our sole illustration.

Bryozoan remains are numerous, though they appear to be confined within the narrow limits of the crinoidal band. Several species of *Fenestella* make a seeming confusion upon some surfaces in this bed, by the wildness and luxuriance of their growth; of these, the commonest are *Fenestella plebeia* and *F. Morrisii*. Associated with them is the elegantly sculptured *Vincularia megastoma*, and some other slightly branching *Bryozoa*.

No well-defined remains of *Crinoideæ* have been found, although one band of rock appears to be made up of the separated ossicula and pelvic plates of these animals, chiefly referable to *Poteriocrinus gracilis*, *Cyathocrinus macrocheirus*, and *C. quinquangularis*.

The fish-remains tabulated below, and contrasted with those from the Mountain Limestone of other districts, though numerous, do not, as we believe, exhaust the series. Some of the smaller forms of *Helodus* and *Psammodus*, unrepresented in the Oreton column of the annexed Table, probably occur in those limestones, but we are unable at present to verify this assumption.

In concluding our remarks, we have to express regret that the distance and the difficulty of removing the large collection liberally offered us for study by Mr. Weaver Jones prevent us now entering upon other questions of interest connected with the relative value of the palæontological contents of this interesting locality; for we see in this, as in other instances, the possibility of giving decisions of value, by carefully elaborating the treasured-up systems of organic life preserved by a single district.

Table showing the Geographical Range of the Fishes of the Mountain-Limestone.

[*Note.*—The materials of this Table are derived from the following authorities: the British species from Agassiz and M'Coy; the Belgian from De Koninck; and the Russian from those cited by E. d'Eichwald in his 'Lethæa Rossica,' 1861. The column for Ireland is chiefly made up from the Armagh specimens, and includes the new species with MS. unpublished names contained in the cabinet of the Earl of Enniskillen, upon which it is the intention of Professor Agassiz to publish papers; and also those, from the Lower Carboniferous rocks, cited by M'Coy. The column for North Britain refers to the Lower Carboniferous rocks of Westmoreland, Northumberland, and Scotland.]

	Oreton and Farlow.	Bristol.	Yorkshire and Derbyshire.	Ireland (chiefly Armagh).	North Britain.
Acrolepis Hopkinsii, *M'Coy* ...	......	......	*		
Asteroptychius ornatus, *Ag.* ...	......	......	......	*	
Carcharopsis prototypus, *Ag.*...	......	......	*	*	
—— Portlockii, *Ag.*	......	......	......	*	
—— semiornatus, *M'Coy*	......	......	......	*	
Characodus angulatus, *Ag.*......	......	......	......	*	
—— cuneatus, *Ag.*	......	......	......	*	
Cheirodus pes-ranæ, *M'Coy* ...	......	......	*		
Chomatodus cinctus, *Ag.*........	*	*	......	*	*

	Oreton and Farlow.	Bristol.	Yorkshire and Derbyshire.	Ireland (chiefly Armagh).	North Britain.
Chomatodus clavatus, *M'Coy*	......	......	......	*	
—— denticulatus, *M'Coy*	......	......	......	*	
—— linearis, *Ag.*	*	*	......	*	
—— obliquus, *M'Coy*	......	......	......	*	
—— truncatus, *Ag.*	......	......	......	*	
—— sp.	......	......	*		
Cladacanthus paradoxus, *Ag.*	......	......	......	*	
Cladodus acutus, *Ag.*	......	......	......	*	
—— basalis, *Ag.*	......	......	......	*	
—— conicus, *Ag.*	......	*			
—— lævis, *M'Coy*	......	......	......	*	
—— marginatus, *Ag.*	......	......	......	*	
—— Milleri, *Ag.*	......	*			
—— mirabilis, *Ag.*	......	*	*	*	
—— striatus, *Ag.*	......	......	......	*	
Climaxodus imbricatus, *M'Coy*	......	......	*		
? Coccosteus carbonarius, *M'Coy*	......	......	......	*	
Cochliodus contortus, *Ag.*	*	*	*		
—— magnus (?), *Ag.*	*				
—— striatus (?), *Ag.*	*				
? —— n. s.	*				
Colonodus longidens, *M'Coy*	......	......	......	*	
Copodus cornutus, *Ag.*	......	......	......	*	
—— falcatus, *Ag.*	......	......	......	*	
—— lunulatus, *Ag.*	......	......	......	*	
—— spatulatus, *Ag.*	......	......	......	*	
Cosmacanthus carbonarius, *M'C.*	......	......	......	*	
Cricacathus Jonesii, *Ag.*	......	......	......	*	
Ctenacanthus arcuatus, *Ag.*	......	......	......	*	
—— brevis, *Ag.*	*	*			
—— crenulatus, *Ag.*	......	......	......	*	
—— distans, *M'Coy*	......	......	......	*	
—— heterogyrus, *Ag.*	......	......	......	*	
—— major, *Ag.*	*	*			
—— tenuistriatus, *Ag.*	*	*			
—— n. s.	*				
Ctenopetalus serratus, *Ag.*	*	......	*	*	
Deltodus sublævis, *Ag.*	......	......	......	*	
—— n. s.	*				
Deltoptychius acutus, *Ag.*	.. ...	*	*	*	
—— gibberulus, *Ag.*	......	......	......	*	
Dimyleus Woodii, *Ag.*	......	......	*		
Dipriacanthus falcatus, *M'Coy*	......	......	......	*	
—— Stokesii, *M'Coy*	......	......	......	*	
Erismacanthus Jonesii, *M'Coy*	......	......	......	*	
Glossodes lingua-bovis, *M'Coy*	......	......	......	*	
—— marginatus, *M'Coy*	......	......	......	*	
Gyracanthus tuberculatus, *Ag.*	......	......	......	*	
Harpacodus dentatus, *Ag.*	......	......	......	*	
Helodus appendiculatus, *M'Coy*	......	......	......	*	
—— didymus, *Ag.*	*	......	......	*	
—— gibberulus, *Ag.*	......	*	......	*	
—— lævissimus, *Ag.*	*	*	......	*	
—— mammillaris, *Ag.*	*	......	......	*	
—— rudis, *M'Coy*	......	......	......	*	
—— subteres, *Ag.*	*	*			
—— turgidus, *Ag.*	......	*	......	*	
—— sp.	......	......	*		
Holoptychius Hibbertii, *Ag.*	......	......	......	*	
Homacanthus macrodus, *M'Coy*	......	......	......	*	

	Oreton and Farlow.	Bristol.	Yorkshire and Derbyshire.	Ireland (chiefly Armagh).	North Britain.
Homacanthus microdus, *M'Coy*	......	......	......	*	
Labodus planus, *Ag.*	......	......	......	*	
—— prototypus, *Ag.*	......	......	......	*	
Leptacanthus junceus, *M'Coy*	......	......	*		
—— priscus, *Ag.*	......	......	......	*	
—— Jenkinsoni, *M'Coy*	......	......	......	......	*
Mesogomphus lingua, *Ag.*	......	......	......	*	
Mylacodus quadratus, *Ag.*	......	......	......	*	
Mylax batoides, *Ag.*	......	......	......	*	
Nemacanthus priscus, *M'Coy*	......	......	......	*	
Onchus falcatus, *Ag.*	......	......	......	*	
—— hamatus, *Ag.*	......	*			
—— plicatus, *Ag.*	......	......	......	*	
—— rectus, *Ag.*	......	......	......	*	
—— sulcatus, *Ag.*	......	*			
Oracanthus confluens, *Ag.*	......	......	......	*	
—— Milleri, *Ag.*	......	*			
—— minor, *Ag.*	......	*	......	*	
—— pustulosus, *Ag.*	......	*			
Orodus angustus, *Ag.*	......	......	......	*	
—— catenatus, *Ag.*	......	......	......	*	
—— cinctus, *Ag.*	*	*	......	*	
—— compressus, *M'Coy*	......	......	......	*	
—— gibbus, *Ag.*	......	......	......	*	
—— porosus, *M'Coy*	......	......	......	*	
—— ramosus, *Ag.*	*	*	......	*	
Petalodus acuminatus, *Ag.*	......	......	*	*	*
—— Hastingsiæ, *Owen*	......	......	......	*	
—— lævissimus, *Ag.*	......	......	......	*	
—— marginalis, *Ag.*	......	......	......	*	
—— sagittatus, *Ag.*	......	......	*	*	
Petalorhynchus psittacinus, *Ag.*	......	......	*	*	
Petrodus petalliformis, *M'Coy*	......	......	......		
Pinacodus gelasinus, *Ag.*	......	......	......	*	
—— gonoplax, *Ag.*	......	......	......	*	
Physonemus arcuatus, *M'Coy*	......	......	......	*	
—— subteres, *Ag.*	......	......	......	*	
Platycanthus isosceles, *M'Coy*	......	......	......	*	
Pleurogomphus auriculatus, *Ag.*	......	......	......	*	
Pœcilodus aliformis, *M'Coy*	......	......	*		
—— foveolatus, *M'Coy*	......	......	*		
—— Jonesii, *Ag.*	......	......	......	*	*
—— obliquus, *Ag.*	......	......	......	*	
Polyrhizodus pusillus, *M'Coy*	......	......	......	*	
—— radicans, *Ag.*	......	......	......	*	*
Pristodus falcatus, *Ag.*	......	......	*		
Pristicladodus dentatus, *M'Coy*	......	......	*		
Psammodus Goughii, *M'Coy*	*	......	......	......	*
—— porosus, *Ag.*	*	*	*	*	*
—— rugosus, *Ag.*	......	*	......	*	*
Psephodus magnus, *Ag.*	......	......	*	*	*
Rhizodus ferox, *Owen*	......	......	......	......	*
Rhymodus transversus, *Ag.*	......	......	......	*	
Streblodus Colei, *Ag.*	......	......	......	*	
—— Egertoni, *Ag.*	......	......	......	*	
—— oblongus, *Ag.*	......	......	......	*	
Tomodus convexus, *Ag.*	......	*			
Xystrodus augustus, *Ag.*	......	......	......	*	
—— striatus, *Ag.*	......	......	......	*	

BELGIUM.—(From De Koninck.)
Helodus lævissimus, *Ag.*
Orodus ramosus, *Ag.*
Psammodus porosus, *Ag.*
—— rugosus, *Ag.*

GERMANY.
Psammodus rugosus, *Ag.*

NORTH AMERICA.—(Lord Enniskillen.)
Psammodus porosus, *Ag.* (Warsaw in Illinois.)
Psephodus magnus, *Ag.*
Cladodus.

RUSSIA.—(From E. d'Eichwald.)
Cladodus mirabilis, *Ag.*
Cochliodus contortus, *Ag.*
Ctenoptychius denticulatus (?), *Ag.*
Dicrenodus Okensis, *Rom.*
Helodus gibberulus, *Ag.*
—— lævissimus, *Ag.*
Hybodus polyprion (?), *Ag.*
—— Panderi, *Eichw.*
Leptacanthus remotus, *Eichw.*
Petalodus acuminatus, *Ag.*
Pœcilodus Rossicus, *Keys.*
Psammodus porosus, *Ag.*

For revising this list, and for much assistance in correcting the names of the species examined by M. Agassiz during his last visit to England in 1859, we are greatly indebted to the Earl of Enniskillen and Sir Philip Egerton. In explanation of the changes in many names of genera and species referred to in the Table, we have been favoured by these gentlemen with the following notes:—

	Found at	Is now the
Cochliodus magnus	Bristol	*Tomodus convexus.*
C. magnus	Armagh, Richmond, and Kendal	*Psephodus magnus.*
C. acutus	Armagh	*Deltoptychius acutus.*
C. acutus	Bristol	*D. gibberulus.*
C. oblongus	Armagh	*Streblodus oblongus.*
C. oblongus	Hook Point, Co. Wexford	*S. Egertoni.*
C. oblongus	Armagh	*S. Colei.*
C. striatus	Armagh	*Xystrodus striatus.*
	Armagh	*X. angustus.*

Glossodes lingua-bovis Agassiz supposes to be the front tooth of *Helodus didymus*; but he has taken the specimen to America.

Helodus planus is now merged into *Psephodus magnus.*

—— *rudis* is supposed by Agassiz to be a young tooth.

Orodus ramosus occurs also in Monmouthshire.

Petalodus acuminatus and *P. Hastingsiæ* are said to be of the same species; if so, the name must remain *P. Hastingsiæ.* The localities for this species are Richmond in Yorkshire and Ticknall in Derbyshire. It is not found at Armagh.

Petalodus radicans is now *Polyrhizodus radicans*; and *Petalodus rectus* is a young tooth of the same species.

Petalodus psittacinus is now *Petalorhynchus psittacinus.*

Pœcilodus sublævis „ *Deltodus sublævis.*

P. parallelus is a second tooth of the above species.

P. transversus is half a tooth of *Pœcilodus Jonesii.*

Pristodus falcatus is a new genus and species from Mr. Wood's collection.

Psammodus canaliculatus is now merged into *Psammodus porosus* and *rugosus.*

Psammodus rugosus. The type-specimen of the genus is from Eskey, Co. Sligo.

P. cornutus is now subdivided into the following genera and species:—

Characodus angulatus	Armagh.
C. cuneatus	„
Copodus cornutus	„
C. furcatus	„
C. lunulatus	„
C. spatulatus	„
Dimyleus Woodii	Richmond, Yorks.
Labodus planus	Armagh.
Labodus prototypus	Armagh.
Mesogomphus lingua	„
Mylacodus quadratus	„
Mylax batoides	„
Pinacodus gelasinus	„
P. gonoplax	„
Pleurogomphus auriculatus	„
Rhymodus transversus	„

On a New Species *of* Pterichthys (Pterichthys macrocephalus, Egerton), *from the* Yellow Sandstone *of* Farlow, Co. Salop. By Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S., &c.

[Plate III. Figs. 7, 8, 9.]

The specimen of *Pterichthys* discovered by Mr. Baxter, F.G.S., in the yellow sandstone of Farlow is the smallest example of the genus which has come under my notice. Its total length, from the anterior margin of the head to the termination of the dorsal shield, is exactly one inch, of which the head occupies four-tenths. The breadth of the shield is half an inch. The fish reclines on the ventral plates, thus presenting to view the upper surface of the body. The tail and left pectoral appendage are deficient; but the right arm is preserved, and measures eight-tenths of an inch in length, or two-tenths more than the carapace. See woodcut, fig. 1, and Pl. III. fig. 7.

Fig. 1.—*Outline of Mr. Baxter's Specimen of* Pterichthys macrocephalus *from Farlow.* (See Pl. III. fig. 7.)

On comparing these dimensions with those of the other members of the genus, it appears that, although the small size of the body suggests a resemblance to the *Pterichthys Milleri* of Cromarty, yet the disproportionate length of the pectoral appendages (a feature of safe guidance in discriminating the species) assimilates it more closely to *Pterichthys hydrophilus* (*Pamphractus* of Agassiz) found in the yellow sandstone of Dura Den in Scotland. It differs, however, remarkably from this species in the large proportionate size of the head. The breadth of this member in the Farlow species is just commensurate with its length, whereas in *Pterichthys hydrophilus* it is one-third greater. The form of the head is also very different in the two species; the outline in the former is nearly circular, whereas in the latter it is subtriangular, broad at the base, and contracting towards the snout.

The length of the pectoral oars in the *Pterichthys* of Dura Den exceeds considerably that of these organs in any other species, being equal to that of the dorsal shield; but the English *Pterichthys* (the only one yet discovered on this side the Border) transcends in this respect that of Dura Den as much as the latter outstrips its congeners; for the arms project one-fourth beyond the posterior margin of the carapace. The plates of the cranium are not sufficiently perfect for description.

I may here remark that a specimen recently acquired by the Museum of Practical Geology, from the Dura Den deposits, fully bears out the opinion advanced by the late Hugh Miller and myself in 1848, as to the identity of the genera *Pterichthys* and *Pamphractus*.

Since the foregoing description of the solitary specimen of *Pter-*

ichthys discovered by Mr. Baxter in the Farlow sandstone was penned, the researches of Mr. Roberts have brought to light from the same locality several additional specimens of the same species, which enable me to add the description of the ventral and thoracic plates. The former specimen is still so far unique that it is the only one yet discovered which gives a view of the dorsal surface, or reveals the proportions of the head, from which the specific title was derived. One of the more recently found specimens is quite a gem. The fish reclines upon its back, and thus presents to view the ventral plates, the thoracic plates, and their appendages; the head and tail are both wanting. See woodcut, fig. 2, and Pl. III. fig. 8 & 9.

Figs. 2 & 3.—*Outlines of Specimens of* Pterichthys macrocephalus *from Farlow.* (See Pl. III. figs. 8 & 9.)

Fig. 2.

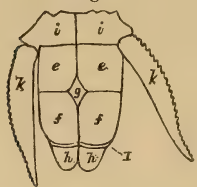
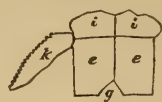
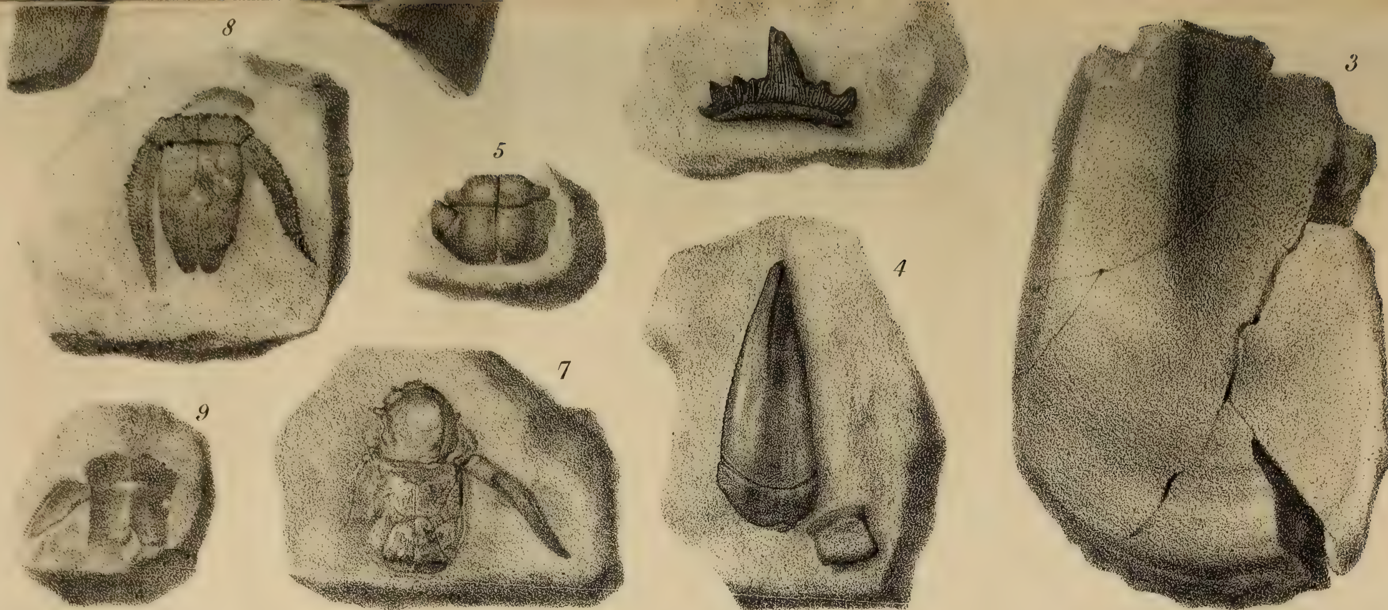


Fig. 3.



In a former paper, read before the Geological Society in April 1848 (Quart. Journ. Geol. Soc. vol. iv. p. 302), the arrangement of the plates composing the integument of this genus was so fully described that it is needless to go over that ground again. I wish, however, to correct an error in the number of the ventral plates. Two plates are there enumerated as the posterior ventral plates, lettered *h h* on the outline-figures, *ibid.* p. 305, which (as shown by Professor M'Coy) are not independent elements of the shield, but prolongations of the posterior ventro-lateral plates. I was led into this mistake by the semblance of a suture visible on most specimens, which proved to be the impression of the posterior marginal rim which encircles the inner posterior edge of the dorsal plates, but traverses the inner surface of the posterior ventro-lateral plates in the direction of the supposed suture. The impression of this marginal rim is distinctly preserved in the Farlow specimens (figs. 1, 2,—l), and affords a secure datum for measuring the dimensions of the plates. The antero-posterior dimensions of the dorsal surface were taken from the front of the first dorsal plate to the posterior marginal rim; a similar measurement of the ventral surface, namely from the anterior margin of the shield to the impression of the posterior marginal rim, exactly coincides with the former; the width of the body and the length of the arms also correspond so exactly that the two specimens might have been derived from the same individual. The hinder prolongations of the posterior ventro-lateral plates extend in this, as in all other species, beyond the termination of the dorsal shield. In front of the anterior ventro-lateral plates

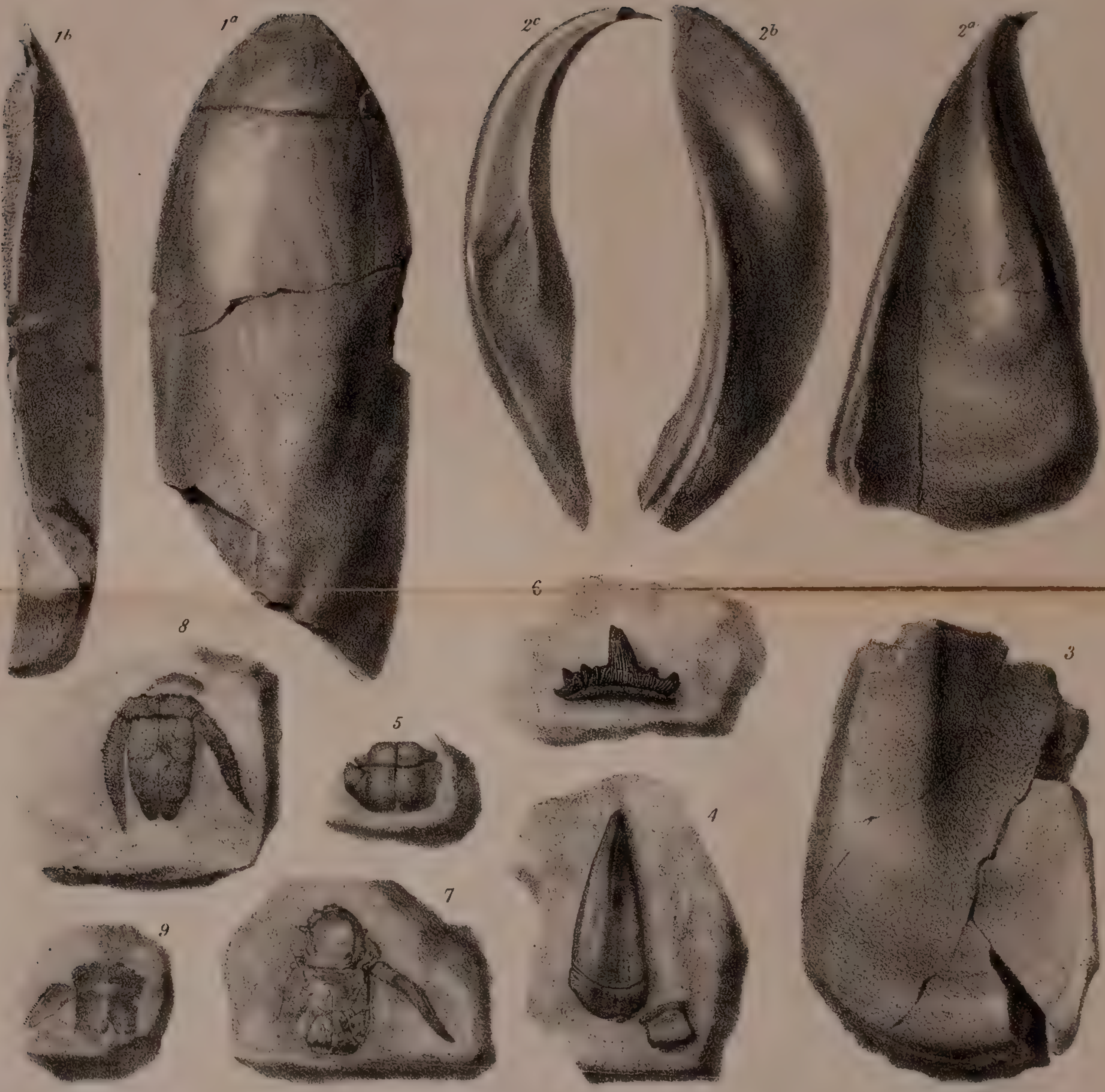

1b
1a
2c
2b
2a



Dinkel del & lith

W.West imp

NEW FISH-REMAINS FROM FARLOW & ORETON.



Dinkel del. & lith. W West imp.

NEW FISH REMAINS FROM FARLOW & ORETON

two plates are situated, which, in the memoir before alluded to, I named the thoracic plates. These constitute an important item in the structural economy of *Pterichthys*, inasmuch as they afford attachment to the lateral appendages, and form the basis of support for these organs in all their movements. This being undoubtedly the case, as shown in specimens of every species I have examined, I am at a loss to conceive how Professor Pander can have been led to assign the attachment of the arms to the ventro-lateral plate, as shown in the magnified figure on tab. 6 of his magnificent work on the Devonian Fishes, although in the preceding plate these organs are correctly drawn as appended to the thoracic plate. The thoracic plates are well preserved in three of the specimens of *Pterichthys macrocephalus*, and in two of them one or both arms are seen in their natural position. On comparing these plates with the homologous parts of other species, they differ so remarkably, that, in the absence of all other characters, a *specific* discrepancy might be affirmed. The ordinary appearance of these plates when in conjunction is that of a narrow band or belt, hollowed out anteriorly in a crescentic form, to allow space for the vertical movements of the head. In the Farlow species these plates are quadrilateral, with an anterior margin convex rather than concave, each of them being nearly half as long as the anterior ventro-lateral plates (figs. 2, 3,—*i i*). We cannot but recognize in these peculiarities characters strictly in accordance with the other deviations of structure from the allied species detailed in the foregoing remarks. The greater length of the pectoral organs required a stronger fulcrum, and the large-sized head a firmer support. One of the specimens last forwarded for examination shows the character of the surface-ornament of the plates. (See Pl. III. fig. 9, and woodcut, fig. 3.) This resembles the tubercular pattern so constant in *Pterichthys* and *Coccosteus*, and offers no peculiarity worthy of remark. The ornamentation of the arms is, however, more than ordinarily coarse, and along the outer margins of these organs the single row of tubercles gives, in section, the appearance of a strongly serrated border.

EXPLANATION OF PLATE III.

Illustrative of some new Fish Remains from Farlow and Oreton, Shropshire.

Fig. 1 *a*. Palatal tooth, allied to *Deltodus* and *Cochliodus* (?).
Fig. 1 *b*. The same, edge-view.
Fig. 2 *a*. *Deltodus*, new species.
Fig. 2 *b*. } The same, edge-views.
Fig. 2 *c*. }
Fig. 3. *Deltodus*, probably of the same species as fig. 2, but a larger specimen (broken).
Fig. 4. *Deltodus*, possibly of the same species as the foregoing, but much smaller, and transversely sulcated where the surface of the others is but slightly undulated. A small, flat, quadrate palatal tooth, flanged on two of its edges, accompanies this specimen.
Fig. 5. A palate, or part of a palate, composed of four subquadrate and subconvex plates.
Fig. 6. *Cladodus*; the only specimen of this form.

} From the Carboniferous Limestone of Oreton and Farlow, Shropshire.

Fig. 7. *Pterichthys macrocephalus*, Egerton. Dorsal aspect. In the Collection of Mr. T. Baxter, F.G.S.
Fig. 8. —— Ventral aspect. The head is wanting. In Mr. G. E. Roberts's Collection.
Fig. 9. —— Impression of the anterior ventral and thoracic plates and of a part of one limb. In Mr. Weaver Jones's Collection.

(From the Yellow Sandstone of Farlow, Shrops.)

(All the figures are of the natural size.)

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2. *On some* Fossil Plants, *showing* Structure, *from the* Lower Coal-Measures *of* Lancashire. By E. W. Binney, Esq., F.R.S., F.G.S.

[Plates IV. V. VI.]

Of all the fossil plants found in the Coal-measures, probably none is more widely diffused, or its whole internal structure considered to be better known, than the genus *Lepidodendron*. The investigations of Messrs. Witham, Lindley and Hutton, Corda, Brongniart, and J. D. Hooker appeared to have almost exhausted the subject, so far as the structure of the stem was concerned. Dr. Hooker, after describing the double system of vessels in *Stigmaria*, first shown by Goeppert, and the consequent approach in this respect to the *Diploxylon* of Corda, says—" In *Lepidodendron*, again, there is the same double vascular system; but that from which the bundles arise, which proceed to the leaves, is placed externally to the wood, where it formed a continuous zone with a well-defined inner edge (in juxtaposition with the outer circumference of the inner zone) and a sinuous outer edge from which the diverging bundles are given off."* He, as well as all the other authors before named, considered the pith of *Lepidodendron* to be composed of cellular tissue, and that it was surrounded by a zone of large barred vessels, of hexagonal shape, which was succeeded by a narrow circle of lesser hexagonal vessels, also barred on their sides. Then came the great mass of cellular tissue containing the bundles of vessels which traversed it, leading from the outer vascular cylinder to the leaves. This was succeeded by a radiated series of elongated utricles forming the outer bark of the tree. The whole of the structure, as above described, was clearly proved by the specimens of Mr. Witham to belong to *Lepidodendron Harcourtii*. Corda proved *Protopteris Cottonea* to have the same structure; and Mr. Dawes, of Smethwick, near Birmingham, possesses in his cabinet most beautiful specimens which fully confirm the above views, and especially with respect to the pith being entirely composed of cellular tissue.

The specimens intended to be described in this communication show that fossil plants having all the external characters of *Lepidodendron* have a pith, if it may be so called, or, more properly speaking, a central axis, composed not of cellular tissue, but of very large hexagonal vessels (*a*) mixed with smaller ones, both having all their sides barred with transverse striæ. This is succeeded by

* Memoirs of the Geological Survey of Great Britain, vol. ii. part ii. p. 435.

hexagonal vessels (*b*) of much less size, arranged in radiating series of a wedge-shape, and divided by medullary rays of finely barred vessels, as *Stigmaria* and *Sigillaria*. Outside this series are some circular bundles of small vascular tissue, similar to those described by Brongniart in *Sigillaria elegans*. Next comes a mass of delicate cellular tissue (*d*), which has generally been destroyed, and replaced by mineral matter. This is succeeded by a zone of coarse cellular tissue (*f*), which gradually passes into the outer circle, composed of small hexagonal utricles (*g*), arranged in radiating series; and then comes some coarse cellular tissue, which appears to have been the outer bark (*h*).

The fossils were found by me in the lower part of the Lancashire coal-measures, as were also the specimens of *Trigonocarpon* described by Dr. Hooker and myself in the 'Philosophical Transactions'* for 1855, but in a different seam of coal. They occur in calcareous nodules of various shapes, dispersed throughout the seam, and evidently afford a fair sample of the vegetable matter of which such coal was formed; they having been calcified, and thus preserved, before the bituminizing process commenced, which ultimately converted the rest of the vegetable matter surrounding them into coal. The seam varies from 2 to 5 feet in thickness. It has a good floor, full of *Stigmaria*; and its roof, a black shale containing rounded and depressed nodules of calcareous and ferruginous matters, abounds with remains of *Aviculopecten papyraceus*, *Goniatites Listeri*, *Nautilus*, *Bellerophon*, and other marine shells, the destruction of which has most probably afforded materials for the calcification of the nodules found in the seam of coal. Although fossil shells occur abundantly in the nodules found in the roof of the coal, they have not as yet been met with near the locality where the specimens were met with in the nodules containing the fossil wood amidst the coal itself†.

The *Lepidodendron* is the most common plant in the coal found preserved in the nodules, although specimens of *Lepidostrobus*, *Halonia*, *Sigillaria*, *Stigmaria*, *Anabathra*, *Calamites*, *Lycopodites*, and other plants, all more or less showing structure, are frequently met with.

In the present paper it is my intention to confine myself to the description of three specimens of fossil plants which would generally have been designated *Lepidodendron* in England, and *Sagenaria* on the Continent.

No. 1. The specimen illustrated in Pl. IV. consists of a cylindrical stem $\frac{8}{10}$ths of an inch in diameter, nearly enveloped in its stony matrix, and only showing its external characters on one side. These consist of rhomboidal scars, of an elongated and somewhat irregular form, arranged in quincuncial order, but not so perfectly as seen in most species of *Lepidodendron*. In the middle of each scar there is an oval depression, from which rises a rounded prominence where the leaf was attached. These scars resemble those of *Lepidodendron*

* Vol. cxlv. p. 149, &c.

† I have in some few instances found nodules in the coal itself containing shells, but these are rare.

selaginoides, figured by Messrs. Lindley and Hutton in their 'Fossil Flora,' vol. i. fig. 12; but the depression in the scar on their specimen is not so marked as in mine.

In the middle of the large cylinder last described is a smaller one, of about $\frac{1}{7}$th of an inch in diameter. This is composed of large hexagonal vessels, of irregular sizes (*a a*), placed one beside the other, without order, but becoming smaller as they approach the circumference, all having their sides barred with transverse striæ, and some of the smaller ones (*a' a'*) being divided at short intervals by horizontal and oblique partitions. The outside of this inner cylinder* (*b b*) is composed of hexagonal vessels barred with transverse striæ, of about $\frac{1}{6}$th of the diameter of those contained in the centre, arranged in radiating series of a wedge-shape, and divided by medullary rays or vessels very finely barred (*c c*), as in the vascular cylinders of *Sigillaria* and *Stigmaria*, respectively described by Brongniart and Hooker. Around, and placed next to, the cylinder are a number of round bundles of fine vascular tissue (*d d*), some of which are opposite to the medullary rays or vessels, and others apparently away from them near the wedges of the wood. These bundles seem to be connected with the vessels which supply the leaves, but cannot be well traced to the medullary rays in all cases. It is probable they may be sections of vessels passing from the medullary rays or vessels to the leaves. They are evidently the same vessels as are figured by Messrs. Lindley and Hutton ('Fossil Flora,' vol. ii. pl. 99. fig. 1), and also resemble the vessels described by Brongniart as occurring on the outside of the woody cylinder in *Sigillaria elegans*. On the external portion of the outer radiating cylinder of the specimen similar vessels can be distinctly traced into the projecting scars from whence the leaves arise.

Next occurs a space of about $\frac{4}{10}$ths of an inch (*e e*), in which the tissue has for the most part disappeared and been replaced by mineral matter; but it seems to have been composed of delicate cellular tissue, which was traversed by bundles of vessels leading from the axis to the leaves. Then comes a zone of coarse cellular tissue (*f f*) which gradually passes into small elongated utricles, of hexagonal form, and arranged in radiating series, which probably formed the inner bark. These, in their turn, pass into a black carbonaceous matter (*h h*), the remains of the outer bark of the tree. The vessels traversing the external cylinder are of the same character as those traversing the internal one, except that they are of much greater size, each of the latter being probably composed of two or more of the former, as Dr. Hooker describes in *Sigillaria* †. A transverse section of the specimen No. 1 is similar to the same section of *Sigillaria elegans*, with this exception, namely, that the inner lunette-shaped bundles of vessels found within and next to the woody cylinder in M. Brongniart's specimen fill the whole of the central axis in

* In this specimen, by some cause, a portion of the inner cylinder has been destroyed, either by the section not being cut true, or by a part of the woody cylinder having been destroyed in calcification.

† Memoirs of the Geological Survey of Great Britain, vol. i. part ii. p. 436.

mine. At first sight, it might have been supposed that the specimen of *Sigillaria elegans* before named had had some of its middle portion destroyed, and that the lunette-shaped bundles once occupied the whole of the central axis; but having, by the kindness of M. Brongniart, been permitted to examine the original specimen preserved in the Museum of the Jardin des Plantes, it appears to me that the learned author's description of the specimen, as well as the figure in the plate, are both remarkably correct. Although his specimen does not show the external structure of large *Sigillariæ*, my own observations lead me to the conclusion that we shall find the latter very much resembling, if not altogether identical in structure with, *Sigillaria elegans*. In large specimens of *S. reniformis* and *S. organum*, whose structure is preserved, in my own cabinet, there is distinct evidence of the internal cortical envelope formed of elongated cellular tissue or utricles, and disposed in radiating series, in all respects like that described by M. Brongniart in his Autun specimen.

The longitudinal and tangential sections of my specimen show that the vessels of the central axis and the woody cylinder are barred transversely on all their sides. M. Brongniart found this to be the case with *Sigillaria*, and gives it as characteristic of *Sigillaria*, *Stigmaria*, and *Anabathra**. Specimens of these three, now in my cabinet, clearly prove that their central axes and their woody cylinders are exactly the same in structure and arrangement; thus affording evidence from structure that *Stigmaria* is the root of *Sigillaria*, and that *Anabathra* is a *Sigillaria*—which has long been expected would prove to be the case.

The specimen No. 2, in Pl. V., to a great extent resembles No. 1 last described, except that it is not so perfect with respect to the outermost cylinder; but its external characters, its inner bark showing the vessels traversing it, its tangential section showing also the vessels traversing the inner cylinder, and some singular delicate vessels in the central axis, render it a valuable specimen and worthy of description.

It is of somewhat larger dimensions than No. 1 specimen, and shows its external characters on one side only of the stem. These, like those of No. 1, consist also of rhomboidal scars arranged in quincuncial order, each scar having on its upper part a comparatively large circular cicatrix, where the leaf was attached. The scar, like that of No. 1 specimen, most resembles *Lepidodendron selaginoides* in the rounded figure of the cicatrix left by the leaves, except that it is much larger, occupying the greater portion of the upper part of the surface, whilst that of the latter is scarcely one-fifth of the minor diameter of the scar. In other respects it cannot be distinguished from *L. selaginoides* figured by Messrs. Lindley and Hutton.

The internal cylinder is $\frac{2}{10}$ths of an inch in diameter, and is composed of large hexagonal vessels (*a a*); those in the middle being more irregular in shape, placed wider apart from each other, and in

* Extrait des Archives du Muséum d'Histoire Naturelle, p. 424. Paris, 1839

some instances surrounded by much smaller vessels ($b\,b$), than in the specimen first described; but the outer range of vessels next the vascular radiating cylinder ($b\,b$) is, like it, composed of smaller vessels. The extremely minute vessels ($a''\,a''$) seen in the longitudinal section of the central axis show a remarkably delicate tissue, of which the first specimen exhibits no trace. The inner cylinder is more perfect than that first described, owing to the transverse section being cut truer, or being better preserved, than that specimen: but the vessels are of the same size with relation to the larger ones in the centre; they are barred with striæ on all their sides; and the tangential section shows the small openings for conveying vascular bundles from the axis to the leaves, which is not shown in the first specimen. In all respects as to its internal structure, so far as it can be examined, it is the same as No. 1, with the exception of the small vessels in the central axis ($a''\,a''$), which have not yet been seen in that specimen.

No. 3 is an oval specimen, its original circular form having been changed by pressure. It is $\frac{8}{10}$ths of an inch across its greater, and $\frac{6}{10}$ths of an inch across its lesser axis. The external characters are well shown all round the specimen; and the scars are more elongated and placed further apart than in either of those previously described. Like No. 1, the scars have in their middle along their greater axis a depression, in the centre of which is a small projection, to which the leaf was attached. The appearance of the scar somewhat resembles those of a *Knorria* described by Goldenberg*. An oblique fracture of a portion of the stem displays the position of the vascular bundles which traverse the stem and communicate between the central axis and the leaves (Pl. VI.).

The central axis much resembles that of No. 2, especially in the fact of the large hexagonal vessels in the middle being replaced and parted by smaller ones, and appearing in more regular order near the circumference; but the radiating cylinder of barred vessels described in specimens Nos. 1 and 2 is wanting, and a band of fine cellular tissue appears to occupy its place. This tissue has, for the most part, been destroyed in the specimen; but traces of it are left in portions, showing numerous round bundles of fine vascular tissue traversing it, springing from the side of the central axis and extending to the leaves, similar to those bundles described in the two preceding specimens as occurring on the outside of the vascular cylinder. In this specimen a zone of coarse cellular tissue bounds the band of fine cellular tissue last described. A small space then appears which has been for the most part destroyed, but traces of the vascular bundles traversing the stem are met with at intervals. Then again coarse cellular tissue occurs, which graduates into small elongated cellular tissue or utricles of hexagonal form, arranged in radiating series similar to that seen in Nos. 1 and 2, and most probably forming the bark of the stem.

In the longitudinal section of the vascular axis about the centre

* Flora Saræpontana fossilis. Die Pflanzenversteinerungen des Steinkohlengebirges von Saarbrücken. 1855, pl. iv. fig. 8*a*.

are seen some of the smaller vessels ($a' \, a'$) divided by horizontal and oblique partitions similar to those before mentioned as occurring to a less extent in No. 2; but in this specimen there is no trace of the fine tissue ($a'' \, a''$) seen in the centre of that stem.

The tangential section shows the vascular bundles traversing the cellular tissue from the axis to the leaves, in a similar manner to those described in specimens Nos. 1 and 2.

Upon the whole, No. 3 may be said to resemble Nos. 1 and 2 in every respect, except that the internal radiating cylinder of barred vessels is wanting in it. At first, it was supposed that this cylinder might have disappeared in the cutting and polishing of the stone; so several other specimens were examined, but in all cases the cylinder was found wanting; so there is no doubt that this is a plant more nearly allied to the common *Lepidodendron* than Nos. 1 and 2, which it will be more convenient, for the present, to class under the genus *Sigillaria*, on account of their internal structure, notwithstanding their external characters. It is proposed to distinguish these two specimens (Nos. 1 and 2) by the name *Sigillaria vascularis*, from the circumstance of each of them possessing a central axis composed of barred vessels, in the place of the cellular tissue so generally formed in piths. No. 3 it is proposed to designate as a *Lepidodendron*, and to give it the specific name of *vasculare*, from the fact of its central axis being also composed of barred vessels, similar to those of *Sigillaria vascularis*.

EXPLANATION OF PLATES IV. V. & VI.

Plate IV. *Sigillaria vascularis.*

Fig. 1. Specimen (No. 1) of a stem of *Sigillaria vascularis* in a calcified state, found in the Lower Coal-measures of Lancashire, in the middle of a seam of coal; showing a portion of the exterior surface, the bark of which is preserved, displaying the leaf-scars and the cicatrices which characterize this genus.

Fig. 2. Transverse view of the same stem; magnified $3\frac{1}{2}$ diameters.

Fig. 3. Portion of the same transverse section of stem; magnified 12 diameters.

Note.—The same letters indicate the same parts in this and the preceding figures.

a a. The central part, showing the central axis or pith, composed of large hexagonal vessels having all their sides barred.

a' a'. The smaller hexagonal vessels in the axis or pith, found sometimes interspersed amongst the larger ones.

a'' a''. Small vessels, of very delicate tissue.

b b. The vascular cylinder of wedge-shaped hexagonal vessels.

c c. The spaces where the medullary rays passed between the bundles on their passage from the centre to the leaves at the circumference.

d. Small round bundles of fine vascular tissue, placed next the outside of the woody cylinder, often apparently displaced from their original position.

e e. Space where the greater part of the cellular tissue has been destroyed, and replaced by mineral matter.

f. Coarse cellular tissue arranged without order.

g. Elongated tissue or utricles, arranged in radiating series.

h. Coarse cellular tissue, forming the outer bark of the tree.

i. Indication of fibro-vascular bundles, which traverse the bark to communicate with the base of the leaves.

Fig. 4. A longitudinal section of *Sigillaria vascularis*, from the central axis to the exterior of the stem, showing the structure of the plant; magnified 12 diameters.

a a. The central axis composed of large vessels, barred on all their sides by transverse striæ.

a' a'. The smaller vessels, divided into parts by horizontal and oblique divisions.

b b. The vascular cylinder of wedge-shaped hexagonal vessels, barred on their sides by transverse striæ.

d d. Traces of the vascular bundles of vessels communicating from the centre to the leaves.

f f. Coarse cellular tissue, arranged without order.

g g. Elongated tissue or utricles arranged in radiating series, forming the inner bark.

h h. Coarse cellular tissue, forming the outer bark.

Fig. 5. A tangential section of *Sigillaria vascularis* at right angles to the outer radiated cylinder, showing the vascular bundles of vessels, *d d*, traversing the elongated tissue or utricles, *f f*; magnified 12 diameters.

Fig. 6. A transverse section of a portion of the outer radiated cylinder of *Sigillaria vascularis*, showing the vascular bundles, *d d*, passing through the scar into the leaf; magnified 25 diameters.

PLATE V. *Sigillaria vascularis.*

Fig. 1. Specimen (No. 2) of this stem in its calcified state, showing portions of its external surface and internal bark, displaying the vascular bundles of vessels, *d d*.

Fig. 2. Transverse view of the same specimen, showing the central axis, woody cylinder, and bundles of vessels placed on the outside of the latter; magnified 12 diameters.

Fig. 3. Longitudinal section of the same specimen, showing the vessels of the central axis, *a a*, the small vessels of very delicate tissue, *a'' a''*, sometimes enclosing portions of barred vessels, and the small barred vessels of the woody cylinder, *b b*; magnified 12 diameters.

Fig. 4. Longitudinal section of a portion of the same specimen, showing the small vessels, *a'' a''*; magnified 25 diameters.

Fig. 5. Tangential section of the same specimen, showing the small vessels traversing the woody cylinder, *b b*; magnified 25 diameters.

PLATE VI. *Lepidodendron vasculare.*

Fig. 1. Specimen (No. 3) of a stem of *Lepidodendron vasculare* in a calcified state, showing portions of the external surface and its scars, as well as a portion of the inner bark, with the vascular bundles of vessels, *d d*, traversing it.

Fig. 2. Transverse view of the same specimen; magnified 3½ diameters.

Fig. 3. Portion of the same transverse section of the stem; magnified 12 diameters.

The central axis, composed of large barred vessels, *a a*.

a' a'. The smaller vessels, divided into parts by horizontal and oblique divisions.

d d. Traces of the vascular bundles of vessels communicated from the centre to the leaves.

f f. Coarse cellular tissue, arranged without order.

g g. Elongated tissue or utricles arranged in radiating series, forming the inner bark.

h h. Cellular tissue, forming the outer bark.

Fig. 4. A longitudinal section of the *Lepidodendron* from the central axis, showing the structure of the plant; magnified 12 diameters.

The letters indicate the same parts as in fig. 3.

Fig. 5. A tangential section of the coarse cellular tissue, *f f*, traversed by the vascular bundles of vessels communicating from the central axis to the leaves; magnified 12 diameters.

3. *Supplemental Note on the* Plant-bearing Sandstones *of* Central India. By the Rev. Stephen Hislop.

(In a Letter to the Assistant-Secretary, dated Nagpur, July 19, 1861.)

[Printed in the February No. of the Journal, p. 36, by permission of the Council.]

January 22, 1862.

Samuel Sharp, Esq., Dallington Hall, near Northampton, and George Parks Wall, Esq., The Hills, near Sheffield, were elected Fellows. Señor Casiano di Prado, Madrid, was elected a Foreign Member.

The following communications were read:—

1. *On some further Discoveries of* Flint Implements *in the* Gravel *near* Bedford. By James Wyatt, Esq., F.G.S.

(Abstract.)

Since Mr. Prestwich described the occurrence of flint implements near Bedford (Geol. Soc. Journ. No. 67, p. 366), Mr. Wyatt, Mr. Nall, the Rev. Mr. Hillier, and Mr. Berrill have added seven or eight to the list, from the gravel-pits at Cardington, Harrowden, Biddenham, and Kempston.

Mr. J. G. Jeffreys, F.G.S., having examined Mr. Wyatt's further collections of shells from the gravel-pits at Biddenham and Harrowden, has determined seventeen other species besides those noticed by Mr. Prestwich; and among these is *Hydrobia marginata* (from the Biddenham Pit), which has not been found alive in this country. At Kempston, Mr. Wyatt has examined the sand beneath the gravel (which is destitute of shells), and at 3 feet in the sand (19 feet from the surface) he found *Helix*, *Succinea*, *Bythinia*, *Pupa*, *Planorbis*, &c., with a flint implement. The upper gravel contained several flint flakes.

Mr. J. Gwyn Jeffreys, F.R.S., F.G.S., having had the shells submitted to him, says,—

"I have carefully examined and assorted the shells sent to me by Mr. Wyatt from the Harrowden and Biddenham Pits, and I find that they belong to the following species (distinguished by H. & B. respectively):—

H. B. Sphærium corneum, *Linn.* (*Cyclas cornea* of authors.)
H. B. Pisidium nitidum, *Jenyns.*
H. B. —— Henslowanum, *Jenyns.*
H. —— ——, monstr. (*P. sinuatum*, Normand.)
B. Bythinia tentaculata, *Müller.*
H. B. Valvata piscinalis, *Müll.*
B. —— cristata, *Müll.*
B. Hydrobia marginata. (*Paludina marginata*, Michaud.)
B. Succinea putris, *Linn.*
H. —— ——, dwarf var. resembling *S. oblonga*, Drap.

H. B. Helix hispida, *Müll.*
H. B. —— pulchella, *Müll.*
B. —— concinna, *Jeffr.*
H. B. Pupa marginata, *Drap.*
H. B. Planorbis glaber, *Jeffr.* (Ranging from Sweden to Madeira.)
H. B. —— vortex, *Linn.*
H. —— leucostoma, *Michaud.* (*P. spirorbis* of some authors.)
B. —— nautileus, *Lightfoot.*
B. —— marginatus, *Müll.*
H. Limnæa peregra, *Müll.*
H. B. —— auricularia, *Linn.*, var. acuta, *Jeffr.*
H. B. —— stagnalis, *Linn.* (Var. *Helix fragilis*, Montagu.)
H. B. —— truncatula, *Müll.*
H. —— ——, dwarf var.
H. —— palustris, *Drap.*
H. B. Ancylus fluviatilis, *Müll.*
B. —— oblongus, *Müll.*

"The nature and condition of the shells from the Harrowden Pit show that, in all probability, the area formed part of the site of a large lake or piece of fresh water, having a sandy bottom and banks; that it was situated very near an estuary or flat sea-shore; and that a small stream flowed into the lake at its upper end from a hill of considerable eminence. The lake must have had water-plants in it and rushes or flags (*Iris pseudacorus*) at its margin. I assume that all the shells came from one and the same stratum.

"The area of the Biddenham Pit did not apparently form part of the site of the same lake as at Harrowden; but it was, in all probability, a smaller piece of water, with more weeds in it. In other respects, as well as in its being the receptacle of a small stream, the conditions appear to have been the same. I take for granted in this case also that all the shells last named came from only one stratum. It may be a question as to whether both these pieces of water existed at the same time. This must in some measure depend on the relative position of the fossiliferous strata in each of the pits in which the shells were found. The occurrence of *Hydrobia marginata* in the Biddenham Pit is interesting. See Sir Charles Lyell's Paper in the Quarterly Journal of the Geological Society "On the Crag Districts of Norfolk and Suffolk," and the Appendix to Searles Wood's 'Monograph on the Crag Mollusca,' published by the Palæontographical Society. I lately noticed it in the freshwater bed at Mundesley, while in company with Mr. Prestwich. It has never been found alive in this country."—J. G. J.

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2. *On some* Flint Arrow-heads (?) *from near* Baggy Point, North Devon. By N. Whitley, Esq.

[Communicated by J. S. Enys, Esq., F.G.S.]

(Abstract.)

Beneath the surface-soil (at the depth of 18 inches from the top) above the "raised beaches" of North Devon and Cornwall, the author has observed broken flints; and even at the Scilly Isles such flints are found. At Croyde Bay, about half-way between Middle-Borough and Baggy Point, at the mouth of a small transverse valley, Mr. Whitley found them in considerable number, collecting about 200 specimens. About 25 per cent. of the splintered flints at this place have more or less of an arrow-head form, but they pass by insensible gradations from what appear to be perfect arrow-heads of human manufacture to such rough splinters as are evidently the result of natural causes. Hence the author suggested that great caution should be used in judging what flints have been naturally, and what have been artificially shaped.

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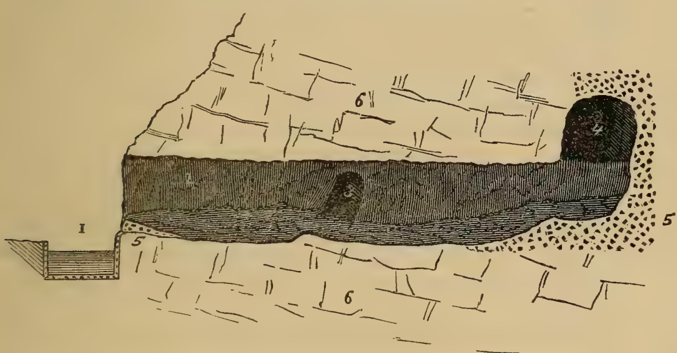
3. *On a* Hyæna-den *at* Wookey-Hole, *near* Wells.

By W. Boyd Dawkins, Esq., B.A., F.G.S., Burdett-Coutts Geological Scholar in the University of Oxford.

Of all the ossiferous caverns of this country which have from time to time been explored since 1821, there are none, perhaps, which form so exact a parallel to the Hyæna-den at Kirkdale as that which I bring before your notice this evening.

Fig. 1.—*Diagrammatic Section of the Hyæna-den at Wookey-Hole, near Wells.* Length of the excavation 34 feet; maximum height, 9 feet; width of cave at the entrance, 36 ft.



1. Canal for the River Axe.
2. Excavated portion of the cave.
3. Lateral branch to the left.
4. Upward branch.

5, 5. Undisturbed débris (cave-earth and bones).
6, 6. Dolomitic conglomerate.

It is situated at Wookey-Hole, a village on the southern flanks of the Mendips, and about two miles to the north-west of Wells. The ravine in which it was discovered is one of the many which pierce the dolomitic conglomerate, or petrified sea-beach of the Permian (?) age, still underlying its ancient sea-cliffs of Mountain-limestone, and overlying the lower slopes of the Mendips. Open to the south, it runs almost horizontally into the mountain-side, until closed abruptly northwards by a perpendicular wall of rock, 200 feet or more in height, ivy-covered, and affording a dwelling-place to innumerable jackdaws. Out of a cave at its base, in which Dr. Buckland* discovered pottery and human teeth, flows the River Axe, in a canal cut in the rock. In cutting this passage, that the water might be conveyed to a large paper-mill close by, the mouth of the Hyæna-den was intersected some ten years ago; and from that time up to December 1859, it was undisturbed save by rabbits and badgers; and even they did not penetrate far into the interior, or make deep burrows. Close to the mouth of the cave the workmen (employed in making this canal) found more than 300 Roman coins, among which were those of the usurper Allectus and of Commodus. When Mr. Williamson and myself began our exploration in 1859, about 12 feet of the entrance of the cave had been cut away, and large quantities of the earth, stones, and animal remains had been used in the formation of an embankment for the stream which runs past the present entrance of the cave. Of the animal remains, some found their way to the British Museum and to the Museum of the Somerset Archæological Society at Taunton; but the greater portion were either thrown away or scattered among the private collections of the neighbourhood. According to the testimony of the workmen, the bones and teeth formed a layer about 12 inches in thickness, which rested immediately upon the conglomerate-floor, while they were comparatively scarce in the overlying mass of stones and red earth. The workmen state also that at the time of the discovery of the cave the hill-side presented no concavity to mark its presence. When we began our exploration, so completely was the cave filled with *débris* up to the very roof, that we were compelled to cut our way into it. Of the stones scattered irregularly through the matrix of red earth, some were angular, others water-worn; all are derived from the decomposition of the dolomitic conglomerate in which the cave is hollowed. Near the entrance, and at a depth of 5 feet from the roof, were three layers of peroxide of manganese†, full of bony splinters; and, passing obliquely up towards the southern side of the cave, and over a ledge of rock that rises abruptly from the floor, further inwards they became interblended one with another, and at a distance of 15 feet from the entrance were barely visible. In and between these the animal remains were found in the greatest abundance.

While driving this adit, we found an angular piece of flint, which

* *Vide* 'Reliquiæ Diluvianæ,' p. 164. On examining this cave in September 1861, I was not fortunate enough to find human remains. During the winter, the stream flowing through the cave overflows, and covers the floor with a fine red earthy sediment, similar in every respect to that which is found in the hyæna-den. It varies in thickness from a few inches to a few feet.

† As in the case of the Kirkdale Cave. And here let me mention that I have taken for granted the fact of the cave having been filled with remains by the agency of hyænas, to avoid reproducing Dr. Buckland's arguments about the normal inhabitants of Kirkdale. *Vide* 'Reliquiæ Diluvianæ.'

had evidently been chipped by human agency, and a water-worn fragment of a belemnite, which probably had been derived from the neighbouring Marlstone-series. Bones and teeth of *Rhinoceros tichorhinus*, *Cervus Bucklandi*, of other species of Deer, Irish Elk, Mammoth, *Hyæna*, *Ursus spelæus*, Wolf, Fox, and Horse, rewarded our labours; and at the mouth of the cave, and cemented together by stalagmite, were frogs' remains. Remains of *Felis spelæa* also were found at the time of the discovery of the cave, and are at present in the Museum of the Somerset Archæological Society. The teeth preponderated greatly over the bones, and the great bulk were those of the Horse. The Hyæna-teeth also were very numerous, and in all stages of growth, from the young unworn to the old tooth worn down to the very gums. Those of the Elephant had belonged to a young animal, and one had not been used at all. The hollow bones were completely smashed and splintered, and scored with tooth-marks, while the solid carpal, tarsal, and sesamoid bones were uninjured, as in the case of the Kirkdale Cave. The organic remains were in all stages of decay, some crumbling to dust at the touch, while others were perfectly preserved and had lost very little of their gelatine.

In 1860 we resumed our excavations; and, in addition to the above remains, found satisfactory evidence of the former presence of Man in the cave. One white flint spear-head, of rude workmanship (figs. 2–5), one chert arrow-head, a roughly chipped piece of chert, a round flattened piece of chert, together with various splinters of flint, which had apparently been knocked off in the manufacture of some implement, rewarded our search. Two rudely fashioned bone arrow-heads were also found, which unfortunately have since disappeared; they resembled in shape an equilateral triangle with the angles at the base bevelled off. All were found in and around the same spot, between the dark bands of manganese, in contact with some Hyæna-teeth, at a depth of 4 feet from the roof, and at a distance of 12 feet from the present entrance.

That there might be no mistake about the accuracy of the observations, I examined every shovelful of *débris* as it was thrown out by the workmen; while the exact spot where they were excavating was watched by Mr. Williamson. The white flint spear-head was picked out of the undisturbed matrix by him; the remainder of the implements were found by me in the earth thrown out from the same place. Thus there can be no doubt as to their exact position; and error of observation is rendered very improbable. Two of the specimens are similar in workmanship and general outline, though not in size, with two of the typical forms found at Amiens and Abbeville, which Evans terms respectively spear-heads and sling-stones. The spear-head is of white flint (figs. 2–5): in outline, size, and workmanship it resembles a beautiful semitransparent quartz-rock specimen from the burial-mounds of North America, in the possession of Dr. Acland. The bone arrow-heads resembled most strongly in size and outline a flint arrow-head, also from the burial-mounds of North

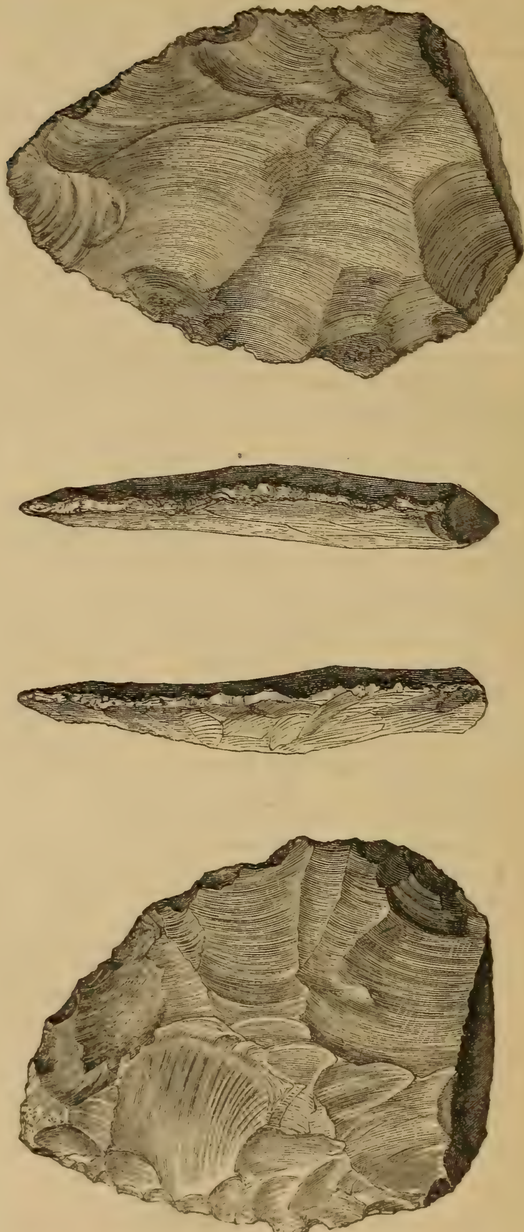


Fig. 2. Fig. 4. Fig. 5. Fig. 3.

Figs. 2–5.—*Four Views of a Flint Implement found in the Hyæna-den at Wookey-Hole, near Wells.*

America, and in the possession of Dr. Acland*. The chert arrow-head is dissimilar to any that I have seen. A splinter, which is bounded on one side by a straight cutting edge, appears to me to have been used as a knife, and to have been intentionally chipped into its present form for that purpose.

But what inference can be drawn from these signs of Man's presence in a Hyæna-den filled with unmistakeable remains of a fauna now extinct in Europe? Was the fabricator a contemporary of the British Cave-bear, Rhinoceros, Mammoth, and their congeners? Or did he leave his implements in the cave at a time posterior to that of the other creatures whose remains are associated with them in the Post-glacial period? If the former be answered in the affirmative, Man, instead of having appeared on the earth some 6000 or 7000 years ago, must have existed at a time anterior to the glacial epoch†, and at a time when the relations between land and water were altogether different,—a period that we cannot sum up in years. But if the latter, the great antiquity of the implements is by no means proved, and they may have belonged to any period anterior to that of the Saxons. The facts of the case, to my mind at least, lead but to one conclusion—that these implements were deposited in the cave during the Preglacial period. The cave at the time of its discovery (assuming the statement of the workmen to be true) was completely blocked up, so that the ravine-side presented no concavity to indicate its presence; there were no traces of disturbance posterior to the filling up of the cave either on the spot where they were found, or as we were driving our adit thither. And, as 12 feet of the former mouth of the cave have been cut away, we must double the distance from the present entrance to the spot itself, which will thus be 24 feet. The motive certainly has yet to be assigned that would induce a savage to excavate a trench 24 feet long with his miserable stone implements, and consequently with great labour; and, having excavated it, again to fill it up to the very roof with the *débris* which he had removed—earth, stones, and animal remains. The absence of charcoal, pottery, and human bones precludes the idea of the cave ever having been a place of sepulture, as was the cave close by, also one on the northern flank of the Mendips at Burrington-Comb, and a third in Cheddar Cliffs‡.

But, on the other hand, it may be said that the fact of their being found in and around the same spot is a weighty argument in favour of their introduction in the Post-glacial times. Had they been subjected to violent watery action, they would, like most of the animal remains, have been scattered confusedly through the matrix, and

* The chert of which some of these implements are made appears to have been derived from the Greensand series of Blackdown.

† In making use of the terms Preglacial, Glacial, and Post-glacial, I have followed Phillips's division of the Pleistocene. (*Vide* Phillips's Manual of Geology, p. 408.)

‡ *Vide* Buckland's 'Reliquiæ Diluvianæ,' p. 164. In one cave in this Comb Dr. Buckland found human bones encrusted with stalagmite; in another, about two years ago (1859), I discovered numerous fragments of charcoal, and one of the sternal bones of *Canis lupus* mixed with numerous shells of *Helix*.

would not have been found as they were left by their former possessor. They would moreover have lost their sharp edges. On this point, indeed, they, as well as a large number of the animal remains, where slender processes and points of bone are left uninjured (as, for instance, the palatine process of the right maxilla of a Wolf), agree in showing that violent watery action had a very small share in filling the cave.

I should infer that, as the dolomitic conglomerate of the roof and walls gradually yielded to the attacks of the carbonic acid in the air, the *débris* was gradually accumulated at the same time that the Hyænas from time to time brought in the remains of their victims. On this hypothesis the fact of the occurrence of these implements in the same place, coupled with the absence of all traces of an entrance having been effected posterior to the filling up of the cave, is easily explicable; as also is the fact of the bones and teeth being confusedly scattered, and yet in no instance water-worn. This gradual process may at times have been varied by floodings, by which a large quantity of earthy sediment, derived from higher levels, may have been introduced, as now in a cave close by, in which sediment similar in every respect to the red earth of the bone-cave is deposited during a rainy season (p. 116, *note*). Had the numerous large stones been put in motion by water in the cave, they would soon have ground down the animal remains to an impalpable dust.

Thus, indeed, the discovery of these implements in the same spot, so far from proving that they were introduced subsequently to the other remains, adds additional testimony to the method by which the cave was filled,—that it was filled gradually and by causes still in operation, and not by any great cataclysm, by which the contents of numerous bone-caves are supposed to have been introduced. And the only alternative left us is to believe that they were deposited during the time that the *Rhinoceros tichorhinus*, Irish Elk, and Cave-bear inhabited the British Isles, and before the great submergence of land in the Northern Hemisphere.

In April 1861 we resumed our excavations; and, as we made our way inwards, found that the cave began to narrow, and ultimately to bifurcate; one branch extending vertically upwards, while the other, which is undisturbed, appeared to extend almost horizontally to the right hand. As we reached the middle constricted passage, the teeth became fewer, while the stones were of larger size than any that we had hitherto discovered. The great majority of the gnawed antlers of Deer were found at this part, also the posterior half of a cervine skull, the right maxilla of *Canis lupus*, and, what is more remarkable, a stone with one of its surfaces coated with a deposit apparently of stalagmite: this, however, was much lighter than stalagmite, and not so good a conductor of heat; and, on analysis, I found that it consisted of phosphate of lime, with a little carbonate, and a very small portion of peroxide of manganese. Doubtless the surface of the stone, covered with phosphate of lime, formed part of the ancient floor of the cave, and hence was coated with excrement, while the lower part, being imbedded in the earth on the floor, was not so coated. This deposit may, perhaps, explain the absence of round balls of *Album græcum*, which, assuming that the cave at the time was more damp than that at Kirkdale, would be trodden down on the floor by the hyænas, instead of presenting a rounded form. The stone also itself exhibits tooth-marks, and probably was gnawed by the hyænas, like the necrosed antlers, for amusement. Dogs are very fond of exercising their teeth in this way. This discovery also proves that violent watery action had but small share, if any, in filling the cave; for in that case the soft *Album græcum* would have been removed from the stone.

The section made in cutting this passage presented irregular layers of peroxide of manganese, full of bony splinters, and in general covered by a layer of bones in various stages of decay. These layers disappeared in the upper portion of the passage. There were masses of prismatized stalactites scattered confusedly through the matrix. After excavating the vertical branch as far as we dared (for the large stones in it made the task dangerous), we were compelled to leave off, having penetrated altogether only 34 feet from the cave's mouth. In this vertical branch, the bones, stones, and red earth are cemented together by carbonate of lime,—a circumstance which added materially to the difficulty of the excavation.

A short distance from the entrance the cave gives off a lateral branch to the left, which tends obliquely upwards, and is abruptly closed by stalagmite. This forms a marked contrast to the rest of the cave, being covered with stalactite and stalagmite, and free from *débris*; while the other parts are full of *débris*, and at the same time free from any but the merest traces of carbonate of lime, except in the case of the vertical branch above mentioned, where, however, it does not assume a stalagmitic form.

There are numerous caverns in the vicinity which, in all probability, are connected with the one under notice, and which, to say the very least, are parts of the same great system*, and all open upon the same ravine. And even this probably is but a cavern unroofed by the chemical action of the carbonic acid in the air, by which the insoluble carbonate of the stone is changed into the

* By a system of caverns I mean all those which open upon a common ravine. Through this a stream often flows, supplied in many cases by feeders out of one or more caverns. On close examination of a number of the caves in the Mendips, I find them, in the main, ranged round their ravines as branches are arranged on a tree. Burrington-Comb, Cheddar Pass, and Wookey-Hole Ravine, each surrounded by its system, are eminently typical. I do not see the reason why the change of insoluble carbonate into soluble bicarbonate of lime, by which swallow-holes and parts of caverns are perpetually and gradually being enlarged, should be limited in its effects, if infinite time be granted, and why it should not have been the chief agent in forming the ravines so common in all limestone districts. By this process one of the caverns at the top of Cheddar Pass is gradually being unroofed, and is becoming a miniature ravine. On this view, the great majority of limestone ravines are but ruined caverns. The loose stones on the summit of the Mendips in many cases present a ground-plan of a system of caverns on the upper surface, by the chemical action of the carbonic acid, the main channel being surrounded by numerous accessory ones, which collect all the moisture on the surface in their ramifications.

soluble bicarbonate, and conveyed away atom by atom. It probably was the main trunk fed by numerous tributaries, now represented by caverns, all of which are dry, with the exception of that at the head of the ravine, through which the drainage still passes, though not to the same degree as formerly.

On measuring the cave, we found that the maximum height of the entrance was 8 feet and the width 36 feet; in the interior the maximum height was 9 feet.

Organic Remains.—I will now proceed to a description of the organic remains found, selecting out of my descriptive catalogue those which present points of the greatest interest.

To begin with the Perissodactyles. The remains of *Equus* by far predominate over the rest: 4 astragali, os calcis of colt, metatarsals and carpals, a distal end of tibia, more than 70 molars, 7 incisors, and one canine attest how numerous Horses were at this period in the West of England. And here let me remark that the vast preponderance of the teeth of *Bos* in the Kirkdale Cave over those of *Equus* seems to indicate that the Ox preponderated over the Horse in Yorkshire, at the same time that Horses were more abundant than Oxen in the plains of Somerset. The remains show that *Equus* was of the ordinary size. Of the *Rhinoceros tichorhinus* also 14 lower and 10 upper molars, and 2 molars in the possession of Williamson, also the proximal ends of 3 ulnas, fractured exactly in the same place, a metacarpal, astragalus, and 2 phalanges rewarded our search. And one upper-jaw deciduous molar, of the right side, presents this difficulty—that, while the posterior island of enamel in its depth, and the shape of the valley advancing obliquely outwards, approximate closely to the typical species (*R. tichorhinus*)*, the broad entrance of the valley, and the presence of a small cusp in it, at first sight appear to be referable to *Rhinoceros leptorhinus*. The absorbed fangs and the small size indicate a deciduous tooth. In another upper molar of the left side, according in every other respect with this, the cusp is absent.

The Artiodactyle division of Herbivores is represented by the remains both of *Bovidæ* and *Cervidæ*. Of the remains of *Bos primigenius*, one os calcis was far larger than any in the Oxford Museum, and about twice the size of an average recent Ox; another was of the same size as those from Wirksworth, Kirkdale, Banwell, and Plymouth; a right astragalus was larger than three out of four specimens from Kirkdale, but was identical with one from Caswell Bay near Swansea. A phalanx larger than any which I have seen, a scapho-cuboid of the same size as those from Kirkdale, a fragment of left femur, identical in size with those found at Banwell, and three molar teeth were also found. Of the remains of the *Cervidæ*, I regret to say that I have been unable to identify more than three species:—1. *Megaceros Hibernicus*; four premolars, and one molar of the upper jaw, four molars of the lower jaw, and two fragments of the lower jaw containing respectively $\overline{\text{P. M. 2·3}}|$ and $|\overline{\text{M. 1·2·3}}$ †.

* Comp. Owen's British Foss. Mam. p. 374.

† In identifying teeth and bones, I have found that a concise mode of distinguishing right from left was extremely useful, as it adds great precision to the

The accessory column in the interspaces between the lobules of the crowns of the true molars * on the outer side in the lower jaw, and on the inner of the upper jaw, is rudimentary, being developed basally as a small tubercle. These tubercles are much narrower than those in specimens in the Oxford Museum, from a turbary, and consequently are more pointed, and do not keep the lobules, as it were, so far apart.

2. Antlers of *Cervus Bucklandi* † characterized by the brow-antler arising at a distance of 2½ inches or more from the base of the beam. These had fallen off by necrosis. Two antlers of *Cervus Guettardi* ‡: the one, a mere fragment and broken in exactly the same fashion as one from the cavern of Breugue, figured in the fourth volume of Cuvier's 'Ossemens Fossiles,' pl. 6. fig. 15; the other also is exactly similar to fig. 17 of the same plate, and is characterized by the brow-antler arising 2½ inches from the base of the beam, and by the bez-antler arising from the posterior and opposite side. The beam is round, and in circumference is 2 inches, and in length 14 inches. The branches have a tendency to become palmated.

Among the equivocal cervine remains is the posterior portion of a skull §, which in the posterior position of the antler-basement, and in general form, strongly resembles that of *Cervus Tarandus*, figured in Owen's 'Fossil Mammals' and in the 'Ossemens Fossiles,' and one in the British Museum. The antler-basements are but one inch removed from the occipital crest, and are about one inch and a half in diameter. On comparing this latter measurement with the diameter of the necrosed bases of antlers of *Cervus Bucklandi*, I find that it exactly coincides with one of them, and with the short diameter

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inquiry. To effect this I use a vertical line, which is supposed to represent the median line of the animal, putting teeth and bones of the right side to its right, and of the left side to its left, as in the text. This method is very useful in cataloguing.

* See Owen's British Foss. Mam. pp. 449, 450.

† Dimensions of two fragments of antlers of *Cervus Bucklandi*:—

	in.	lin.	in.	lin.
Distance of brow-antler from the base of beam	2	6	2	6
Circumference near the base	6	0	6	3
Diameter at the base	1	6–9	1	6

Both are rounded basally and rather flattened where the brow-antler is given.

	in.	lin.
‡ Length of beam	14	0
Brow-antler, distance from base	2	6
Bez-antler	8	9
Circumference of rounded beam	2	0

§ Dimensions of skull:—

	in.	lin.
Diameter of antler-basement or frontals	1	6
Distance between antler-basements	1	9
Distance of antler-basement from occipital crest	1	0
From the summit of median crest on occipital to foramen magnum	2	3
From the summit of mastoid to the superior and median portion of foramen magnum, where the crest on occipitals impinges upon it	2	9
Diameter of occipital, measured between the points where the squamous portion of the temporal impinges upon the occipital crest...	3	6

of the other, the length being 1 inch 9 lines. This similarity is striking, though perhaps it is a mere coincidence. An antler with rounded beam and brow-antler arising close to the base, and having a circumference at the base of 3 inches 3 lines, and at mid-beam 2 inches 6 lines, probably belonged to *Cervus Tarandus.* There are also numerous pieces of palmated antlers, which either belonged to *Cervus Dama, C. Tarandus,* or *C. Guettardi.* There are also teeth, fragments of carpals and tarsals, and other fragments, which are undoubtedly cervine, though I have not been able to make out the species.

Of *Elephas primigenius* the only remains found were a portion of a tusk of a large, and the second molar of a small individual*. Of these latter, one has not been used at all, and the other is hardly worn.

Of *Ursus spelæus*†, the only representative of the Plantigrade family in the cave, were found the left humerus (of the same size as some from Gailenreuth), also canines and molars. The latter are larger than any from Quinger or Gailenreuth, in the Oxford Museum. The humeri and tibiæ of the Fox indicate a creature of the average size. On the other hand, the upper jaw and sectorial upper molar, and humerus of *Canis lupus* are much larger than any of the recent specimens with which I have had an opportunity of comparing them. But, to pass from the *Canidæ* to the cognate family of *Hyænidæ*, as at Kirkdale, the normal inhabitants of the den, numerous teeth of all ages, the ilium and metacarpals and jaws, which were in various stages of decay, rewarded our research. The great preponderance of teeth ‡ may perhaps in some degree be accounted for by the decay

	in.	lin.
* Length of crown of perfect molar	2	5
Breadth of ditto	1	0

It is broader posteriorly than a molar from Kirkdale, in the Oxford Museum, and figured in the 'Reliquiæ.'

† The third molar of the upper jaw (M. 3) is 2 inches in antero-posterior length, and in breadth 0·875 of an inch; while the largest from Quinger and Gailenreuth (in Oxford) measures but 1·875 in length and 0·75 in breadth. The canines are smaller than the largest from Quinger, but of equal size with others:—

	in.	lin.
Length of perfect canine	4	3
Circumference at base of crown	2	3

‡ In identifying the premolars, I made out the following points which may perhaps be found useful. A ridge passing over the crown in the lower-jaw series divides it into two equal or subequal parts, while in the upper jaw it circumscribes the inner third only of the crown, or at least divides it very unequally. Of the lower jaw, premolar 2 (P. M. 2) is characterized by the small crown, large posterior talon, and by having its anterior fang suddenly reflected to afford room for the root of the canine; premolar 3 (P. M. 3) by the slight backward curvature of the anterior fang, coupled with the transverse compression of the posterior talon; premolar 4 (P. M. 4) by the straight diverging fangs and the enormous development of the posterior talon, the posterior and inner side of which is bevelled off obliquely to allow of the close apposition of (M. 1) the molar. In the upper jaw, the first premolar has its single root incurved, the second has its crown divided into two unequal portions and its fangs divergent; while the length and great curvature of the fangs, the incurved crown, and the ridge circumscribing its inner third characterize the third premolar. About the fourth no mistake can be made.

of the jaws while the teeth remained perfectly sound; though, in the main, as in the case of the solid bones, their rejection by the Hyænas was the main cause. One jaw, which I did not see dug out, is stated by the workmen to have been found in two portions, the one at least a foot from the other, in the undisturbed matrix. Supposing this to be true (and the fracture of the parts appears to be old), I have had the satisfaction of putting together what the Hyænas left dissociated, and additional testimony is afforded that the contents of the cave were never subjected to violent watery action. This was found about 13 feet from the entrance, and at a considerable depth from the roof. Fragments of bone are polished by the tread of the Hyænas, as at Kirkdale.

The absence of the Water-rat and Hippopotamus from these remains seems to indicate that the cave was further removed from a river or lake than the Hyæna-den at Kirkdale.

In conclusion, I will only add that, after carefully weighing the facts of the case, on the site of our excavation, I cannot but infer, from the evidence afforded by this cave alone, that Man was a contemporary of the gigantic *Ursus spelæus*, the Hyæna, the Mammoth, and their congeners; and I feel convinced that the cave was filled with its present contents, not by a violent cataclysm, but by the ordinary operations of nature now, as then, in progress; with this difference only, that the remains of Foxes and Badgers are now being entombed in the caverns still open in the district, instead of the extinct preglacial fauna.

List of Mammalian Remains.

CARNIVORA.

HYÆNIDÆ. *Hyæna spelæa*, 4 jaws, 49 teeth, left ilium, 2 metacarpals, portion of right rib, and right maxillary.

CANIDÆ. *Canis vulpes*, 4 humeri, 3 ulnæ, 5 tibiæ, left radius.

Canis lupus, right maxillæ with P. M. 4 and incisors 2, right humerus.

URSIDÆ. *Ursus spelæus*, 3 molars, 2 canines, left humerus.

PERISSODACTYLA.

SOLIDUNGULA. *Equus*, os calcis, 4 astragali, metacarpal, metatarsal, distal end of tibia, upwards of 70 molars, 7 incisors, one canine.

MULTUNGULA. *Rhinoceros tichorhinus*, 3 proximal ends of ulnæ, astragalus, phalanges, 29 molars.

ARTIODACTYLA.

BOVIDÆ. *Bos primigenius*, 2 ossa calcis (right), astragalus, phalanx, portion of shaft of femur, scapho-cuboid, 2 molars.

CERVIDÆ. Teeth, antlers, and various fragments.

Megaceros Hibernicus, 7 molars, fragment of jaw containing M. 1, 2, 3.

Cervus Bucklandi, 2 antlers (skull?).

C. Guettardi, 2 antlers.

C. Tarandus (?), (skull?), (antler?).

C. Dama (?), fragments of antlers.

PROBOSCIDIA.

Elephas primigenius, 2 second molars, portion of tusk, innumerable splinters.

February 5, 1862.

Captain William Henry Mackesy (79th Highlanders), Waterford; Harry Seeley, Esq., Woodwardian Museum, Cambridge; and Thomas Francis Jamieson, Esq., Ellon, Aberdeenshire, were elected Fellows.

The following communications were read:—

1. *On some* Volcanic Phenomena *lately observed at* Torre del Greco *and* Resina. By Signor Luigi Palmieri, Director of the Royal Observatory on Vesuvius.

[In Letters addressed to H.M. Consul at Naples, and dated December 17, 1861, and January 3, 1862. Sent from the Foreign Office, by order of Earl Russell.]

(Abstract.)

The evolution of gases, the outburst of springs of acidulous and hot water, and particularly the upheaval of the ground at Torre del Greco to a height of 1·12 mètre above the sea-level, are mentioned in this communication.

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2. *On the recent* Eruption *of* Vesuvius *in* December 1861. By M. Pierre de Tchihatcheff.

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

(Abstract.)

On the 8th of December the ground in the neighbourhood of Torre del Greco was shaken by repeated earthquakes from dawn up to 3 o'clock in the afternoon. As many as twenty-one distinct shocks were counted there, but only one of them was felt at Naples. At the hour above mentioned the atmosphere over Torre was wrapt in complete darkness, clouds of ashes having been projected from several mouths which had opened on the slope of Vesuvius, a short distance above the town. Early on the next day (the 9th) I visited Torre del Greco, and leaving the town below, mounted towards the stream of lava which had in the preceding night poured forth from the apertures already mentioned. It had cooled so rapidly that I was enabled to walk upon the scoriaceous crust, though the interior was so hot that my stick took fire on being thrust into its cracks.

After proceeding about 600 mètres to the N.E., I came to the smoking hills, which were still vomiting glowing scoriæ and ashes so abundantly as to prevent a near approach. The white steam and black ashes, ejected from them with violent shocks resembling the intermittent puffs of a steam-engine, rose in globular masses so as to form a columnar shaft, which, spreading laterally at a great height, reproduced the "pine" of Pliny. On my return to Torre del Greco I saw two new mouths open before me. About this time the central cone of Vesuvius, which had been tranquil hitherto, began to eject steam and ashes in thick clouds, attended by frequent flashes of lightning. The explosions of the new craters, as well as the flow of the lava, ceased almost wholly about the third day, viz. by the 12th of December.

J. W. Lowry, sculpt.

On the 16th heavy rains fell, the weather having been quite clear and tranquil up to that time. On a second visit made on the 23rd of December, I ascertained the number of openings, marked by minor cones with funnel-shaped craters, that had been formed on the flank of the mountain were about twelve—ranged close together on a line from E.N.E. to W.S.W. at the distance of about 600 metres S.S.E. from the old lateral crater whence the lava-stream of 1794 proceeded which had poured down on Torre del Greco. Thus it appears that a fissure had on this occasion been formed in the side of the mountain, either on the prolongation of that of 1794, or parallel and close to it. The lavas produced by the two eruptions are also almost identical in mineral character, being very poor in leucite, but rich in augite crystals.

On returning to Torre del Greco, I was surprised to find the principal fountains of the town overflowing with an excessive supply of water, as in general during eruptions the springs are rather apt to fail. Bubbles of carbonic acid gas were rising abundantly from the water. Many of the cracks which had been formed by the earthquakes in the pavement of the streets of the town were seen, it is said, to emit small flames (of carburetted hydrogen?). It is certain that the shore beneath Torre del Greco was permanently elevated by above a metre—a long white line composed of mollusks and zoophytes attached to the rock, which only live under water, being now generally raised that much above the sea-level, through a space of at least two kilometres.

The cone of Vesuvius continued to smoke at intervals for several days. On the 23rd of December ashes fell abundantly in the streets of Naples—a circumstance that has not occurred since 1822.

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3. *On* Iso-diametric Lines, *as means of representing the* Distribution *of* Sedimentary Clay *and* Sandy Strata, *as distinguished from* Calcareous Strata, *with special reference to the* Carboniferous Rocks *of* Britain. By Edward Hull, B.A., F.G.S., of the Geological Survey of Great Britain.

[Plate VII.]

Contents.

[*Note.*—In the following pages the term "Sedimentary" is used to denote exclusively such inorganic strata as sandstones, clay, shales, &c., in opposition to Calcareous strata or limestones.]

§ 1.—*Introduction.*—A large and interesting field of inquiry is open to us in comparisons of the relative distribution of the calcareous and the truly sedimentary members of different geological formations. We have, as it appears to me, been too much in the habit of classing limestones (whether coralline, crinoidal, shelly, or oolitic) as strictly sedimentary; yet it will be found, by such comparisons as those alluded to, that the relation which is borne by sandstones and shales to limestones is one, not of similarity, but of contrast. In other words, that where we have a group of strata, as, for example, the Lower Carboniferous, composed partly of "sedimentary" and partly of calcareous members, it will generally be found that the one series is complemental of the other, and developed from opposite directions. This arises from the differences in the origin of the two classes of stratified rocks, the calcareous being essentially organic, and the "sedimentary" essentially mechanical; so that where the forces and agencies tending to the accumulation of the latter are in active operation, these very forces and agencies are in direct antagonism to the other, and, as a result, calcareous strata are either not formed or only sparingly*.

(*a*.) Of these two ever-acting principles we have numerous examples both in recent and in geologic periods. If we take as an illustration the Gulf of Mexico and the West Indian Islands, we find the sediment brought down by the Mississippi forming deposits of sand and clay which are spread along the coast and far out to sea by the Gulf-stream, while around the West Indian Islands coralline

* That limestones are either directly or indirectly the production of animals is now so generally admitted that it seems scarcely necessary to cite authorities. Bischof in his work on Chemical Geology (vol. iii. p. 35) says, "So long as the formation of mechanical deposits was predominant, the organic action of the marine animals that separate limestone, or at least that of the corals, could not be exercised." This passage (which did not come under my notice until these pages had been brought before the Geological Society) fully bears out the principle of opposition between the origin of the two classes of rocks, which I am now endeavouring to illustrate. See also Lieut. Nelson's 'Account of the Bermuda Coral-formations,' Trans. Geol. Soc. 2nd series, vol. v.

limestones are being accumulated in a clear ocean*. If we take the North Atlantic, we find reason for believing, on the evidence of the deep-sea soundings, that the central area is composed of a fine calcareous mud†, the production of *Foraminifera* and other marine animals, while along the shores of the American continent and those of Europe deposits of sand, gravel, and clay are in course of accumulation. If these regions were elevated into land, we should probably find a formation composed in one direction of limestone, like chalk, and in the other of sandstones and shales, both classes of material being developed from opposite areas of dispersion.

Indeed, the representative positions of the pelagic and littoral formations—the one calcareous, the other sedimentary—are very clearly stated by Sir C. Lyell, who says‡, "It has been ascertained by soundings in all parts of the world, that where new deposits are taking place in the sea, coarse sand and small pebbles commonly occur near the shore, while further from land and in deeper water finer sand and broken shells are spread over the bottom ; still further out, the finest mud and ooze are alone met with. Mr. Austen observes that this is the rule in every part of the English Channel." I think, however, that experience will bear us still further than this, and that we may regard the predominance of sedimentary strata as highly unfavourable to the development of calcareous, in the same group of rocks.

(*b.*) The same general principle is in force over our globe at the present day, and probably has been from the times when calcareous strata, which are the representatives of marine life, first began to be formed. Wherever large rivers pour sediment into the ocean, or where currents take up and distribute this sediment over the sea-bed, there limestones will be very sparingly formed. On the other hand, where, from certain causes, such as the great distance from land, or the absence of such rivers and currents, the water of the sea is *clear* and *free from mud* within the temperate or tropical regions, there calcareous matter will be accumulated. Of the strata at present forming, the great calcareous members are to be found occupying principally mid-oceanic regions, and their representative sedimentary members range themselves in the direction of the coasts. Still there may be frequent cases where the limestones may be formed along the coasts of large tracts of land, as on the shores of Australia and Southern India, but in every such case there is an absence or scarcity of sandy or muddy sediment§. Reverting to geologic periods, I have no wish here to repeat what has been frequently shown by Lyell, Darwin, Phillips, Godwin-Austen, and other writers, that calcareous forma-

* For this illustration I am indebted to my friend Dr. J. Hector, lately Surgeon and Geologist to the exploring expedition under Capt. Palliser.

† Capt. Maury's 'Physical Geography of the Sea.' A very interesting account of these soundings has been published by Dr. Wallich for private distribution.

‡ 'Principles of Geology,' 8th edit. p. 770.

§ On this point Ehrenberg states "that he never saw corals grow where the sea was frequently rendered turbid by shifting sand, but only where it was clear and pure."—Poggendorff's Annalen. The same fact is stated by Mr. Jukes, Mr. Darwin, and other writers.

tions of one region are represented by shales and sandstones in another; but the point I wish to urge particularly is that such contemporaneous strata are necessarily developed from opposite directions, and that the region over which one of these classes of strata is most fully represented is that in which the other has been most sparingly deposited. Thus the White Chalk of Europe is replaced by sandstones, shales, and lignite in America*, in which there is very little calcareous matter. We may therefore believe that a clear ocean, uncontaminated by muddy sediment, overspread the greater part of Europe, while the waters of North America were charged with sediment. The cause of the change of mineral character is here sufficiently evident. The animals which flourished in the clear waters of Europe, and by whose vital powers the soluble calcareous matter was converted into chalk, were incapable of living where the sea was turgid. In this case the animals were Corals, Sponges, *Bryozoa*, *Cytheridæ*, and *Foraminifera*.

(*c*.) Confining our view to narrower limits, let us take for another illustration the Great Oolite as it occurs in Oxfordshire and on the east coast of Yorkshire. In Oxfordshire the most conspicuous member is the "White Limestone" (not unlike hardened chalk), interposed between the Stonesfield Slate series† and the Forest-marble. The White Limestone is generally very free from any admixture of sand or clay, and is essentially organic in its composition. On the other hand, the Forest-marble and Stonesfield Slate contain a large admixture of sedimentary ingredients; but neither of them is as thick as the White Limestone. Yet, when traced to the coast-section of Scarborough, a great change is found to have taken place in the relative development of these three members of the Great Oolite. The lowest and highest members have expanded by an accession of sedimentary materials. They are (as it seems to me) the "lower" and "upper sandstone and shale series," stated by Prof. Phillips to be 700 feet in thickness (but possibly more), while the central calcareous member has become so thin and debased as to be scarcely recognizable.

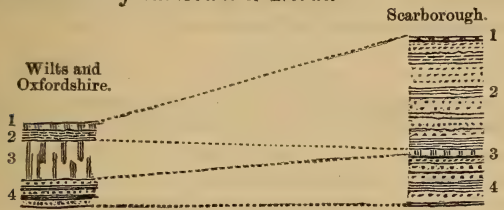
(*d*.) We may also instance the Permian Rocks of England. Thus we find the calcareous members attaining their maximum development of 500 feet according to Prof. Sedgwick, or 600 feet according to Mr. Kirkby, in Durham, dwindling to 440 feet in South Yorkshire; and when last exposed towards Nottingham, showing evident symptoms of debasement. Over these districts the Lower Permian strata are but sparingly represented, but as we proceed south-westward are found gradually to augment, till in Warwickshire and Salop they attain their full thickness of 1500 or 2000 feet, the whole of which is formed of sandstones, shales, breccias, and conglomerates. It will be observed that the points of maximum development of the calcareous and sedi-

* Lyell's Manual of Elem. Geol., 5th edit. p. 255; Dr. Hector, Quart. Journ. Geol. Soc. vol. xvii. p. 412, &c.

† In the Memoirs of the Geological Survey, 1858, the White Limestone is called "the Upper Zone," and the Stonesfield Slate "the Lower Zone" of the Great Oolite.

mentary elements are situated at opposite extremities of the area occupied by the Permian group.

Fig. 1.—*Comparative Sections in Oxfordshire and Yorkshire, showing the Changes in the Sedimentary and Calcareous Members of the Great Oolite, when traced from South to North.*



1. Cornbrash.	=1. Cornbrash.
2. Forest-marble.	=2. Upper Sandstone and Shale.
3. White Limestone, or Upper Zone of Great Oolite.	=3. Limestone.
4. Stonesfield Slate, or Lower Zone.	=4. Lower Sandstone and Shale.

(*e.*) To take another example of development, from opposite directions, of calcareous and sedimentary strata, we may select the Lower Carboniferous Rocks of Belgium and Westphalia, which present phenomena analogous to those of the same formations in our own country. In Belgium the Coal-measures rest upon a thin floor of sandstone representing the Millstone-grit. Below this is the Carboniferous Limestone in great thickness, which in turn rests on a thin series of shales. On tracing these strata north-eastward towards the vlaley of the Rhine, they are found to undergo marked changes in their development, as shown by Sir R. Murchison and Prof. Sedgwick†. The limestone thins away, while the grits and shales proportionably expand. Thus it is found that the series which underlies the Coal-measures of Westphalia resembles the Lower Carboniferous series of Scotland, consisting of sandstones (Flötz-leerer Sandstein) and shales with *Posidonomya Becheri*, the limestone itself having disappeared*. These changes I consider to be intimately connected with those undergone by the same formations in Britain, and to be due to the same general cause, namely, the northerly drift of sediment during the Carboniferous Period.

Similar illustrations might be multiplied, did space permit; but, without here entering further into the general principle, I will merely state my belief that a comparison of the relative distribution of the calcareous as distinguished from the argillo-arenaceous, or sedimentary, strata of the Carboniferous, Devonian, and Upper Silurian formations would show, as a general rule, that the regions of maximum development of the one series are those of minimum de-

* "Siluria" 2nd edit. p. 427.

† Although there is a marked unconformity between the Lower and the Upper Carboniferous Rocks of Westphalia, I do not consider it, of itself, sufficient to account for the interchange of development between the arenaceo-argillaceous and the calcareous strata.

velopment of the other, and, consequently, that the relationship of the two classes of rocks is complemental.

Fig. 2.—*Section of the Carboniferous Rocks of Belgium and Westphalia, showing the augmentation in the thickness of the "Sedimentary" Strata, and the simultaneous thinning-out of the Carboniferous Limestone towards the North-east.*

1. Coal-measures.
2. Millstone-grit (Flötz-leerer Sandstein).
3. Carboniferous Limestone (absent in Westphalia).
4. Lower Shales, expanding in Westphalia.
* Devonian Schists, &c. at the base of the Carboniferous Rocks.

(*f.*) I have already hinted at the cause of this inherent distinction, but it may be as well to state it in more precise language. As limestones are by universal consent allowed to have resulted from the exuviæ of living animals, they will be accumulated in greatest quantity wherever the conditions of life are most favourable. Now, the fact that limestones, when they occur in considerable thickness, are generally pure, and free from foreign matter, shows that one of the first requisites for limestone-making animals is that they should inhabit waters free from mud or sand. Where the White Chalk is in greatest thickness, it is pure; the same is the case with the Oolite limestones, and with the Carboniferous Limestone of Derbyshire which is of enormous thickness and contains very few beds of shale; but whenever these massive calcareous rocks begin to be split up by the admixture of shales or sandstones, they become impoverished in mineral character and diminished in thickness*. The formations in which these phenomena occur show us that the *Mollusca* are to some degree independent of such changes, as the remains of animals of this class are often abundant in sandy and muddy deposits containing small quantities of lime; but, as a general statement, it may be affirmed that clear and unpolluted water was essential to the full development of those delicately organized animals, the *Foraminifera, Zoophyta, Polyzoa*, and *Crinoidea*, which are, and have ever been, the most efficient elaborators of limestone rocks.

It is almost superfluous to observe, that, in speaking of the necessity of pure water to the full development of the marine animals above named, carbonate of lime in solution is not understood as a source of impurity. This mineral must necessarily be present as the material from which the Zoophytes and other animals construct their

* The limestones of the Culm of Devonshire, as compared with their representatives at Bristol, are illustrations of this principle. At Bristol, where it occurs in great force, the limestone is pure and crystalline; but in Devonshire, where black shales are largely distributed amongst the beds of limestone, these latter are frequently of so poor a quality that "even in the richer portions there is seldom more than a third or fourth part which is actually burnt for lime." See Memoir of Sedgwick and Murchison, in Geol. Trans. 2nd ser. vol. v. p. 674.

stony skeletons and habitations. Carbonate of lime, however, when dissolved by the agency of free carbonic-acid gas, does not interfere with the transparency of the water; and this transparency is the all-important condition to the organic growth of limestones. And notwithstanding that the amount of carbonate of lime in solution in the mid-ocean is often extremely minute, yet its solubility enables it to be carried to all parts of the ocean where no particle of sand or clay can reach; and thus it may be possible that all sedimentary formations have had their contemporary calcareous representatives at some one or more parts of the globe.

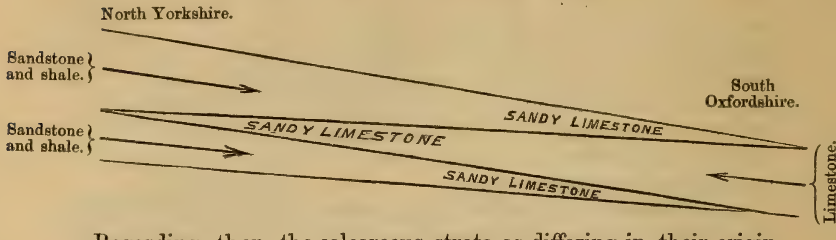
(*g.*) There is one objection which may be urged against this view of the relations of true sedimentary and the calcareous strata. In the cases just cited of the Carboniferous Rocks of Belgium and Westphalia, and of the Great Oolite of our own country, the development of the sandstones and shales from the one direction, and of the limestones from the opposite, are not strictly contemporaneous. Thus the lower and upper sandstone and shale of the Great Oolite, which are thickest in the North, are earlier and later than the "white limestone," which is most highly developed in the South. This, however, arises from the very slow progress of those changes in the character of the land and sea which have conduced to the differences of the strata formed in each district. While the lower series of sandstones and shales were being formed over the Yorkshire area, the sea-bed was gradually preparing for the future development of calcareous strata over the Oxfordshire area; and while limestones were forming under Oxfordshire, the sea of Yorkshire was still sufficiently charged with sand and mud to prevent their full development in that quarter. Another change occurred: the Yorkshire sea again became charged with sand and mud, which so far extended its influence to Oxfordshire as to check the formation of pure limestone.

In this instance, as in others, there was a series of oscillations as the two agencies alternately predominated; but, while each in turn obtained the ascendency, the influence of the other never entirely ceased within certain limits. Thus, while sandstones and shales were accumulating in Yorkshire, sandy limestones and calcareous shales were forming in Oxfordshire, as the influence of the calcareous element was always more or less in force in the southern direction, when it was entirely overpowered by the ascendency of the sedimentary element in the north. And if we adopt the conclusion of Bischof, that it is impossible for any carbonate of lime to be precipitated at the bottom of the open sea by chemical action, but only by the intervention of organized beings, we must allow that these agencies, by whatever terms they may be designated, are not mere figures of speech, but real and ever-acting forces of nature.

It is difficult to represent by means of a diagram what is here discussed; but perhaps fig. 3, representing the Great Oolite of Yorkshire and Oxfordshire, may assist in rendering my meaning more clear*. (See also fig. 1, p. 131.)

* I am aware that Dr. Wright, than whom there is no better authority, calls in question, on palæontological evidence, the parallelism here stated, which is, I

Fig. 3.—*Showing the Distribution of the Calcareous and "Sedimentary" Strata of the Great Oolite.*



Regarding, then, the calcareous strata as differing in their origin and in their mode of distribution from the other stratified rocks with which they are associated, it appears to me that it is incorrect to class them together under the same term of "sedimentary." I therefore propose to eliminate the limestones from this category, and to place them as a distinct class of rocks, confining the term "sedimentary" to gravels, sandstones, shales, and clays, with their variations. The presence of each class of rock in the same geological group is no argument in favour of their similarity. Whenever interstratifications occur, they may be regarded as occupying the neutral ground between their respective areas of dispersion; and I have little doubt, could it be possible to trace the sources of the "sedimentary" strata of any formation on the one hand, and of the limestones on the other, they would be found expanding in opposite directions, and, as it were, originating at opposite poles. The relationship here contended for will be rendered more clear in the case of the British Carboniferous Rocks by the iso-diametric lines presently to be described.

(*h.*) *Cause of the frequent occurrence of a Threefold Arrangement in Groups of Rocks, with a central Calcareous Member.*—We cannot fail to have observed that many groups have a tendency to arrange themselves into threefold divisions, the upper and lower being composed of sands or clays, the middle of limestone. This has been remarked as the result of his observations on the continent by Sir R. Murchison, and we have many examples in this country. Thus in the Upper Silurian Rocks there is a calcareous centre. This is also the case in the Devonian group of Devon and Cornwall; in the Carboniferous, the Permian, the Triassic (when complete), and the Jurassic Rocks.

Phenomena of so general a character cannot be accidental, but must be in accordance with the system of nature. May not the following be the true explanation?

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believe, in accordance with the order of succession determined by Prof. Phillips. Notwithstanding, however, the existence in the Scarborough Limestone of an Ammonite which is characteristic of the Inferior Oolite in Gloucestershire, I am strongly inclined to believe, on stratigraphical grounds, that there has been a "migration" of species; and that this is a case where identity of fossil remains does *not* prove that the strata are contemporaneous. In either case, however, the illustration is of equal value for my purpose.

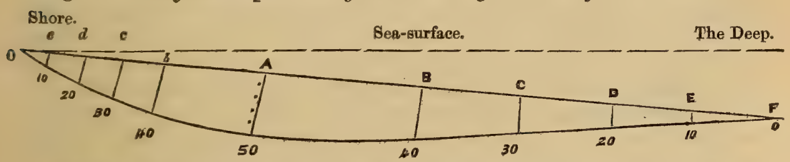
We may consider a group of rocks as primarily representing three periods: the first of movement, the second of quiescence, the third of movement again. We have already seen that the formation of calcareous strata depends mainly on the absence of sandy or muddy matter in the sea, which we may believe would be most likely to occur during a long period of repose from oscillations of land, as every movement of that kind would tend to increase the quantity of sediment poured into the sea. Hence we have the following parallelism in the three stages:—

Upper stage	*presenting*	movement	*resulting in*	sedimentary strata.
Middle stage	„	quiescence	„	calcareous strata.
Lower stage	„	movement	„	sedimentary strata.

The movements of the introductory stage have generally been more powerful than those of the closing stage; and thus, while we seldom or never find a Geological Epoch introduced with the formation of limestones, we sometimes find limestones maintaining their position to the close, as in the case of the Clymenia-limestone of the Upper Devonian of the Rhine, and in the Upper Silurian Group of North America. The earliest stage is generally formed of sandstones and conglomerates, representing those physical changes which introduced the new epoch.

(*i.*) *Iso-diametric Lines.*—We may regard all formations composed of sedimentary materials as exhibiting in cross-section a figure included by the arc of a curve and its chord (fig. 4). The end of the figure which tapers the more rapidly will represent the shore, the other the sea-deep; and the form of the figure will be variously modified by circumstances. The thickest or deepest portion will be *not at the centre,* but between the centre and the shore.

Fig. 4.—*Diagram representing the Primary Section of a Formation.*



Now, if we divide this figure by a series of lines (A, B, C, &c., and *a*, *b*, *c*, &c.), each decreasing by the same amount, and trace these lines over the region occupied by the formation, each will be a sort of stratigraphical contour; but, instead of representing equal altitudes, will show equal thicknesses. As such, these lines should properly be called *iso-picthic*; but this word is so difficult of pronunciation that I prefer the term *iso-diametric*, or simply *isometric*. Such lines are not intended to show the present or actual thickness of the strata, which may have been in part denuded, but the *original development before denudation*, and may thus be traced over areas where the whole has been swept away. In tracing out such lines, it is necessary to make accurate comparisons of sections scattered over the entire area, and of the original thickness of the strata which are either partially or altogether denuded, estimated upon certain definite principles. Of such principles *the development of calcareous and "sedimentary" strata from opposite directions* is one of the most important.

It will be perceived that isometric lines may be used in representing the thickness of an individual stratum, as well as of formations, groups, or systems; and the chief point to be attended to in tracing them is that the calcareous elements be eliminated from the "sedimentary."

In the case of "sedimentary" strata, a series of isometric lines, each representing an equal increase or diminution in thickness, will become nearer or wider apart as they approach or recede from the centre of maximum development.

In the case of calcareous formations, the focus or centre of maximum development will be at opposite points to that of the "sedimentary" in the same group or system of rocks, and the isometric curves will intersect, gradually diminishing in force from their respective centres, just as a series of waves propagated from two centres of disturbance cross each other and gradually die away in opposite directions. (See Map, Pl. VII.)

§ II. *Carboniferous Land-surface of Central England.*—Having thus explained the nature of isometric lines, we proceed to consider their application to the Carboniferous Rocks of Britain. I believe they will be found of essential service in bringing clearly and intelligibly before the eye several phenomena connected with the distribution of the sedimentary as compared with the calcareous portions of this group.

It is necessary that a few words should be said in reference to a point of interest in the physical geology of our island, which should be clearly understood before treating of the distribution of the Carboniferous strata. I refer to the existence of a barrier of land which there are grounds for supposing to have stretched from Wales eastward, skirting the southern ends of the South Staffordshire and Warwickshire Coal-fields, and including the Cambrian Rocks of Charnwood Forest. The evidences for the existence of this land-surface I cannot here stop to point out in detail, having already done so elsewhere *; suffice it to say that they are numerous and satisfactory, both on general physical grounds and from phenomena observed in the mines of the coal-fields on approaching its borders. This barrier (which possibly was an extension of the Scandinavian promontory on the one hand, as very clearly indicated by Mr. Godwin-Austen, and thence stretched across the Irish Sea to embrace the Cambro-Silurian districts of Wicklow and Carlow on the other) divided the Carboniferous Rocks of South Wales, Somersetshire, and Dean Forest from the coal-tracts of Central and Northern England and Scotland (see Map); and, as we shall see, the strata on each side belong to two distinct systems of distribution, and are due to two different sets of oceanic currents.

* 'The Coal-fields of Great Britain,' 2nd edit. p. 246 *et seq.*

1. Region North of the Barrier.

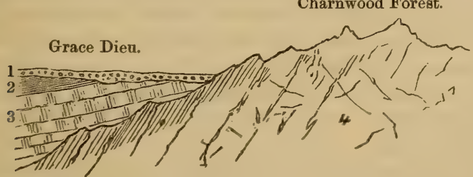
(*a.*) *South-easterly attenuation of the "Sedimentary" Strata; North-westerly attenuation of the Calcareous Strata.*—If we take a series of vertical sections of the various sandstones, grits, and shales of the Carboniferous Period, from the midland counties of Leicester, Warwick, and South Stafford, then through the adjoining districts to the north, and ultimately into Scotland, we shall find a constant accession of material along this course. Thus, I find that the increase from Leicestershire to Lancashire, along a line running north-west, is no less than 8000 feet of strata in a horizontal distance of 65 miles, which gives a slope of 1 in 43, or about 1° 30′, as the angle of increment of sediment in this distance; the maximum thickness of the strata in Lancashire being 12,000 feet, and in Leicestershire 4000 feet.

If, on the other hand, we make a similar series of sections of the limestones, from Derbyshire as a centre, either west, north-west, or north, we shall find that these calcareous strata constantly diminish in thickness in these directions. In other words, the limestones become thin as the sandstones and shales become thick.

We may thus regard Derbyshire as a focus of activity from whence the calcareous elements have been propagated with constantly diminishing intensity, at least in the directions here stated. Whatever be the extreme thickness of the Derbyshire limestone, it is apparently not less than 5000 feet, as determined by several measured sections of the Geological Survey,—a bulk of calcareous matter truly astonishing when we regard it in its true aspect as the work of marine animals. Nowhere else in Britain does the formation attain such vertical dimensions; but they may possibly be less than those which it reaches in the Rocky Mountains and elsewhere. Traced northwards into Northumberland and Scotland, the limestones, as is now well known, dwindle down in thickness as they become more and more mixed with transported sediment, and in Lancashire appear on the point of expiring.

Traced southwards, the limestone ends against the shelving shore of the old land-surface of the barrier, as at Charnworth Forest (fig. 5);

Fig. 5.—*Section of the Carboniferous and Triassic Strata lying on the edge of the Cambrian Rocks of Charnwood Forest.*



1. Triassic Breccia.
2. Carboniferous Limestone-shale.
3. Carboniferous Limestone.
4. Cambrian slate and porphyry.

or is altogether absent, as in South Staffordshire*, on account of this district having been above the sea, as shown by Mr. Jukes †.

* Murchison, Proc. Geol. Soc. vol. ii. p. 407.
† 'Memoir on the South Staffordshire Coalfield,' 2nd edit.

From this old land, however, little or no sediment was given off, as the limestone attains a very great thickness, and is pure dolomite at a short distance from the present site of the Cambrian rocks *. Over Derbyshire the sea must have been remarkably clear; but it became more muddy northward, till in Scotland the sediment was so abundant as to extinguish life in the Crinoids and Corals, by whose labours the limestone was formed. *Hence we have a clear proof that the sources of the sediment were in the north.*

In Yorkshire these variations in the relative distribution of the calcareous and non-calcareous strata of this group have long since been pointed out by Prof. Phillips. In a diagram appended to 'The Geology of Yorkshire' these variations are represented by an ingenious design, "and prove," as the author remarks, "that the agencies which resulted in the formation of the limestone acted with greatest effect from the south-east, while those which resulted in the deposition of sandstones and shales acted with greatest effect from the north-west."

He then proceeds to trace the range of the Lower Scar-limestone, showing that towards the south-east of its course between Ribblesdale and Wharfdale it is 1000 feet in thickness. Northward at Pen-y-ghent it is about 600 feet; at Kirkby Stephen even less. North of the line from Kettlewell to Bar Fell it becomes split up by beds of shale, grit, and coal, which continually augment northwards, until at length it assumes all the characters of the Lower Carboniferous group of Scotland.

He then shows that the Yoredale series increases in thickness towards the north-west (that is, in the direction along which the limestone becomes attenuated), attaining at Bar Fell 1000 feet or more, and dwindling down to 300 feet under Great Whernside.

These passages describe changes in the Lower Carboniferous series of Yorkshire, which are applicable on a much wider stage to England and Scotland, from the edge of the *barrier* northwards. Had Prof. Phillips extended his observations, and followed out the train of thought upon which he had entered, I can well understand what a fund of illustration and force of reasoning this subject would have received at his hands.

The thickness of the Carboniferous Limestone over every part of Britain is indicated by the isometric lines on the Map. These thicknesses have been obtained from the carefully measured sections of the Geological Survey—so far as it has extended,—and from the published works of various authors on the northern districts of England and in Scotland: the following are a few special instances. Thus, the thickness of the limestone in Coalbrook-Dale is 50 to 100 feet; in Denbighshire, 1000 to 1500 feet; in Flintshire, 1000 to 1500 feet; Anglesea, 360 feet; south side of the Lake District, 1500 feet; Scottish Borders, 500 feet; the Lothians, 162 feet; and Lanarkshire, less. In Fifeshire it is sometimes on the point of expiring.

* At Breedon Cloud, where its thickness is upwards of 1000 feet, with few or no bands of shale.

(*b.*) *Distribution of the "Sedimentary" Strata of the Carboniferous Period.*—The isometric lines on the Map will indicate better than any description the development of the grits, sandstones, and shales, from the north towards the south, collected from the most reliable sources. We shall commence with South Staffordshire.

South Staffordshire.—As is well known, the Lower Carboniferous Rocks, including the Millstone-grit, are absent here, for the same reason that the limestone is absent, namely, that this was a district of land forming a portion of the northern side of the barrier at this period. As the land became submerged during the Coal-period, the sea gradually encroached, and spread the Coal-measures as far south as the Lickey. Notwithstanding the uneven nature of the Silurian sea-bottom on which the Coal-measures were spread, we feel certain that near Dudley there exists the full series of the Coal-formation, as proved by the fossil shells from the ironstones, which are identical with those from the Lower Coal-measures of Coalbrook-Dale and Lancashire *. Here the combined thickness of the lower, middle, and upper Coal-measures (as determined by Mr. Jukes) is 1810 feet, which becomes considerably expanded north of Wolverhampton. This northerly expansion is remarkably exemplified in the case of the "thick coal" of Dudley, which, forming at that place one solid seam 10 yards in thickness, becomes split up into nine distinct seams by the intercalation of 420 feet of strata over the northern area of the coal-field.

In the *Warwickshire Coal-field* we find the Coal-series attaining, according to Mr. Howell †, a combined thickness of 2950 feet, in addition to which the Millstone-grit and Limestone-shale is 500 feet. The main coal here also presents an example of the thinning of the strata towards the south; for, at the north side of the field, this seam is split into five beds by the intervention of 120 feet of strata.

In the *Leicestershire Coal-field*, the Coal-series attains a thickness of about 2500 feet, while the Millstone-grit and Limestone-shale never exceeds 150 feet. The "main coal" of Moira offers another illustration in addition to those mentioned above of southerly attenuation ‡.

The three coal-fields of South Staffordshire, Warwickshire, and Leicestershire, presenting, as they do, a somewhat similar development of sedimentary strata, lie in the direction of the same series of isometric lines, and are to be compared with the coal-fields of North Staffordshire, Notts, and Derbyshire, immediately to the north of them.

North Staffordshire.—The development of the strata in this coal-field, as compared with that in any of the three just described, is

* The following are some of these, determined by Mr. Salter:—*Discina nitida, Producta scabricula, Lingula elliptica.*—Mr. Jukes's Memoir, 2nd edit. p. 27. The presence of these Lower Coal-measures is distinctly stated by Sir R. Murchison in his original description of this coal-field (Proc. Geol. Soc. vol. ii. p. 407).

† "Memoir on the Warwickshire Coal-field," Mem. Geol. Surv. 1859.

‡ Memoir by the Author, "On the Geology of Ashby-de-la-Zouch," &c., Mem. Geol. Surv. 1860.

great indeed. The three divisions of the Coal-measures attain a thickness of 6000 feet, in addition to which the Millstone-grit and Yoredale series are about 4000 feet, forming in all 10,000 feet of sedimentary strata, which is an increase of 6550 feet over the Warwickshire coal-field. The Carboniferous sands and clays appear to have been poured in greatest quantity along a tract of country running south-eastward through this district, causing the isometric lines to make a southerly bend when crossing it, and entitle this tract to be called " the line of maximum accumulation " *.

Flintshire and Derbyshire.—The development of both the calcareous and " sedimentary " elements in these counties are probably nearly similar. The combined thickness of the upper, middle, and lower Coal-measures reaches 3000 feet; and the Millstone-grit series from 800 to 1000; in all 3800 or 4000 feet. The Carboniferous Limestone varies from 1000 to 1500 feet †.

Anglesea.—The thickness of the Carboniferous series in Anglesea (as determined by Prof. Ramsay) is as follows:—Coal-measures, 1300 feet; Millstone-grit, 200 feet; Carboniferous Limestone (containing some beds of sandstone and shale), 450 feet ‡: separating the two elements we may say for the "sedimentary," 1600 feet; for the calcareous, 360 feet. The whole series, however, is not present, as the little coal-field has suffered from denudation, for which allowance must be made.

Notts, Derbyshire, and Yorkshire.—Crossing the limestone anticlinal into Derbyshire, we find the thickness of the strata in the neighbourhood of Alfreton as follows:—lower (or Gannister series), middle and upper measures, 3500 feet; Millstone-grit and Yoredale series, 600 feet; in all 4100 feet. As we do not, however, throughout the whole of this great coal-field reach the top of the Carboniferous rocks, which have either been denuded or are hidden beneath the Magnesian Limestone, several hundred feet ought to be added to the above, making the total thickness about 4500 feet, as compared with 2600 feet in Leicestershire. The thickness of these strata augments, though not rapidly, along their extension into Yorkshire. The development of the series in Durham varies from 3500 to 4000 feet.

Lancashire.—In this county there is a greater development of Carboniferous sedimentary strata than in any district in England. The upper Coal-series of Manchester is 2000 feet in thickness; the middle, 3200 feet; and the lower, 2000 feet; the thickness of the Millstone-grit series is unascertained, but is at least 3000 feet; and the Yoredale Rocks, 2000 feet; in all 12,200 feet. This thickness is

* I may here explain that it appears probable that the barrier of land was broken through to the south of Warwickshire, allowing the northern current, which brought the sediment, to escape through the opening. (See Map.) On this hypothesis we can explain the enormous accumulation of sediment along this line. The thicknesses of the strata are taken from several sections made by the Geological Survey.

† These thicknesses are taken from the horizontal section by the Geological Survey.

‡ Horizontal Sections, Sheet 40, with description.

greater than that of North Staffordshire by 2200 feet, and of Warwickshire by 8750 feet*.

Cumberland.—It might have been expected, according to the principle of north-westerly expansion which I am now endeavouring to explain, that the sedimentary series of Cumberland should be even thicker than that of Lancashire, lying, as it does, to the north of this latter county. This, however, is not the case; and to account for the meagre development of the Carboniferous rocks there appeared to me for some time extremely difficult. I feel confident, however, it is only an apparent anomaly, and is capable of explanation. The proximity of the Cumbrian Mountains is evidently the primary cause of the thinness of the strata; and my friend, Mr. Salter, has suggested to me that a shallow sea and a shelving shore are sufficient to account for these phenomena. There is at least another explanation, and that is, that the Cumbrian Mountains having been islands in the Carboniferous sea, and rising in front of the current which brought the sediment, caused it to bend from its course, and by increasing the velocity, prevented the deposition of the full supply near their coasts. Either of these explanations appears sufficient.

Scotland.—From the position of the Carboniferous rocks which occupy the great depression between the Firths of Forth and Clyde, as compared with their representatives south of the border, and from the substitution of stratified shales, sandstones, &c., for limestones in the lower portion, it seems probable that, when the whole series was originally deposited, the sedimentary portion attained a development unsurpassed in any other district in Britain. In reality, however, we have no means of judging of the thickness of the Upper Coal-series, as it is incomplete, a vast quantity of strata having probably been removed by denudation from off the present coal-areas.

The highest member of the Carboniferous series is the "Flat-coal Group," representing (as shown by Messrs. Howell and Geikie) a portion of the true Coal-measures of England, as being more recent than the Roslyn sandstones, the equivalent of the Millstone-grit†. The thickness of this division is 1000 feet in the Lothians, and 840 feet in Lanarkshire, according to Mr. Ralph Moore‡. The "Flat-coal Group" would appear from the fossil shells, which consist of various species of *Anthracosia*, to be the equivalent of the Middle Coal-series of England; and we have hitherto looked in vain for representatives of the Lower Coal-measures, or Gannister Beds, with their peculiar Lower Carboniferous Mollusca. The Millstone series is then, compared with that of Lancashire or Staffordshire, only 1500 feet, as is also the case with the "Edge-coal Group," while the sedimentary strata of the Carboniferous Limestone have enormously expanded. It thus appears that there has been an increase

* Most of these thicknesses have been determined by Mr. Binney, F.R.S., with the exception of the Millstone-grit and Yoredale series, which were partly measured by myself. (See Mr. Binney's papers in Trans. Geol. Soc. of Manchester, vol. i.)

† "Memoir on the Geology of Edinburgh," p. 105. 1861. ‡ "Vertical Section."

of sediment in the lower portion, and a decrease in the upper, as compared with the northern districts of England.

The following seems to be the corresponding series in both countries:

Carboniferous Series of England and Scotland.

England (Lancashire).	Feet.	Scotland (Lothians).	Feet.
1. Upper Coal-measures	2,000	1. (Lost by denudation?)	——
2. Middle Coal-measures	3,200	2. (Partially denuded?)	1000
3. Lower Coal-measures	2,000	3. (Supposed to be absent)	——
4. Millstone-grit	3,000	4. Roslyn Sandstone Group	1500
5. Yoredale Rocks	2,000	5. Edge-coal Group	900
6. Limestone (no "sedimentary" strata)	2,000	6. Lower Carboniferous series (shales and sandstones, with little limestone)	3000
Total "sedimentary" strata	12,200	Total "sedimentary" strata	6400

It will thus be observed that, even allowing 2000 feet for the upper portion of the Scotch series, lost by denudation, the amount of "sedimentary" strata in Scotland could not reach that of Lancashire, notwithstanding the accession it receives in the horizon of the Carboniferous Limestone. Future investigation will probably result in adding considerably to the thickness of strata, and in throwing some light on the equivalents of the Gannister Beds, which in the north of England form a most interesting and important group of strata*.

Two other suppositions, however, may be advanced, one of which is that we have here a case of compensation not unfrequently to be observed; and that, as the sedimentary strata have received so large an accession in the lowest member of the series, they have had a corresponding reduction in the upper portions of the system, as compared with England. But the supposition which I regard as the more probable is, that we may here have passed across the position of maximum accumulation, and may have reached the point where the beds begin to thin away in the direction of the old coast-line, as represented in fig. 4, page 135†.

2. Region South of the Barrier.

We must now retrace our steps to the district south of the barrier, which includes the coal-fields of South Wales, Forest of Dean, Bristol and Somerset—Mr. Godwin-Austen's hypothetical trough of the Thames Valley, and the culm series of Devonshire.

The sedimentary strata of this region appear to have been derived not from the north-west, as in the case of the coal-fields north of the barrier, but from the west-south-west, as indicated by the isometric

* Mr. Geikie has suggested to the author, as a possible explanation of the absence of the Gannister Beds or Lower Coal-measures of England, that the Scottish area was elevated into land during the period in question.

† Taking the line A as the point of maximum accumulation, this may represent the Carboniferous series of Lancashire and Yorkshire, while the Scottish Coal-fields will be situated at *b*, and the English at B, C, D, E,—E being the vanishing point towards the South-east of England.

lines. The variations of development of the Carboniferous rocks have been fully discussed by Sir H. De la Beche*, who shows that the greatest vertical thickness is attained in Glamorganshire of 12,000 feet or more, while east of Bristol the same beds are only 5500 feet, and in the Forest of Dean 3385 feet thick.

To what extent the true Coal-measures once surmounted the culm-measures of Devonshire it is, of course, impossible to say; but, from the position of these beds with reference to the Glamorganshire coal-field, from which they are separated by an anticlinal axis, there was probably a large amount of strata now lost by denudation. We must, with Sir R. Murchison†, regard the culm-measures themselves as the representatives of the Carboniferous Limestone, and probably the Yoredale series and Millstone-grit; but, as there are only thin bands of limestone, with *Posidonomya Becheri*, to represent the great limestone formation of Bristol and Chepstow, it is evident the "sedimentary" elements have predominated in Devonshire to the disadvantage of the calcareous. These changes I have endeavoured to illustrate by means of the isometric curves.

The Carboniferous series, therefore, to the north and to the south of the barrier belong to two different systems, not of time, but of circumstances. Their materials have been accumulated in nearly opposite directions. The sources of these materials have been different, and also the direction of the currents. That the Carboniferous series was connected by sea, round the western extremity of the barrier, is proved by identity of fossils in the limestones and Lower Coal-measures of the North of England, Central Ireland, and South Wales, &c. In each of these districts *Pecten papyraceus* and *Goniatites Listeri* occur in the Lower Coal-series. The calcareous member was more fully developed in the east than in the west, and extends from Somersetshire into France and Belgium, until, as already stated, it thins away on approaching the Rhine.

3. North Atlantic Continent.

Readers of the works of Sir C. Lyell will recollect how that author, in treating of the distribution of the Carboniferous rocks of North America, shows that the sedimentary materials increase in thickness and become coarser in texture as they approach the north-eastern seaboard. Thus in Nova Scotia these materials attain, according to Dr. Dawson, a thickness of 14,000 feet‡, in which the limestones play a subordinate part, as they do in Scotland. From the flanks of the Alleghany range, westward and southward, into Central America, the "sedimentary" strata gradually thin away, while the calcareous as constantly augment in bulk, until, on reaching the Rocky Mountains, they attain magnificent proportions§, forming, as shown by Sir J. Richardson and Dr. Hector, the huge and rugged masses of the central range. The tendency of the calcareous and sedimentary elements of the system to become developed in opposite directions is therefore strongly marked over this Continent.

* Memoirs of the Geological Survey, vol. i. † "Siluria," 2nd edit. pp. 293-4.
‡ "Acadian Geology." § Quart. Journ. Geol. Soc. vol. xvii.

From the north-easterly expansion of the sandstones and shales, as well as their increased coarseness in the direction of the North Atlantic, Sir C. Lyell has inferred the existence of a continent (occupying the position of this ocean), from the waste of which these strata have been derived. Mr. Godwin-Austen has also indicated its position*. The probability of such a continent is reduced to certainty by the similarity and frequent identity of the Carboniferous flora of Europe and America, the land having formed a bridge for the migration of the plants from one country to another. We may suppose this land to have included Greenland, Iceland, and Scandinavia. Recollecting, then, the south-westerly attenuation of the American strata, and the south-easterly attenuation of the North-British, can it be doubted that the same continent was the parent of the coal-bearing strata of both countries? This being admitted, we may also infer that the shores of this *Atlantis* were washed on the west side by a current running south-west, which drifted the sediment in that direction; and on the other by a current running south-east, which carried the sediment over the submerged portions of Scotland, England, and Ireland†. It may be assumed as a general principle, that all the oceanic currents north of the equator running west come from the north, and those running east come from the south. Hence we may infer that, during the Carboniferous Period, there was open sea in the arctic regions of the Western Hemisphere, generating an arctic current—a proposition borne out by the occurrence of plants and shells of this period‡ as high as lat. 78°; and on the other hand we may infer land to have existed to the north of Europe, or at least of Britain, whose shores were swept by a current similar in its direction to the Gulf-stream. Throughout this long geological period did these currents carry the sands and clays southward; and as the distance from the sources of these materials increased, so did the amount deposited diminish; which to my mind is a satisfactory explanation of the thinning out of the strata in certain directions.

I would here beg to remind the Society of a former communication, in which it was attempted to be shown that the sedimentary strata of the Lower Mesozoic Formations undergo a similar diminution of volume, when traced from the north-west towards the south-east of England. Now it is remarkable that the *line of maximum development* of the Carboniferous and the Mesozoic Rocks very nearly correspond in each case, stretching from Lancashire in the direction of London. So rapid does the attenuation of the Trias and the Lias appear to be, that I inferred that these formations would be found to terminate somewhere about the position of the Chalk escarp-

* In his elaborate memoir "On the possible Extension of the Coal-measures, &c.," Quart. Journ. Geol. Soc. vol. xii.

† I do not propose to touch on the subject of the derivation of the Carboniferous strata of Belgium and Germany; but there can be little doubt of the northerly origin of the sedimentary strata, drifted by currents from land lying to the eastward of the Scandinavian Promontory.

‡ Brought to this country by Sir E. Belcher.

ment*. The whole series, therefore, may be considered as a system of wedges lying with their thin edges pointing towards the escarpment of the Chalk; and the absence of these formations under the Cretaceous Rocks at Harwich (for an account of which we are indebted to Mr. Prestwich) is, I submit, a proof of the soundness of the views here advanced†.

Is it not therefore a remarkable circumstance, that the north has been the source for the supply of so many non-calcareous formations, including those of the Carboniferous, Triassic, Liassic, and Oolitic Periods, and that there has been a general "northern drift," repeated at intervals from a period so far remote (at least as far as the commencement of the Carboniferous) until that immediately preceding our own epoch? Such a series of events, when we consider the great physical changes which have occurred throughout this enormously long period, must, I think, be traced to some general law regulating the course of oceanic currents, and exhibits a remarkable uniformity in the operations of nature through long periods of geological history.

The extent of the land which was capable of supplying so vast a quantity of material must have been very large, and, judging by the characters of some of the Carboniferous and more recent strata, seems to have been composed principally of granitoid or metamorphic rocks. Its southern limits may have reached the western and northern coasts of Scotland; and the Highland mountains may have formed outlying islets and headlands.

§ III. *Summary of Conclusions.*

(*General.*)

1. It appears, from the above considerations and examples, which further research will enable us to multiply, that calcareous strata are distinct from argillaceo-arenaceous, not only from differences of origin (a fact now generally admitted), but also in the manner of their distribution; so that limestones ought to be removed from the class of rocks termed "sedimentary."

2. That in any *natural* group or system of strata, consisting, on the one hand, of "sedimentary" strata, and on the other of calcareous, it appears that the direction of the greatest vertical development of the one will be that of the smallest vertical development of the other. In a word, where the one becomes thin, the other becomes thick.

3. That, on the principles here stated, the frequent occurrence of natural groups of rocks consisting of three members, the first and third "sedimentary," the second (central) calcareous, admits of explanation.

* "On the South-easterly Attenuation of the Lower Secondary Rocks, &c.," Quart. Journ. Geol. Soc. vol. xvi.

† In my work on 'The Coal-fields of Great Britain,' I have given a full exposition of these views, and a section showing the limits of the Carboniferous and Mesozoic Rocks over the South-east of England (pp. 253 *et seq.*, 2nd edit.).

(*Special.*)

4. That a barrier, or tract of dry land, existed nearly across Central England, dividing the Carboniferous Rocks into two distinct regions.

5. That to the north of this barrier the "sedimentary" strata of the Carboniferous Period become attenuated from north-west to south, while the *calcareous* strata thin out from south to north, Derbyshire being the centre of greatest development.

6. That to the south of this barrier the "sedimentary" strata become attenuated from west to east; while the calcareous thin out from east to west.

7. That, while on the north side of the barrier there was a current bringing the sediment from the north, on the south side there was a current bringing sediment from the west.

8. That richly productive Coal-measures do not exist under the Eastern Counties.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 26, 1862.

SPECIAL GENERAL MEETING.

It was Resolved that the Annual Contribution to be paid by both Resident and Non-resident Fellows elected after the 1st of March next shall be Two Pounds Two Shillings per annum: the Composition for future Annual Contributions being Twenty-one Pounds.

ORDINARY GENERAL MEETING.

George Charlton, Esq., Mining Engineer, Dukinfield, near Manchester, and Julius Schvarcz, Ph.D., Stuhlweissenburg, Hungary, were elected Fellows.

The following communications were read:—

1. *On the* Drift *containing* Recent Shells, *in the neighbourhood of* Wolverhampton. By the Rev. William Lister, F.G.S.

(Abridged.)

These drift-deposits lie for the most part upon a nearly level surface of Lower Keuper Sandstone, overlooked eastward by a range of low Bunter and Permian hills, of which Show Hill and Bushbury Hill are the chief. Other exposures are upon Permian sandstone in the town of Wolverhampton, and upon the Coal-measures of the district adjoining. Bushbury Hill is chiefly remarkable for the number of travelled blocks of granite and greenstone lying around its north-western base—the side lying most open to bygone arctic and glacial influences. No boulder-clay nor drifted material of other kind is associated with these blocks upon the hills in this immediate neighbourhood. The drift at three localities, viz., Bushbury Junction, Oxley Manor, and Wobaston Big Meadow, had probably a parallelism in time of deposition and agency of formation; though I cannot satisfy myself whether to regard them as the remains of a low terrace-line skirting the valley, or as the result of undercurrents, relaying the derived material in banks parallel with its strike. In the exposure of this drift at Bushbury Junction, where it is an apparently unstratified bed of clay and sand, with an admixture of both rounded pebbles and angular flints, I have met with the following marine shells, which have been kindly determined for me by Mr. J. Gwyn Jeffreys, F.G.S.:—*Nassa reticulata, Turritella communis, Purpura lapillus, Littorina squalida, Astarte arctica, Cardium edule, Tellina solidula,* and *Cyprina Islandica.*

Rolled shells and other fossils derived from Liassic rocks accompany these, such as *Gryphææ, Ammonites, Cardiniæ,* and *Belemnites.* I have also met with a fragment of Downton Sandstone (Upper Silurian), bearing a cast of *Rhynchonella,* together with pieces of coal, having rounded edges and striæ upon their surfaces, and of unfossilized wood similarly rounded.

At the exposure of this drift at Oxley Manor, half a mile N.W. of Bushbury, its physical character was that of a clay-bed resting upon sand. The following shells were met with in the clay, though the condition of all the imbedded remains was more fragmentary than at the first-named place:—*Cardium echinatum, Tapes virginea, Venus striata, Modiola modiolus,* and *Turritella communis.* In connexion with his determination of these and the before-mentioned species from Bushbury Junction, Mr. Jeffreys has favoured me with the following note:—

"All of these shells are much rolled and broken, and they appear to have been cast up by the tide on a pebbly beach. They indicate also the former presence of a gradually shelving tract of sand below the beach seawards, as well as of an intermediate belt of loose stones or shingle in the littoral zone. It is possible that these shells may have been carried off with the pebbles from a beach in the Arctic regions by an iceberg, which, after traversing a considerable distance in a glacial sea, may have stranded or melted, and deposited its load in the spot where the shells and pebbles have now been found. The present data are, however, insufficient to enable me to form any opinion on this point. All the species now inhabit the Arctic Sea. Two of them, *Astarte arctica* and *Littorina squalida,* are not found living in our seas; but all the rest are common British species. The period of this deposit in Staffordshire, whether original or derivative, may have been coeval with that of the Kelsey Hill formation, which has been lately described by Mr. Prestwich in the 'Quarterly Journal of the Geological Society*.' Eight species enumerated in his paper also occur in the deposit under notice, which in its turn possesses four

* Vol. xvii. p. 446.

(*Astarte arctica, Cardium echinatum, Modiola modiolus,* and *Tapes virginea*) wanting in the Kelsey Hill catalogue. The *Cyrena,* or *Corbicula,* is absent."

The third exposure of this line of drift-deposit is a partially stratified mound of sand and gravel, 88 yards long, 38 yards wide, and about 2 yards in height, situated in Wobaston Big Meadow, about a mile and a half north of Bushbury Junction. The long axis of this mound corresponds with the strike of the before-described beds, and with the direction of the valley, which is due N. and S. This deposit has not at present yielded me any shells nor specimens of angular flints. The chief of its derived contents are the following:—pebbles of limestone, slate, quartzite, vein-quartz, black quartz, veined lydian-stone, a fragment of syenite, and a small Silurian coral (*Cyathophyllum Loveni*). The part cut into exhibits the following section:—

	ft.	in.
Vegetable mould	0	6
Pebbles and sand (the pebbles vary in size, are largest at the top of the bed, and become gradually smaller below)........................	2	6
Bed of stratified sand, with a few small pebbles ..	1	6

Two other patches of drift, lying at a somewhat higher level, occur in this immediate neighbourhood, and are probably related by coincidence of time and deposition. The first locality is that of Compton Holloway, in the parish of Tettenhall, where clay-deposits are seen to fill up eroded hollows of the Keuper Sandstone on the hill-sides west of the plain. These contain derived fossils from Liassic rocks, similar to those met with at Bushbury. A suite of them has been collected by Henry Hill, Esq., of Dunstall. Many like remains were found some years ago at Wightwick, another point at this higher level. Here, however, the clay contains angular flints, as at Bushbury, and the low hills are covered with scattered drift-pebbles.

In drift-clay, at about the same level, near the Hospital in Wolverhampton, Liassic *Gryphææ* have been met with; and fossils of like age in a similar bed at the New Cemetery. I am indebted to Mr. Henry Beckett, F.G.S., for some notes respecting this easterly extension of the boulder-clay, as also for a notice of other exposures at Penn, from two to three miles south of Wolverhampton. At Upper Penn, the clay yielded pieces of wood and a broken tibia of *Bos.* I am also informed by Mr. George E. Roberts of a considerable extension of these clays, with sandy layers, westerly; for they are well exposed at Acleton, eight miles S.W. of Bushbury, and there abound in *Turritellæ.* A recent exposure in that district is at a spot half a mile north of Badger Hall.

In conclusion, I would call attention to the deep and wide-stretching sand deposit described by Prof. Beete Jukes as lying in immense quantities around West Bromwich and upon the district east of Birmingham*. In the lower part of this sand, which in places

* "The South Staffordshire Coal-field," p. 325.

attains a thickness of 100 feet, marine shells identical with those found by myself at Bushbury and Oxley Manor have been detected by Mr. Beckett, at Mr. Sparrow's colliery of Portobello. This fact is valuable as a determination of the relative position in which we shall be justified in placing these shell-bearing clays in the drift-deposits of Staffordshire.

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2. *On a* Split Boulder *in* Little Cumbra, Western Isles. By James Smith, Esq., F.R.S., F.G.S., of Jordan Hill.

Split erratic blocks are of frequent occurrence in Switzerland. The only explanation of this phenomenon which I have met with is that of M. Charpentier, in his "Essai sur les Glaciers." Speaking of the blocks, he says, "Quelques uns sont fendus, mais la direction des fentes prouve jusques à l'évidence que les ruptures sont le résultat d'une chute et nullement d'un choc horizontal" (p. 180). M. Charpentier offers no conjecture as to the height from whence the blocks could have fallen; but where there is no superincumbent precipice of rock near, it must have been from one of ice. Indeed, I may say that I obtained proof that such was the case; for upon examining the fragments which lay at the foot of the escarpment of ice which terminates the Glacier of Grindelwald, I observed one which, from the freshness of the fracture, I concluded must have fallen very shortly before my visit, and obviously from the surface of the glacier.

Such blocks occur occasionally in the basin of the Clyde, in situations where there is no adjoining height from which they could have fallen,—a circumstance which I can only account for by supposing the former existence, in the same localities, of ice in the shape of glaciers, icebergs, or coast-ice. I may add that some of the split boulders are also scratched, exhibiting additional proofs of glacial action.

To one of these blocks I wish to call the attention of the Society, on account of the peculiarity of the circumstances of its present position. There is on the west coast of Scotland a well-marked cliff and terrace, indicating an elevation of about forty feet above the present sea-level; and, from the amount of solid rock which has been removed by the washing action of the sea, we may form some conception of the prodigious lapse of time during which the sea-level was stationary at that height.

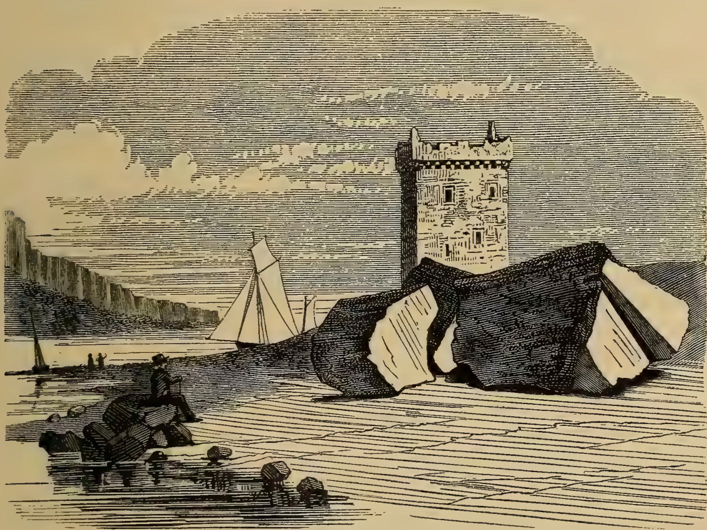
This is nowhere better seen than in the Islands of Great and Little Cumbra. The larger island is composed of red sandstone, traversed by trap-dykes; the smaller one is composed entirely of trap. The trap of the dykes, from its greater hardness, has been worn away more slowly than the sandstone; hence their projection from the sandstone cliff; hence also the greater breadth of the terrace in Great Cumbra than in that of the trap of the smaller island.

The terrace in Little Cumbra, formed by the wasting action of the sea at right angles with the coast-line, has been subsequently ground down and scratched by a force acting parallel to it and the ancient cliff; and it is upon this that the blocks in question must have fallen.

The block is composed of trap, apparently the same as that of the island, but at such a distance from any neighbouring height as to preclude the supposition that it could have fallen from it. I see therefore no other hypothesis by which we can account for its present position than that of supposing that it must have fallen from an escarpment of ice.

We have thus two independent glacial phenomena which belong to a period subsequent to the formation of the forty-feet terrace, showing that the lengthened period of its formation belongs to the Glacial Epoch.

Sketch of the Split Boulder on Little Cumbra, Western Isles.



[N.B. In the foreground the shore shows glacial striæ.]

There is yet one circumstance connected with this locality which requires to be noticed. The scratched surface of the ancient terrace passes under the sea; and although it has been exposed to its wasting action for a length of time equivalent in duration to that of the present sea-level, the striæ have not been obliterated.

Here we have in juxtaposition two distinct cases of the effects of the wasting action of the sea. In the most ancient of these, or that when the cliff and terrace were formed, we have a removal of rock amounting to at least a hundred feet; in the second, or that of the present sea-level, the amount of wearing away of the same rock cannot exceed a small fraction of an inch.

I am convinced that no decided change of level has taken place in the West of Scotland during the historic period; but there may have been small changes: and it is no objection to such a supposition that they have not been observed and recorded; such changes of level either pass unobserved, or are ascribed to the retiring or encroaching of the sea. We may suppose, therefore, that in times comparatively recent a small movement of elevation or depression of the land has taken place, sufficient to have brought the rocks in question within this wasting action of the sea.

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3. *On the* Ice-worn Rocks *of* Scotland.
By T. F. Jamieson, Esq., F.G.S.

Contents.

§ 1. At the bottom of all the Drift-beds there is in our northern latitudes a phenomenon which, if rightly understood, would dispel much of the obscurity that still envelopes the history of that period; I mean that curious scoring and polishing of the rocky bed on which the Drift is found so frequently reposing. Saussure, in his Alpine journeys, had often remarked those rounded masses which he called *roches moutonnées*, and also did not omit to note the polishing of the rocky surface; curiously enough, however, although so familiar with glaciers, he did not refer these appearances to their true cause, but attributed this scoring of the rocks to the passage over them of boulders hurried along by a rush of water. Colonel Imrie, also, and Sir James Hall, who in 1812 both described the same appearances in Scotland, sought to explain them in a similar manner. As this theory of their origin has found favour with several geologists, I am induced to describe here a case of some interest which came under my notice, and was peculiarly fitted to test the sufficiency of a powerful torrent, carrying with it great boulders and stony débris, to affect the rocks in the manner under consideration.

§ 2. In the county of Argyle an artificial channel was cut, a good many years ago, between the Sound of Jura and Loch Fyne, called the Crinan Canal; it is about 9 miles long, and lies in an E. and W. direction, or rather S.E. and N.W. Sloping up from the south side of this canal there is a range of hilly ground, where there are a few small lakes that have been converted into reservoirs for regulating the supply of water, and which are situated at a height of about 700 feet above the canal. Three of these lakes, each of them covering an area of about thirty acres, have been connected, and the depth of their waters increased by artificial embankments. But in February 1859, owing to heavy floods or some other cause, the embankment of the uppermost of these three lakes gave way, and its water, rushing into the next one, caused it also to burst its barrier; and the contents of both, now descending suddenly into the lowermost lake, broke the embankment of it likewise; so that the contents of the whole three were at once let loose, and rushed down the steep channel of a mountain-stream with immense force. Owing, luckily, to the retired, barren nature of the locality, there were no houses in the way, nor much else that could sustain serious damage, except the canal, a great part of which was destroyed, and quite filled up with stones and gravel. It took an expenditure of several thousand pounds to repair the injury done to its channel, and the engineer who superintended the work told me that some of the boulders he had taken out of it weighed eleven tons. Here, then, was a great volume of water rushing violently down the flank of a hill, through a descent of about 700 feet, and carrying along with it stony débris and boulders of several tons weight. Having seen some account of the matter in the newspapers at the time, I was very glad when, in August 1860, I had an opportunity of examining the scene of the catastrophe. By this time the damage to the canal had been repaired, but the channel of the hill-stream was very much as the torrent had left it. The rocks there consist of frequent alternations of clay-slate, greywacke-grit, and syenitic greenstone, covered occasionally by a variable thickness of stony earth or drift. This covering the rush of water had in many places quite cleaned off, carrying the boulders and stony débris before it, and throwing them down in those spots where the force of the torrent began to fail. I saw many blocks that it had borne along, measuring 3 to 4 feet in length, and a few even from 8 to 11 feet. On none of these was there anything at all resembling the glacial polish and striæ; neither were there any such markings on the smaller pebbles. Moreover, the débris was for the most part quite unmixed with clay or mud, and consisted either of clusters of large boulders, or masses of washed gravel,—the finer sediment having been carried away by the retiring water. This débris was therefore quite unlike our boulder-earth, and more resembled some of the coarser kinds of what I have elsewhere described as the upper rolled gravel that is so frequently met with covering the drift in almost all our river-valleys. I also examined the rocks along the bottom and sides of the ravine, to see how they were affected. Now, its direction is right down the hill-slope from S.W. to N.E., with occasional windings, and such was the course of the torrent in descending it; but here there was a circumstance which added greatly to the interest of the case. This was the occurrence of true glacial striæ and scores, beautifully and extensively marked, and running obliquely across, and sometimes even at right angles to the direction of the ravine; so that there could be no risk of confounding them with any ruts made by the descending torrent, which by washing off the drift had finely exposed these markings, and they could be traced passing under banks of undisturbed drift. These glacial impressions, I may also mention, are not confined to this ravine, but are displayed over much of the neighbourhood, and will be again referred to in a subsequent part of this paper. But in no case could I discover the least indication of any such polish, or straight parallel scratching, due to the action of the torrent; I observed, however, in some places on the surface of the greenstone, many round pits or dints, and short irregular scoops or furrows, seldom longer than a man's finger, caused apparently by the bumping of the large boulders as they rolled along. These markings were irregular in their direction, like the scratching of poultry on a gravel walk, and quite unlike the long, rectilinear, parallel grooves and the polish which are ascribed to the action of ice. Here, then, it was evident that not only had this violent torrent no power to cause such markings, but, from the shortness of its duration, it had also failed in most places to obliterate the real glacial markings of a former period.

Agassiz likewise mentions that the *débâcle* of the Dent du Midi—another example of a current of water charged with fragments of rocks—left no trace of this kind in any part of its course*.

§ 3. In 1837, the Swiss naturalist whom I have just mentioned communicated to the Academy of Sciences at Paris some observations on the mode in which glaciers thus affect their rocky bed; and his force of character, together with the ardour he threw into the pursuit, effectually roused attention to the subject†. In 1840 (nearly 30 years after Imrie and Hall wrote) he paid a visit to this country, and, in an extensive tour through Britain and Ireland, everywhere recognized in our rounded, scored rocks appearances precisely similar to those he had long studied among the glaciers of his native country; and he did not hesitate to express his conviction that in Britain glaciers and large sheets of ice, "resembling," as he says, "those now existing in Greenland," had formerly existed, to whose action these markings are due. The occurrence, however, of marine remains belonging to the Pleistocene period at various elevations, and even on the tops of considerable hills, together with a great mass of collateral evidence which went to show that this country had been to a great extent depressed beneath the sea during the Drift-period, led many to believe that the appearances referred by Agassiz to glacier-action might be better accounted for by the agency of floating ice; while the absence of alpine heights, and the comparative lowness of much of the country where these markings occurred, still further conduced to this opinion.

When, therefore, I began the study of the subject, it was rather with a disposition to refer these appearances to sea-borne ice; but a careful examination of such instances as have come under my notice

* The observations of Lyell on the Willey Slide in the White mountains of North America, and those of Dr. Hooker in the Himalaya, go to show that even land-slips do not mark the rocks over which they pass in the same way that a glacier does.

† Although Charpentier, and perhaps others, had previously mentioned the erosive action of glaciers upon their rocky bed, yet Agassiz comprehended better than any the geological importance of the phenomenon; and he seems to have been the first to draw attention to the marked distinction that exists between the features of ice-worn and those of water-worn rocks.

has led me to believe that no modification of this agency will meet the requirements of the case, and that, in the great majority of instances, this grinding down of the rocks has, in Scotland at least, been caused by the long-continued movement of land-ice and glaciers;—that, in short, when this abrasion took place, our country stood quite above the level of the sea, and probably formed part of an extensive northern continent; and that the submergence which led to the formation of the marine beds, with arctic shells, was a phenomenon subsequent to this great glaciation.

One of the first things which convinced me that no icebergs running aground, nor pack-ice driven by the winds, nor coast-ice lashed by the breakers, could explain the case, was the observation that it was always the land-side of the rocks—the exposure facing the highest mountains of the interior—that was most worn and polished, the side fronting the sea being in comparison much more rugged and angular. No instance occurred to me that could be explained by a motion of ice coming from the sea towards the land, while the boulders and scratched pebbles, when traced to their sources, also indicated a seaward transport. Thus, along the eastern border of Aberdeenshire, the glacial striæ and scores run from west to east; in my own neighbourhood at Ellon, the general direction is nearly due E. and W., or a few degrees to the N. of W.; and a low tract of syenitic greenstone has yielded a profusion of large blocks which have been all carried towards the E., while the smaller scratched pebbles are of the kinds which would be got from rocks to the W., many of the varieties not occurring in any other direction, and it is the western sides of the rocks that are most worn and scratched. Again, at Aberdeen, the surface of the granite, when newly uncovered, shows the glacial striæ and grooves pointing a few degrees to the S. of W., in the direction of the valley of the Dee, the rounded and polished faces of the rocks looking up the valley. On the southern shores of the Moray Frith, between Banff and Troup Head, I found glacial markings pointing S.E. and sometimes S.W.; and along the shores of the Firth of Forth a multitude of instances have been recorded by Hall, Maclaren, Chambers, and Fleming, all indicating a movement from W. to E., and at Stirling from N.W. Such is the case in the low grounds along the east seaboard of the island. But when I went to study the facts on the west coast, I found it was no longer the same side of the rocks that had been ground down; it is there the east and north-east fronts that have suffered most abrasion, and the scores and striæ that streak the rocky shores of the fiords of Argyleshire are just such as might be expected from the action of ice moving down from the mountains. The markings along these sea-lochs are often very striking, and have attracted the notice of Agassiz, Murchison, and Maclaren, who have all insisted on the fact of the rounded striated surfaces being invariably presented to the interior, and the rough jagged fronts to the sea. Prof. Nicol has also chronicled the direction of the striæ, as noticed by Sir Roderick Murchison and himself, in several of the glens along the eastern, northern, and western seaboards of Ross and Sutherland, all pointing to the same conclusion, viz., that they are due to the passage of ice down the glens.

Another consideration that impresses me in favour of the theory that land-ice has caused these appearances, and which was also remarked by Forbes in Norway, arises from the fact that they become more extensively and clearly developed as we leave the low flat regions and approach the mountains. For instance, although there is good evidence that the greater portion of England was submerged during the Drift-period, yet it is only in the hilly tracts of Wales and the lake-district that we hear much of the rocks being striated and ice-worn; and in Scotland, although no part of the rocky floor of the country seems quite free from these markings, yet it is in the Highlands that they become so striking and intensely marked. But the instances I have mentioned above, being all purposely taken from localities close upon the present shores of Scotland, in my opinion go to prove that even in the low grounds this glacial erosion has radiated from the interior; and that not only in the mountain-glens has this action been due to glaciers, but down to the present coast-line we must still ascribe it to an agent moving off the land, and not to sea-ice.

The evidence required to distinguish glacier-action from the effects of an icy *débâcle* rushing down the glens, caused by the dislocation of sheets of ice owing to earthquake-shocks or movements of elevation, is somewhat different from what I have brought forward in the preceding paragraphs. Here we have ice moving off the land in the same direction as a glacier, or nearly so; but in the one case the action would be transient, and in the other of vast duration. Now I think the amount of rock which has been worn away, even at the *mouths* of the sea-lochs of the W. Highlands, as at Loch Fyne and at the Kyles of Bute, opposite the steamboat-quay at Colintrive, by the glacial action, is far too great to be accounted for by the passage of even a succession of such débâcles. The rounded outlines of the tough gneiss and syenite, which I there saw, denoted to my mind the long-continued grinding action of ice slowly moving over them; for I think the rapid, hurried rush of a sludgy mass, even although repeated, would not produce such finely rounded contours: neither would the grooves and furrows be so persistent and rectilinear in their direction; for the ice being in broken masses, and accompanied with water and melting snow, would have more freedom of movement than the rigid mass of a huge glacier or ice-stream filling the valley; and in the lower open grounds, where there were no heights to confine the torrent, the straight persistent direction of the scores is even more striking than in the glens and gorges, and to my mind still more inexplicable by such a catastrophe or series of catastrophes. At Ellon, for example, on the east side of Aberdeenshire, there are no hills exceeding 600 feet in height within ten miles, and none exceeding 1000 feet within 20 miles; yet the scores on the rocks exposed in the railway-cuttings and quarries have a remarkably uniform direction, and run across hill and dale with a perfect indifference to the minor contours of the surface. Now here, as in the basin of the Forth, no ordinary glacier-action will suffice for the explanation; yet the proof is clear that the action has come from the west or land side, and not from floating ice propelled inwards or parallel to the coast.

§ 4. In a paper in the 16th volume of the 'Journal of the Geological Society,' at pp. 368 and 370, I gave it as my opinion that at the commencement of the Drift-period this country had stood as high as at present, or perhaps much higher, with an extensive development of glaciers and land-ice, like that of Greenland; and I there described a case near Killiecrankie, in Perthshire, where the flank of a hill called Meal Uaine is rounded, scored, and in some places even polished, as if by the passage of ice down the valley; and I pointed out that, as the markings on the hill-top are about 1800 feet above the present bottom of the glen, it was evident that, were land-ice the cause, it must have been in a volume altogether extraordinary. My curiosity was greatly excited by what I there saw; and since then I have been so fortunate as to discover some other cases quite as remarkable, where the cause of the phenomena is more clearly indicated.

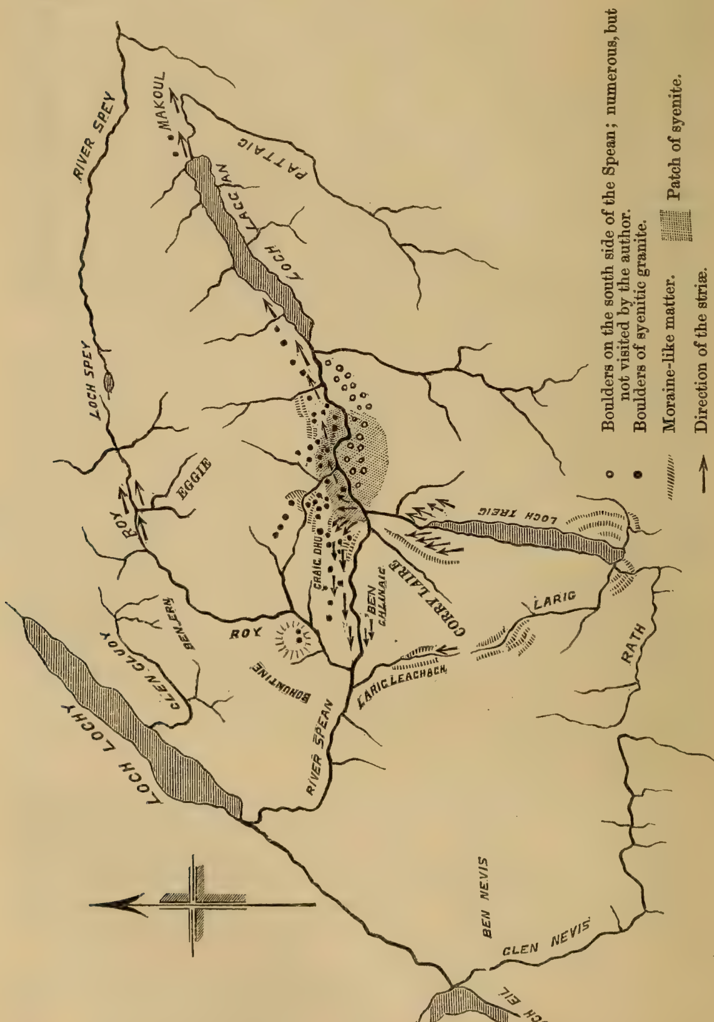
One of the most complete of these was in the Lochaber district of Inverness-shire, so celebrated for its *Parallel roads* or terraces.

High up among a cluster of hills forming the eastern extension of Ben Nevis, there is a mountain-pass, of a beautifully wild and savage character, where two streams take their rise, and flow in opposite directions. One of these runs to the N.W. down a very short glen, called the Larig Leachach, into Glen Spean. This Larig Leachach, or "the Stony Larig," is at its upper end very rocky; and some strata of quartz, that run vertically across the glen, show abundant traces of glacial action, the hardness of the rock having preserved even the finer striæ and scratches: these markings are parallel to the direction of the stream, and the abrasion is most visible upon the faces of the rock looking up the hollow. Further down there is a great deal of moraine-matter—more indeed than is usually seen, owing, I imagine, to the precipices and high corries that overhung the ancient glacier, and had sent down much rocky débris upon its surface.

The other stream, taking its rise at this mountain-pass, flows S.E. into the head of Loch Treig down a much longer glen, known simply as "the Larig." Similar evidence of glacial action occurs along its course, but owing to the nature of the rock being different, and yielding more rapidly to the weather, the glacial impressions have not been so well retained. From this pass, therefore, we may suppose two ice-streams to have set out in opposite directions—one to the N.W., the other to the S.E.

Two other glens, one of them larger than the Larig, contribute their streams to Loch Treig—a beautiful sheet of water, about six miles long, in a N. and S. direction, and scarcely a mile broad at its widest part. It is enclosed by steep hills on both sides, and is so deep that I am told it was never known to be frozen over. Around its upper extremity there are many irregular hillocks of unstratified stony débris, full of boulders; these are most numerous in the curve of the hill at the south-eastern end of the lake. Near its outlet into Glen Spean, Loch Treig tapers to a narrow point, owing to the near

Fig. 1.—*Outline-map of a part of Inverness-shire, showing the Glacial Striæ and the distribution of Moraine-matter on the Spean and elsewhere.*



N.B.—The syenitic area, finely dotted in the map, is mainly after Macculloch. The boundary of the syenite on the south side of the Spean is unknown to me, and even that on the north side is in some parts conjectural. There is much granite in the hill to the N.E. of Craig Dhu; but it is of a different character from the other.—T. F. J.

approach of two mountains, each about 3000 feet high; so that a glacier filling the hollow of the lake would, in issuing out into Glen Spean, be very much compressed by the narrowness of the gorge, and therefore act more powerfully upon the rocks along which it had to force its way: here then, if anywhere, we ought to expect some tokens of its former presence. Accordingly we find that the tough micaceous gneiss, all around the outlet on both sides, has a character that attracts attention even at a great distance. Although the strata are highly inclined, and present their outcrop to the lake, yet, notwithstanding this disadvantageous position, they have been ground down into rounded flowing outlines like those of a feather-bed; and these domes and bosses of rock are scored in many places with long rectilinear furrows, in the direction of the lake, spreading out to either side like a fan as they recede from the gorge, just as might be expected from the action of a glacier issuing from the narrow pass, and dilating as it got out into the more open ground. One bare, flat

Fig. 2.—*View of the North Entrance to Loch Treig, from the hill on the North side of Glen Spean.*

E. W.

1. Gravel terraces, corresponding in height with the lowest of the Glen Roy lines (854 feet above the sea).

surface of gneiss, about 30 yards long, is beautifully smoothed, and covered with parallel scratches, scores, and flutings, running straight from end to end. The preservation of these markings so distinctly is very singular: no vegetation or covering of any kind appears to have sheltered them from the weather, and yet the frosts and storms of many ages have failed to wipe them out. It is right, however, to mention that such cases are exceptional; for in most places, although the rock has a smooth rounded outline, yet only a few of the ruder scores are visible, and often none at all. On the angle of the hill, at the west side of the outlet, this worn character of the rock is very marked, up to a height of more than 1000 feet above the present surface of the lake, while glacial scores running horizontally along the faces of the rock were traced up to 1280 feet (by aneroid)*. Not that I can affirm this to be their upper limit; for on the mountain, at the opposite side of the gorge, I found the scoring fade away so gradually at these great heights, owing to the weathering of the rock, that I was unable to satisfy myself where it ended, perched boulders and rounded surfaces occurring much higher; and even up to the top, which I made out to be about 3055 feet above the sea, the gneiss, although it runs in nearly vertical stratification (dipping N.W. at an angle of about 70° or 80°), is nevertheless so free of any loose fragments on its surface, and the ends of the strata are often so rounded in outline, as to raise a suspicion that some denuding agent has flowed over it at a period geologically recent. This absence of fragments cannot be attributed to the effect of the rain or snow gradually carrying them down; for it so happens that some felspar-porphyry is occasionally interbedded with the gneiss: one such stratum passes over the highest point of the hill; and this porphyry, like similar beds lower down in the gorge, is covered with a quantity of its own angular débris which has not been carried off by the rains. If the gneiss, therefore, had disintegrated to any extent, its débris ought still to be found lying on its surface like that of the porphyry.

As I have already said, the evidences of glacial action are very plain up to rather more than 1000 feet above the lake, and 1800 feet above the sea; and near the angle of the mountain, between Loch Treig and Corry Laire, I found at this great height moraine-matter, consisting of débris of mica-schist, gneiss, quartz-rock, and felspar-porphyry, forming a loose heap of stony rubbish, which the rains, aided by the scraping of the sheep, had laid open to a depth of 12 or 15 feet. The stones were of all sizes, up to about 3 feet in length, and many of them glacially striated. This moraine-matter may be traced down the spur of the hill for a long way, increasing in breadth. Corry Laire, I have no doubt, has also been occupied by a glacier; and, looking down, I observed in the bottom of the glen what appeared to be *moutonnéed* rocks, but had no time to visit them.

Nowhere have I met with such impressive evidence of intense abrading force as these rocks present all about the outlet of Loch Treig. The rounded masses of tough gneiss are so extensive as to form hills several hundred feet high, and so smooth and bare that, over extensive areas, even the moss and heather have completely failed to get a footing on their surface. The amount of mineral matter that has been ground down testifies how lengthened the period must have been during which the abrasion had gone on; and the preservation of the scores and scratches on the present surface,

* These aneroid measurements have, of course, no pretensions to accuracy, and their results are given merely as the best approximation I can offer; yet I believe they are nowhere so far from the truth as to disturb any of the conclusions drawn from them. Indeed, where I have been able to check them by other data, they have turned out to be nearer the mark than might have been expected, being seldom 50 feet wrong.

since the disappearance of the ice, is an excellent proof of the tough, indestructible nature of the substance it had to work upon. Well might Agassiz say of it, "I do not believe that a locality exists, where the facts indicate in a more special manner the cause which has produced them."

The River Spean, which receives the drainage of Glen Treig, runs from E. to W. at right angles to the direction of the lake; and just opposite the gorge there is a mass of syenitic granite, forming some low rocks that extend for some distance eastward. Now it is an interesting fact, that this granite lying on the north side of Glen Spean is, as Agassiz observed, "not only polished with that polish characteristic of glacier-action, but is, moreover, scratched transversely—that is to say, at right angles to the direction of the valley—by a cause which evidently proceeded from Loch Treig." (Ed. Phil. Journ. xxxiii. p. 238.) As the existence of these transverse markings has been disputed, I am glad to be able to confirm the accuracy of the illustrious Swiss, and may mention that an instance of such marking is to be seen on the north side of the Loch Laggan road, about 200 yards west of the thirteenth milestone from Loch Laggan Inn. Proceeding down Glen Spean, the striæ (everywhere to be seen) are found gradually to curve round from N. and S. until they finally assume a normal east and west direction parallel to the valley, and at right angles to their former course; and along the road for four miles westward, as far as the Catholic Chapel, the rocks are seen to be ground down more especially upon their east side, and, where not too much weathered, still showing the glacial scoring. Here I have to mention an important fact that seems to have escaped the attention of previous visitors; and it is this, that from a point in Glen Spean opposite the gorge of Loch Treig, all along the road to Loch Laggan, glaciated rocks are to be found, showing the scores running parallel to the valley, but it is now no longer the east, but the west, side of the rocky masses that has sustained most abrasion; and far away, even for three miles to the east of Loch Laggan, I traced the same appearances. For beyond the Pass of Makoul, the low rocky eminences show evident traces of the passage of ice going out towards the valley of the Spey; as if at a point in Glen Spean, opposite the gorge of Loch Treig, there had been an immense accumulation, which had parted there and gone out in two great streams, one taking an eastward route by Loch Laggan to the Spey basin, while the other flowed west, down Glen Spean, to swell the mass of ice at the mouth of the great Caledonian Valley.

The following are some striking facts that will help to give an idea of the depth and volume of this great ice-stream. Glen Spean is rather a wide glen, and, for some miles below the junction of the Treig, is bounded on its north side by a considerable hill called Craig Dhu, on whose flank the lowermost of the parallel lines of Glen Roy is clearly marked. The bottom of the valley is here about 400 or 500 feet above the level of the sea, while the line is 847 feet, according to the levelling of an engineer employed by Mr. Robert Chambers. The top of Craig Dhu, by aneroid measurement, I made out to be about 2100 feet above the sea, or 1250 feet above the level of the line, and, say, 1600 feet above the bottom of the valley. Now I found the flank of this Craig Dhu strongly impressed with marks of glacial action up to within a hundred yards or so of the very top. Rounded shoulders of rock, scored and fluted horizontally, sometimes even polished, may be seen in many places all over the side of the hill; and it is worthy of notice that these appearances are well displayed immediately above, below, and even *on* the very line itself. The highest well-marked scores observed by me were at a level of 300 feet below the top of the hill, or (say) 1300 feet above the bottom of the valley; but transported boulders (*blocs perchés*) occur up to near the very summit. From the brow of Craig Dhu to the brow of Ben Chlinaig, on the opposite side of Glen Spean, is a distance of two miles

Fig. 3.—*Outline-section across Glen Spean.*

or so; here, therefore, is a striking proof of what a volume of ice must have swept down this valley, if these scores were caused, as I believe they were, by this agency.

The rock of the hill, wherever I saw it, consists of micaceous gneiss or mica-schist, dipping N.W. at a very high angle, with some thin dykes or beds of felspar-porphyry. Now, the cropping out of the ragged edges of the gneiss-strata obliquely to the east must have afforded tough morsels for the bite of even a glacier-stream moving westward; but notwithstandiug this disadvantageous circumstance of the edges being presented towards, and their backs away from the stream, it became evident to me, after a careful examination of much of the hill all along its south flank, that from top to bottom the scoring agent had moved from east to west. This was apparent not only from the greater rounding and polishing of the east faces, but a further proof was afforded by the movement of rock-masses: for instance, from a great dyke of white quartz a large angular block had been torn off and carried some yards to the westward; also porphyry fragments indicated a similar direction of transport. But there was another most striking and convincing proof of this nature. The gneiss over the hill-top being quite bare, or covered only by a thin peel of turf, it was easily seen that no other rock was present; it will therefore be admitted to be a highly interesting fact when I state that large angular boulders of syenitic granite, precisely similar in mineral quality to the low mass of that rock which occurs *in situ* in the bottom of the valley to the eastward, opposite the gorge of Loch Treig, are scattered in great numbers all over the brow of the hill, resting on the bare upturned edges of the gneiss, which is shorn and rounded into smooth outlines; and what is very remarkable, the largest and most angular blocks are more numerous high up on the very brow of the hill, at a level of from 130 to 400 feet from the top, than they are further down. Thus, one measuring 12 feet long, by 9 broad, and 6 high, lay 130 feet lower than the summit of the hill; a few yards from it was another $9 \times 6 \times 4$; and at a level of about 400 feet below the top, or 1700 feet above the sea, was a magnificent block, 15 feet long, by 10 broad, and 6 high: this was the largest, and, from its conspicuous position on the bare brow of the hill, may be seen at a great distance, being visible with the naked eye from the Bridge of Roy Inn, four miles off.

This is another very striking example of boulders being carried up far above the source from whence they were derived; and I have little doubt that these granite blocks have come from the patch of that rock in the bottom of the valley to the eastward; for no mineral mass of the same kind is known elsewhere in the neighbourhood, nor did I see any of it on the sides of Loch Treig, where, by the by, there is an absence of these fragments also. It has been suggested by Mr. Darwin that such cases might be explained by supposing the boulders to have been frozen into coast-ice and carried upwards during a period of submergence, when the land was gradually sinking; and it is also found to be the case that even the sea-waves, unaided by ice, can during a heavy swell throw up boulders upon the rocks out of deep water. But neither of these explanations will, I think, suffice for the phenomena on Craig Dhu; for, in the first place, there are no water-rolled pebbles accompanying these boulders; and in the second place, the repeated stranding of the blocks by coast-ice or a heavy surf would, as Darwin admits, have rounded and reduced them to smaller size the farther up they were carried, whereas we see here that those most conspicuous for size and angularity are highest up on the very brow of the hill. I may also point out that the submergence of an isolated hill, like Craig Dhu, would have left its top but a little round speck of an island, where coast-ice would have had no shelter and been readily driven away. The scoring also of the subjacent rock, if caused by the stranding of the boulders either by coast-ice or waves, would not have been so horizontal and so steadily in one direction; we should have rather found scores running uphill, from the blocks being driven on it by the surf.

The extraordinary profusion of these granitic boulders all about the valley, the manner in which such immense blocks are piled up one over another on the surface of heaps of moraine-like débris, and the way they have been elbowed up the slope of the hill opposite the gorge of Loch Treig, together with the strong scoring and polish on the rocks,—all seem to me to speak an unmistakeable language; for I know of no agency, except that of a great glacier-stream, that could have effected all this.

The granite boulders have been carried westward past Craig Dhu, for I found some of them on the top of Bohuntine—a hill on the west side of Glen Roy, nearly 2000 feet high, and of a remarkably rounded outline, as if it had been moulded by the passage of ice. In an opposite direction they have been carried towards Loch Laggan, affording another proof of what I before stated, namely, that the ice-stream had parted and gone out both to E. and W. I even found some of them to the east of that loch, near Makoul.

On looking up Glen Spean from the top of one of the hills, I was struck by the greater wear and smoothness of the hill-slopes flanking the valley, below a level of about 2000 feet or so; and this moulding I could not help attributing to the same agency that had so powerfully scored the rocks of Craig Dhu.

I have been induced to describe the foregoing case somewhat minutely, because not only is it interesting from the clear evidence it affords of the extent to which the ice had been developed, but it is further important as affording a good example of a movement from both S. and E., thus enabling us to get rid of the notion which has been so prevalent, that this great glacial action had come invariably from the N. and W.

I have still to mention a circumstance perhaps even more singular than any I have described, showing the remarkable state of ice-development that had once existed in this region. Just below Craig Dhu there branches off from Glen Spean, in a N. and N.E. direction, the well-known little valley called Glen Roy, extending in that course to the watershed of the River Spey. Near the head of the Roy, the Glen is contracted and nearly closed by some rocky eminences which seem to form its natural termination, and beyond which there is a wide hollow opening into Strath Spey. Now the surface of these rocky eminences presents clear evidence of glacial action, being rounded off and scored, and also dotted with occasional perched boulders; but I was not a little surprised to find it quite apparent that the ice had come from the S.W. *up* Glen Roy, and gone out in a stream towards the wide valley of the Spey. My first thought was that glaciers might have descended from Glen Eggie and other little side-glens which branch off here; but, on examining the rocks at the junction of the Eggie and the Roy, I found the furrows on the well-moutonnéed mica-schist passing right across the mouth of Glen Eggie; and the strata, which are almost vertical in position, have been so blunted and rubbed on their south-west exposure as plainly to show that the movement came from that quarter; and high up on the brow of the adjoining hill (which is an extension of that marked Tom Brahn on most of the maps, but known to the shepherds by the name of Craig Corrak) I saw several very large blocks and boulders that appeared to have been shifted or moved some distance by glacial action.

In Glen Roy itself, owing to the great accumulations of stratified débris, the rock is not well exposed, and, where seen, is often of a rotten, shivery nature; so that, although I had remarked some striated boulders, I had not seen any ice-worn surfaces except on the top of Bohuntine Hill, where however I could detect no scores or scratches, although the rock was much ground down. But on returning down the glen my eye caught some suspicious-looking lumps of rock on the flank of Ben Erin that had been bared of their earthy covering by the water of a descending rivulet; and on scrambling up to examine them, I found a few clearly marked glacial scores running horizontally along, at a height a little below that of the lowest Glen Roy line, while the worn and rounded edges looked *down* the glen. The amount of rock exposed and thus marked was but small; and I should have attached little importance to the latter circumstance had it not been for the fact already mentioned of the rocks at the head of the glen indicating the motion of ice coming up it, and passing out to N.E.: for this would seem to show that Glen Roy had at one time been filled with ice, which, unable to get out by way of Glen Spean, owing to the vast accumulation in that direction, had been obliged to discharge itself at the upper end into the more open outlet of the Spey basin. When we consider the narrow character of the great Caledonian Valley, bordered by lofty mountains and numerous side-glens, and choked up as it must have been at its mouth by the jostling of all these united ice-streams pressing out past Ben Nevis, and recollect that proof has been adduced of Glen Spean being filled with ice to the level of the top of Craig Dhu, which exceeds by 900 feet the summit-level of this pass into Strath Spey, the above singular fact becomes less mysterious.

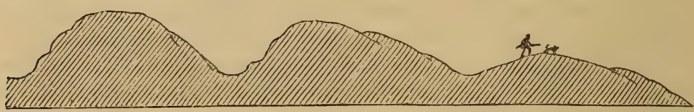
§ 5. I have yet another example I should like to give, as further illustrating and confirming what I have already advanced.

In Argyleshire there is an arm of the sea called Loch Fyne, whose upper branch stretches 25 miles from S.W. to N.E. far into the Highlands. The scored and polished rocks all along its shores, from Inverary down to Loch Gilp, plainly indicate the former passage of ice down the loch; their rounded, worn sides facing the interior, and the rough and more jagged outlines the sea. At Loch Gilp (which is a small inlet off the west side of the lake), a low tract, forming the bed of the Crinan Canal, runs across in an eastern direction to the Sound of Jura. The rocks along this hollow are likewise much worn and rounded, but chiefly on their eastern sides, and scored by glacial furrows pointing W., parallel to the canal, and indicating the course of an ice-current diverging from Loch Fyne.

On looking at the map it will be seen that, if we produce the line of Upper Loch Fyne in a south-west direction, it would run across Knapdale into Jura Sound, near Loch Killisport. Now, I find the glaciation of the rocks of Knapdale looks as if the stream of ice descending Upper Loch Fyne (so great had been its volume, and so immense the *vis à tergo* impelling it onwards) had gone right out, over hill and dale, into the Sound of Jura. Let any one who wishes to satisfy himself of this examine first the course of the Crinan Canal, and he will find the masses of syenite, in the hollow beside the Dunartry locks, all worn and rounded on their south-eastern sides; and searching where the drift has recently been removed, he will find scores and polish indicating a motion to N.W. Let him then ascend the hill-slope from Cairnbaan, following the course of the ravine down which the torrent came when the reservoirs burst, and he will see the scores at the mouth of the stream running from E. 30° S. to W. 30° N.; ascending the slope of the hill, he will find the scores turning gradually to due E. and W., and, as he goes higher up, curving more and more round to the N. of E., and, what will probably surprise him, as it certainly did me, he will see evidence that the agent which impressed these furrows moved obliquely *uphill*, mounting a slope of 700 or 800 feet; he will then find himself on a sort of table-land spotted with several small lakes, and along the rocky sides of these reservoir-lakes he will observe some of the most beautiful examples of glaciation I have ever seen—long rectilinear grooves running uninterruptedly onwards from N.E. to S.W. for many yards, with all lesser degrees of scratching and polish. Let him then ascend over the ridges towards Cruach Lussa, and he will no longer

Fig. 4.—*Profile of the Ice-worn Knolls of Greenstone at the Crinan Canal.*

W. E.



find these markings on their bare, weathered fronts; but he will notice the rounded snouts they present invariably to the N.E., and the more rugged outlines to the S.W. Let him then continue all along until he gains the top of Cruach Lussa, the highest point in North Knapdale (and 1530 feet above the sea, according to the Admiralty chart), from whence, if the day be fine, he will have a view of one of the most beautiful scenes in Scotland, which alone will recompense his toil if he be no geologist.

§ 6. The ice, therefore, descending by Loch Fyne, seems to have passed round and over this hilly ridge, just as the water of a river flows round and over a large boulder in its bed.

It seems odd to talk of a glacier doing this; but nothing short of ice, filling the valleys up to the brim, and covering the whole country in one great winding-sheet, will meet the requirements of the case. In short, we should have to describe it just in the way Rink speaks of Greenland, when he tells us that a spectator standing on the top of a mountain near the coast sees the various ice-streams "approach and unite in an icy level occupying the whole of the eastern tract or area of the continent," and which annually discharges its enormous excess in those great icebergs that infest Baffin's Bay and the neighbouring seas. "To have a correct idea of the glacial accumulations in Greenland," says that observant voyager, Dr. P. C. Sutherland, "we must imagine a continent of ice flanked on its seaward side by a number of islands, and in every other direction lost to vision in one continuous and boundless plain. Through the spaces between these apparent islands the enormous glacial accumulations slowly seek their passage to the sea." In Melville Bay (lat. 75°), it presents to the sea one continuous wall of ice, unbroken by land for a space of 70 or 80 miles; and the average thickness, he tells us, is 1200 to 1500 feet, but in some of the valleys upwards of 2400 feet (Journ. of Geol. Soc. ix. p. 301). Somewhat similar, but much more extensive, is the ice-covering of the Antarctic Continent, where Sir James Ross traced a continuous vertical cliff of ice, more than 1000 feet thick, for 540 miles; and detached portions were found 60 miles from its main edge, aground in 1560 feet of water.

We see, therefore, that in certain parts of the globe land-ice attains a thickness at least as great as is required for the most extreme cases I have adduced in this paper, even allowing that the bottoms of the valleys had been as deep as they are at present when the ice reached the highest scores now found on the flanking hills, which is not at all likely; for I believe that the grinding of the ice for many ages along the glens must have powerfully eroded its bed, and worn the bottoms of the valleys much deeper than they were at the commencement of the Glacial period, and in fact occasioned an amount of denudation of the surface which has been much too little allowed for.

It may seem more probable to some, that the curious features in the erosion and scoring of Knapdale may be owing to the relative levels of the district having undergone considerable derangement since the time at which the rocks were so marked; and indeed, when I first observed them, this seemed to myself the most likely explanation; for although I could not, after much careful examination, resist the evidence of the movement having been uphill over much of the ridge, I felt much puzzled by the fact of the rocky masses on the top towards Cruach Lussa being so uniformly worn on their north-east exposure, while those in the bottom of the Crinan valley were abraded on their east and south-east sides, indicating a movement diverging at right angles from Loch Fyne, where there is at present a wide opening to the sea. But after studying Lochaber, where the facts seem to me clearly to indicate the presence of land-ice in a volume quite as extraordinary as would account for the phenomena in Knapdale (allowing for erosion of the bed of Loch Fyne by the long passage of the ice, as I have above suggested), I am inclined to think that it is unnecessary to require any great local derangement of level.

Those who would solve the facts I have adduced in this paper by means of floating ice have to show how the winds or currents that moved it could have radiated from the central heights of Scotland to all points of the compass, and in each district have always persisted so steadily in one direction;—how, for example, from a point in the middle of Glen Spean, at the junction of the Treig, winds or currents could have set out in opposite directions, and in both cases at right angles to the line of movement in Glen Treig;—how the movement on one side of Scotland should have been continually from W., and on the other from E., and on the north coast from S., and always from the *land* side;—how blocks, 15 feet long, could have been by such an agency lifted up out of the bottom of a valley, and set down on the bare brow of a hill hundreds of feet above their source. The advocates of a *débâcle* have, on the other hand, to show how a sudden and transitory movement, even although repeated, could have lifted these blocks and have worn down ragged masses of tough gneiss at the mouths of the fiords of Argyleshire, and at Loch Treig, into smooth rounded domes, and scored the rocks in a direction so rigidly even;—how, on the brow of a hill like Craig Dhu, at the height of 1200 feet above the bottom of a wide valley, it could impress horizontal scores and fluted hollows along the face of a shelving rock-surface.

§ 7. Land-ice moving in a volume like that seen in Greenland or in the Antarctic Continent explains these and many other facts better, in my opinion, than any other theory yet proposed; and, so far as I can see, the only strong objection against it is the extraordinary climate for this latitude that it requires: but some such extraordinary climate is quite necessary to account for the fact of arctic quadrupeds, such as the Reindeer*, Musk-ox, the Lemming, and the Lagomys, having ranged into the south of England and the heart of Germany during the Drift-period; and one of these Lemmings (*Myodes torquatus*), whose remains were found by Dr. Hensel of Berlin in the Drift near Quedlinberg, is said to delight in so arctic a climate as seldom to ramble further south than the northern limit of the woods, and was found by Parry in latitude 82° N. We cannot suppose these animals to have been mere stray wanderers; for in one of the Welsh caves, called Bosco's Den, Dr. Falconer tells us, upwards of one thousand antlers, mostly shed, and of young animals belonging to the *Cervus Guettardi* and *C. priscus*—species or varieties allied to the Reindeer—were found in the bottom of the cavern (Journ. of Geol. Soc. vol. xvi. p. 489).

Such facts as these, together with boreal and even arctic shells (like the *Cyprina Islandica* and *Natica clausa*) inhabiting the Mediterranean shores of Sicily, bespeak a climate perhaps as severe as, with a certain amount of elevation, would account for Greenland conditions in our latitude. "Not even on the verge of the arctic province," says Edward Forbes, in his last work, "are we to seek for the analogue of the fauna of the Drift, but within its strictest bounds;" and yet this marine Drift to which he refers does not represent the time of severest cold, which was that of the great land-glaciation. We have therefore two sets of facts entirely different from each other, one from the organic, the other from the inorganic kingdom, and both alike demanding an arctic climate for their explanation.

We cannot account for such a development of ice in this country without supposing the whole of the atmospheric moisture, or nearly so, to have fallen in a frozen or snowy condition, and to have had to find its way off the land in the shape of solid ice; and such a climate in the latitude of Scotland cannot with any probability be supposed without some great changes in the physical geography of the northern hemisphere; for it comes to this, that the whole of Scotland must, during the period of greatest glaciation, have been within the snow-line, which renders the conclusion, I think, probable that our island must have then stood far higher above the sea-level than it does at present. Without supposing some such great elevation,

* The recent discoveries of Lartet in the cave at Aurignac show that the Reindeer inhabited even the Pyrenees.

the case would certainly be very marvellous; for even in Greenland, except at its northern extremity, the lower limit of the ice-covering, Rink tells us, is far above the coast-line, and it is only the larger glaciers that protrude into the sea; in the intermediate tracts, the snow and ice lying below the level of 2000 feet annually disappear before the heat of June. The whole of Norway, Sweden, and Lapland appears to be ice-worn from the mountain-tops down to the sea, and a general view of the whole brings out the fact that the scores radiate from the central heights to all points of the compass. Along the coast of Norway they run to W. and N.W.; in Lapland, to N. and N.E.; in Sweden, to E. and S.E.*

The phenomena, as a whole, seem to be better explained by land-ice moving from the central plateaux downwards and outwards than by any other theory†. In order, therefore, to account for this great glaciation of Britain and Scandinavia by land-ice, it is necessary, I think, to suppose that the elevation of these countries above the sea must have been much greater than at present. As regards Scotland, indeed, there can be little doubt of this, if we admit the markings I have described to have been caused by that agency; for along all the wide mouths of its sea-lochs or fiords the glacial scoring everywhere dives in full development underneath the present sea-level, and the same appears to be the fact in Norway and Sweden. Without supposing some such elevation, I do not see how a degree of cold at all like what seems to have prevailed can be accounted for, without supposing either the sun's heat to have suffered some great diminution, or the position of the earth's axis to have differed from what it is at present; and, even granting the elevation, the fact is very remarkable.

§ 8. But, while apportioning to land-ice its due share in the events of the Drift-period, let us not forget the strong evidence which we possess of the great submergence that took place afterwards. No action of land-ice, for example, will account for the marine shells and chalk-flints on Moel Tryfan, in Wales, at the height of 1392 feet; and a mass of good evidence has been collected to show that this submergence amounted to at least some hundreds of feet in various parts of England, Scotland, and Ireland, as well as in the Scandinavian

* It is alleged, however, by Hörbye and others, that in the midland region there is a remarkable exception to this rule. They state, indeed, that between lat. 62° and 63½°, the erosive agent proceeding out of the relatively low ground of Sweden has marched *uphill* right over the Dovrefjeld! "Sans exception, toutes les stries qui se trouvent sur la frontière mentionnée entre le 62^{me} et 63½ dégré de latitude ont leur point de départ dans les contrées de la Suède relativement plus basses." (Hörbye sur les Phénomènes d'érosion en Norvége, p. 40.) And the author of the memoir quoted had traced this "*burinage erratique*" to an elevation of 4590 Norwegian feet above the sea: he also quotes the authority of M. Durocher in support of this assertion as to the ascending movement of the erosive agent.

† "We generally find that the polished or opposing side (*Stos-Seite*) of the rocks is turned towards the principal plateaux of these countries. It is from these plateaux that the impelling power seems to have originated which determined the direction of the bodies which scooped out the grooves." (Bohtlink, Ed. New Phil. Journ. xxxi. p. 253.)

peninsula; sea-shells being found up to these heights imbedded in what look like marine strata. The mere presence of transported boulders, it is evident, can no longer be considered as a sufficient proof of submergence if the existence of an extensive covering of land-ice be once admitted. For the transport of boulders floating ice is doubtless a very efficient cause, but equally so is land-ice; each case, therefore, must rest on its own merits. The polishing and scoring of the rocks, however, will, I think, be found to have chiefly resulted from the latter cause, at least in this country; but there are some curious cases for which probably few will be disposed to admit this explanation: such are the north-east striæ at the extremity of the Island of Anglesea and on the Isle of Man, proceeding apparently from a cause exterior to these islands; also those parallel to the coast at Bray Head in Ireland, pointing N.E. However improbable it may seem, it will be well to bear in mind that it would be *possible* for land-ice to have caused these markings, supposing it to have been developed to an extent sufficient to fill the bed of the Irish Channel. Without venturing to say that it did so, I merely point out that, had such been the case, it might have marked these rocks in the way we find them to be. The continental ice of Greenland fills areas more extraordinary.

§ 9. It is therefore very necessary that we should have some criterion whereby we might be able to distinguish glacier-action from the action of floating ice. Mr. Darwin, in an excellent paper on the glaciers of Caernarvonshire, suggested that boss- or dome-formed rocks would probably serve as such. Another circumstance that, I think, should help us is the case of a deep hollow surrounded by a ridge on the side from whence the glacial agent has come. Such a ridge would evidently defend the hollow from the grounding of floating ice coming from that side, but would be of no avail against the erosion by a glacier. Now, such instances are frequent in Scotland. The well-rounded and scored gneiss which I have cited in the deep hollow of the east Kyle of Bute, opposite Colintrive, is one; that of the Gareloch, described by Mr. Maclaren, is another; the remarkable case of the reservoir-lakes of Knapdale may be mentioned as a third. Again, the steadiness of the direction of the striæ would seem to be inconsistent with the action of floating ice, unless in the case of deep-swimming icebergs in an open sea, moving under the steady influence of an ocean-current; and how could these have grazed the bottoms of our intricate glens? In the case of the Gareloch, Maclaren found that the bearing of the striæ over a length of seven miles does not vary more than a point to the right or left of the axis of the lake, and they are most clearly marked at the lower levels. Now, in Baffin's Bay, Dr. Sutherland tells us the icebergs tumble about and butt against each other in great confusion, like houses in an earthquake, and also occasionally assume a *rotatory* motion from the pressure of ice-floes against them. Further, when an iceberg strikes against a sunken ridge, it will push the broken fragments of the rock over into the first deep hollow, and there leave them; and, if grounded, it would rock about by the action of the surf and thus cause irregular curved markings unlike the straight ones that we always find.

§ 10. In Scotland the whole débris resulting from the erosion of the rocks has often been swept clean off,—over most of the glens in the North and West Highlands such is the case to a remarkable

Fig. 5.—*Sketch-map of Scotland, showing the Direction of the Glacial Markings observed in different parts of the country.*

N.B.—The headless arrows indicate that the side from which the agent moved is not certain.

——➤ Direction of Glacial striæ.

Note.—In this little map I have availed myself of the materials contained in a map of the middle region of Scotland which accompanied an excellent paper by Mr. C. Maclaren in the 'Edinburgh New Philosophical Journal' for 1849, and likewise of various scattered notices by Murchison, Nicol, Milne-Home, Chambers, Forbes, and Smith of Jordan-hill.

degree. I was much struck with this on the high barren ridge bordering the Crinan Canal, where the reservoir-lakes are situated. The upturned edges of the vertical strata there are in many places striated, and show great marks of erosion, as I have already mentioned; and the interstratified beds of greenstone, which are very numerous, stand out like great Cyclopean walls, running for miles high above the softer slaty beds that have yielded more to the action of the ice. But almost the whole wreck of the strata has been carried off, as if the rocks had been swept bare with a great iron besom. Some of the protruding trap-dykes that attracted the notice of Macculloch in many parts of the Western Isles, and were referred by him, with hesitation, to the tedious operation of the atmosphere, are, I have no doubt, due to this erosion of the softer beds by the ice.

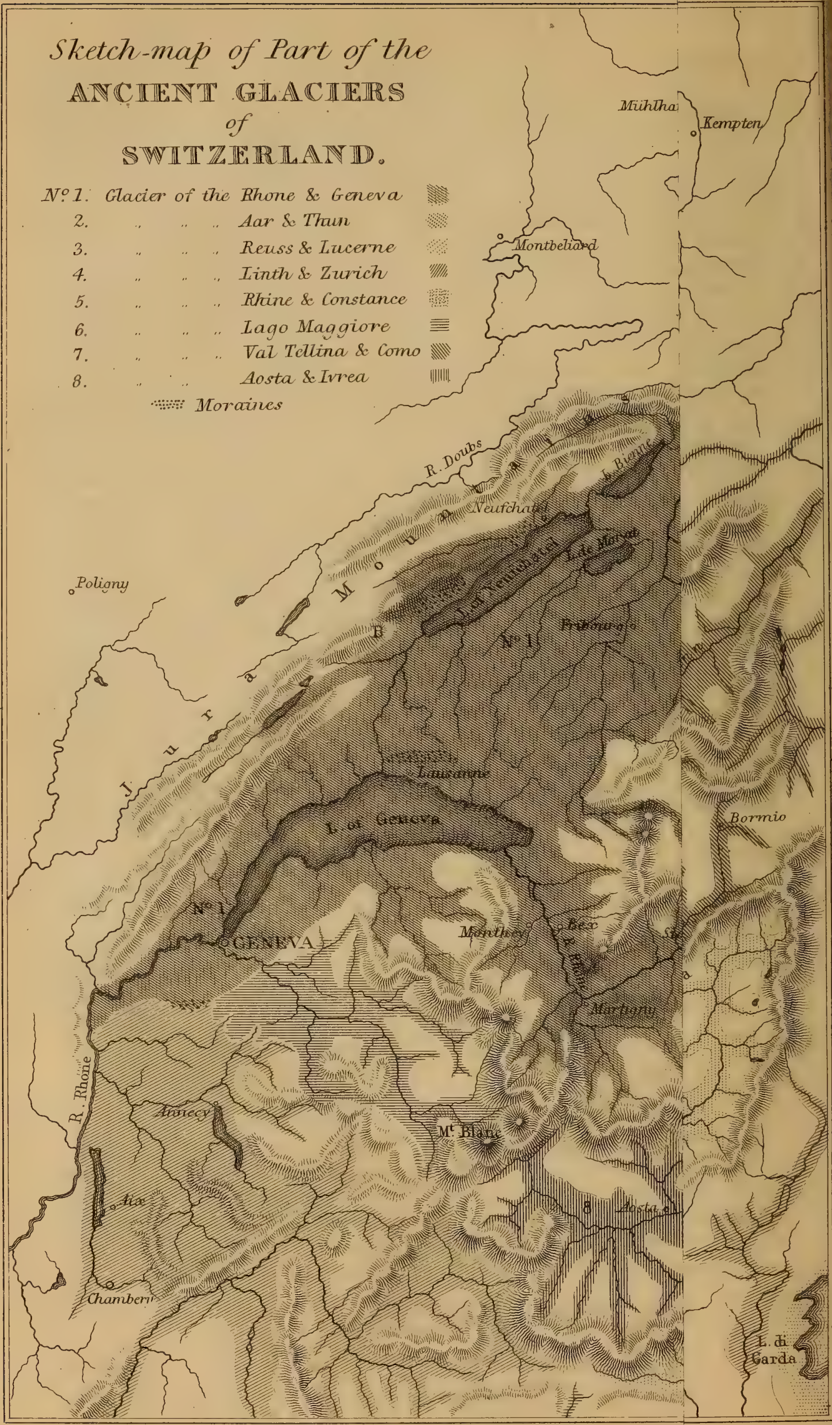
The geological period to which this great glaciation of Scotland belongs was probably contemporaneous with the formation of those "subaërial" beds on the borders of the English Channel, described by Mr. Godwin-Austen, and referred by him to the time succeeding the Norwich Crag. That, at least, it was not of much older date, I am led to think from the discovery of some patches of what appears to be Red Crag in the low coast-district of Slains, in Aberdeenshire, that have partly escaped the denudation caused by the ice. In addition to the Mollusca recorded at p. 372 of the 16th vol. of the Quart. Journ. of the Geol. Soc., I have since found in these so-called "Crag" beds of Slains what I believe to be fragments of the *Voluta Lamberti*, *Nassa elegans*, and *Nucula Cobboldiæ*—three shells eminently characteristic of the Crag-period. Nowhere, however, have I found in them any glacially striated stones; and the absence of these I consider an important fact, showing that glacial action had not then begun in the neighbourhood.

If this development of land-ice coincided with an elevation of a great part of Europe, we may expect to find, to the south of the ice-covered region, traces of contemporaneous freshwater deposits, and remains of the continental fauna that flourished during the long period that the North was covered with ice. The valley of the English Channel and the southern portion of the German Ocean were then probably dry land, and may have been haunted by mammalia of various kinds, and hence the quantity of Elephants' teeth and bones they contain. To a part of this period probably belongs the "forest-bed" underlying the boulder-clay of the Norfolk coast, and whose tree-stumps are rooted in the Norwich Crag.

March 5, 1862.

George Ford Copeland, Esq., M.R.C.S., 5 Bay's Hill Villas, Cheltenham; William James Dunsford, Esq., 14 Taviton Street, Gordon Square; Charles Henry Gatty, Esq., F.L.S., Felbridge Park, East Grinstead, Sussex; and Alexander Henry Green, Esq., M.A., Fellow of Gonville and Caius College, Cambridge, were elected Fellows.

The following communication was read:—



J.W. Lowry sculpt.

On the Glacial Origin *of certain* Lakes *in* Switzerland, the Black Forest, Great Britain, Sweden, North America, *and elsewhere.*

By A. C. Ramsay, F.R.S., President of the Geological Society, &c.

[Plate VIII.]

Contents.

Erroneous Theories of the Transport of Alpine Blocks.—In the year 1859, in a series of papers by the members of the Alpine Club, I published a memoir in which I compared the old glaciers of North Wales with those of Switzerland; and in it, among other matters, I explained the glacial origin of certain rock-basins now holding lakes, on the watersheds and in the old glacier-valleys of both those countries; and in a later edition of the same memoir, published as a separate book, with additions*, I extended these generalizations to many of the lakes in Sutherlandshire.

In the same work I also expressed an opinion that the blocks of Monthey, in the valley of the Rhone, and the great erratic boulders that strew the southern flank of the Jura had been transported by icebergs derived from glaciers which descended in the Alpine valleys to the sea-level, during a period of submergence in which the low country that lies between the Jura and the Oberland was covered with erratic drift.

There was nothing new in this latter opinion, for it had previously been held by several distinguished geologists, both English and continental.

Since then I have twice revisited Switzerland, and have seen good reason to change my opinion respecting the cause of the transport of erratic blocks to Monthey and the Jura, and of *débris* not remodelled by rivers, &c., that lies scattered over the lowlands of Switzerland, or that borders, or lies in great mounds well out in, the plain of Piedmont and Lombardy. I am now convinced, for example, that the vast circling moraine of Ivrea, noticed by Studer in 1844, was shed from a glacier, 105 miles in length, that filled the valley of Aosta to a height of more than 2000 feet, and protruded far into the plain; while on the north a still greater glacier, long ago described by Charpentier, flowed from the valley of the Rhone right across the low country until its end abutted on the Jura. As there are still many persons in England who doubt these conclusions, it

* 'The Old Glaciers of North Wales.' Longman & Co.

J.W. Lowry sculpt.

may not be beside the question to state the considerations that led me to reject the old theory.

Reasons for abandoning the older theories.—I first began to doubt the correctness of my earlier opinions in the summer of 1860, while examining the country near Bonn, the banks of the Moselle, and the Eifel. Neither in the valleys nor on the wide table-lands on both sides of the Rhine and the Moselle is there any sign of glacial drift. Excepting alluvial *débris* in the valleys, the native rock is generally quite bare of transported detritus; and the only marks of glaciation lie low on the sides of the Moselle, where the floating down of the river-ice has frequently rounded, polished, and striated the rocky banks in the direction of the flow. Boulders, transported from further up the stream, also sometimes lie on the shores. But, in the absence of true drift, I considered that, had Switzerland been depressed at least 3000 feet, until its mountains were washed by a sea that floated transported blocks to the higher Jura, the table-lands of Rhenish Prussia and Westphalia would also possibly have been submerged, and more or less covered with glacial detritus. Further up the Rhine and in the Black Forest the same absence of marine drift prevails. There, looking eastward towards the Rhine, the mountains, chiefly of gneiss, are wonderfully scarred, telling the observer of the wasting effects of frost, ice, rain, and rivers, probably ever since the close of the Miocene period. In the valley of Oberweiler, between Mullheim and the watershed, I observed occasional heaps of moraine-like detritus, in which by diligent searching I found a few stones marked with the familiar glacial scratchings.

In the interior towards Schonau and the Belchen, the rocks being generally soft and schistose, no very decided signs of old glaciers occur, and no part of the country shows symptoms of the presence of drift. Altogether the country looks as if it had stood in the air for so great a period that, even if glaciers were once present, they had disappeared so long that all the more prominent signs of degradation are now due to rain and running water. But further in the interior it is altogether different; for the signs of old glacier-ice are plentiful enough, and for miles round the Feldberg, which rises 4982 Baden feet above the sea, the sides of the valleys to the very summits of the mountains are often strikingly *moutonnées*, though the rounded forms are generally roughened and frequently half ruined with age. On these, striations, though rare, may occasionally be discovered (running in the direction of the valleys), although the rapid rate at which the rock weathers is much against their preservation. Moraines also are not uncommon. At the foot of the Feldberg, on the east, there is a beautiful circular lake, called the Feldsee, surrounded by tall cliffs of gneiss and granite in the shape known in Scotland as a corrie—a form eminently characteristic of all glacier-countries past or present. The outer side of the lake is dammed up by a perfectly symmetrical moraine, curving across the valley, and formed of sand, gravel, and of granite and gneiss, often in large boulders. It is now covered with pine-trees. The lake is deep, and the moraine rises from 25 to 40 feet above the water. Outside the moraine lies a flat marsh, still retaining traces of having been a lake, once also dammed by a second and outer moraine, formed chiefly of large angular blocks of gneiss, piled irregularly on each other like the old moraine of Cwm Bochlwyd, above Llyn Ogwen in Caernarvonshire. Quantities of moraine-matter strew the valley for two or three miles further down to the little marshy lake at Waldbauer, which is also dammed up by moraine-rubbish, in one place rudely stratified, like some of the old moraine-heaps on the Jura and parts of the great moraine of Ivrea; or like the heaps of glacier-*débris* that often border the lakes marshes, and flat peat-mosses, once lakes, that diversify the lowlands of Switzerland. At the upper end of the Alb Thal also, at the entrance of Menzenschwanden Alb, I saw four moraines curving across the valley, arranged concentrically one within another, like those at the end of the glacier of the Rhone; and for many miles in the Alb Valley, both above and below St. Blasien, *roches moutonnées* stand like islands through the alluvium, while it is also plain that the sides of the mountains above have been to a great height smoothed by ice. Nowhere however down to Allbruck, where the river joins the Rhine*, did I see any "drift;" and this village lying close on the north side of the Jura, it seemed impossible that the higher ground on the south side of that range, between the Lakes of Constance and Geneva, should have been submerged during any part of the Glacial period, while the country on the Rhine above Basel remained above the sea. I therefore saw that the theory that the *Pierre à bot* and its companion blocks had been floated from the Alps by marine icebergs was untenable; and a later examination of a portion of the Jura, partly under the able guidance of Professor Desor, fully convinced me that the ice that descended the great valley of the Rhone had covered much of the low country and abutted on the south-eastern flank of the Jura.

Old Distribution of the Great Alpine Glaciers.—At that period, then, of extreme cold, when the glaciers of the Alps flowed right across the Miocene basin of Switzerland, a glacier of vast thickness (No. 1 on the Map, Pl. VIII.), running from end to end of the upper valley of the Rhone, debouched upon the lowlands at what is now the eastern end of the Lake of Geneva, and spreading in a great fan-shaped mass extended to the south-west several miles down the Rhone below its present outflow from the lake, and north-east to the banks of the Aar, about half-way between Solothurn and Aarau. The length of this fan-shaped end of the glacier, from north-east to south-west, was about 130 miles, and its extreme breadth about 25 miles. Another great glacier (No. 5) descended in a direction opposite to the higher part of the Rhone glacier, through the upper valleys of the Rhine, and debouched upon a wide area that extends from Kaiserstuhl on the Rhine, far to the north-east. In the centre of this area lies the Lake of Constance. Between these, which were the largest glaciers on the north watershed of the Swiss Alps, several smaller, but still enormous, glaciers flowed in a north-westerly direction from the

* Between Basel and the confluence of the Aar and the Rhine.

mountains,—one down the Linth, through the area now occupied by the Lake of Zurich (No. 4), another down the Upper Reuss, across the area in which lie the Lakes of Lucerne, Zug, and others (No. 3), and a third down the valley of the Aar to Berne, through the country that now contains the Lakes of Brienz and Thun (No. 2). According to this view (the result of the researches of the best Swiss geologists), the greater part of the Swiss Miocene area lay deep under ice*, and I am inclined to think that the country between the great old glaciers of the Reuss, Aar, and Rhone was much more covered with ice than any map shows, the whole helping to swell the prodigious glacier of the Rhone that abutted on the Jura.

Connexion between Tarns and Glaciers.—In 'The Old Glaciers of North Wales' I have shown that in all glacier-countries, whether past or present, there is an intimate connexion between tarns and glaciers. Some of these are dammed by old moraines†, but the greater number lie in *rock-basins,* formed by the grinding of glacier-ice as it passed across the country, whether in valleys, on rough table-lands, or on the watersheds of passes. These lakes and pools are of all sizes, from a few yards in width, lying amid the mammillations of the *roches moutonnées,* to several miles in diameter. Sometimes in the convolutions of the strata (conjoined with preglacial denudation subsequent to the contortion of the beds), softer parts of the country may have been scooped out, leaving a hollow surrounded by a framework of harder rock ; but perhaps more generally they were formed by the greater thickness and weight, and consequently proportionally greater grinding pressure, of glacier-ice on particular areas, due to accidents to which it is now often difficult or impossible to find the clue. Trifling as this phenomenon at first sight may seem, I yet believe the manner of the formation of these lakes is of much importance to the right understanding of the glacial theory, whether taken in connexion with the great extension of extinct glaciers in recognized glacier-regions, or, further, when viewed on a general continental scale ; for *the theory of the glacial origin of many rock-basins* must, I feel convinced, be extended much beyond such mountain-districts as Switzerland, Wales, and the Highlands of Scotland, where they first attracted my attention ‡.

Origin of the Great Alpine Lakes. Subject stated.—From the consideration of the origin of mountain-lakes and tarns, the question easily arises,—What are the causes that have operated in the formation of the great lakes of Switzerland, such as those of Geneva, Zurich, and Constance, and, south of the Alps, of Maggiore, Lugano, Como,

* The limits of the northern glaciers on the Map (Pl. VIII.) are chiefly given from a MS. map compiled by M. Morlot. Those on the south are taken from a map by M. de Mortillet. Both were lent me by Sir Charles Lyell.

† Quart. Journ. Geol. Soc. 1851, vol. viii. p. 371 ; and 'Old Glaciers of North Wales.'

‡ It is not to be supposed that I attribute the origin of all rock-basins to glacial action. Many lie in the craters of extinct volcanos, some, no doubt, in areas of special subsidence, and others may be due to causes of which I know nothing. I now confine my remarks to certain lakes common in all highly glaciated regions such as I know.

and others? To answer this with precision, it will be necessary, first, to examine several other hypotheses that by some may be thought sufficient to account for them.

It is well known that after the close of the Miocene epoch the rocks of the Alps were much disturbed,—a circumstance proved by the contortion of the Miocene strata, as for instance in the neighbourhood of Lucerne, where, on the Rigi (and in other conglomeratic mountains on the same strike), the strata are considered by the best Swiss geologists to be repeatedly folded and fairly inverted, so that the basement-beds form the top of the mountain instead of its bottom, thus, by reversal of dip, plunging under the Eocene and Cretaceous strata of the mountains further south. The whole, as shown by the rapid truncated foldings and the escarpments of the hills, has since been much denuded, the denudation being of a kind and amount that, to effect it, proves the lapse of a long period of time. Witness the outliers of Miocene strata in the upland valleys of the Jura. Among these disturbed and denuded strata of Miocene and of older dates, the Lakes of Geneva, Thun, Brienz, Lucerne, Zurich, Constance, the Wallen See, and the great lakes of North Italy lie. A knowledge of the stratigraphical structure of the Alps, in my opinion, proves that these lakes do not lie among the strata in basins merely produced by disturbance of the rocks, but in hollows due to denuding agencies that operated long after the complicated foldings of the Miocene and other strata were produced.

First, none of these lakes lie in simple synclinal troughs. It is the rarest thing in nature to find an anticlinal or a synclinal curve from which some of the upper strata have not been removed by denudation. I never yet saw a synclinal curve of which it can be proved that the uppermost stratum in the basin is the highest layer of the formation that was originally deposited over the area before the curving and denudation of the country took place. The only approach to this may possibly be in the upper valleys of the Jura, where a part of the Miocene beds lie in basins separated by secondary anticlinally curved strata, the tops of the anticlinal bends having been removed by denudation; but these cases are surrounded with difficulties. The lake-hollows in the Alps are, however, encircled by rocks, the strikes, dips, and contortions of which often exhibit denudation on an immense scale; and in no case is it possible to affirm, here we have a synclinal hollow of which the original uppermost beds remain. If these beds have disappeared to a great extent, then it is evident that denudation has followed disturbance. The fragmentary state of the uppermost Miocene strata of the lowlands of Switzerland proves this denudation. Again, if it be argued that in the lake-areas these denudations have been produced by the waters of the lakes, it is replied that, though waves may form cliffs, neither running nor still water can scoop out deep trough-shaped hollows.

Secondly, the same kind of argument applies to areas of mere watery erosion by rivers. Running water may scoop out a sloping valley or gorge, but (excepting little swallow-holes) it cannot form and deepen a profound hollow, so as to leave a rocky barrier all round; though it may fill with sediment one that had previously been formed.

Thirdly, neither do most of the Swiss lakes lie in lines of dislocation. For many reasons I do not believe that any one of them among the high Alps or on their flanks can be proved to lie in lines of mere gaping fracture. Let us consider the nature of such fractures.

In any country where the strata are comparatively little disturbed and lie nearly horizontally, if it be faulted, there is no reason why the fractures should be open. In the Oolites, for example, in the South of England, where faults are numerous, and in the New Red Sandstone of the central counties, there is generally a simple displacement of the strata up or down, on one side or the other; or, if the disturbance go beyond this, it is that along the sloping line of fracture the beds on the downthrow side are turned up, and those on the opposite side bent down, by pressure and slipping combined. In more disturbed districts, like the Welsh Coal-measures, the same phenomena are observable: witness, for instance, the numerous sections from accurate observation, drawn on a true scale, by Sir Henry De la Beche, Sir William Logan, and others. Experience both above ground and in mines proves the same. Most lodes are in fractures, and many lie in lines of fault. In metamorphic, excessively contorted, and greatly fractured districts like those of Devon, Cornwall, and Wales, the cracks, whether bearing metals or not, vary from mere threads to a few fathoms in width. They are always filled with quartz or other foreign substances, frequently harder than the surrounding matrix. I have often traced lodes on the surface, in Wales, by the hard matter filling the crack standing in relief above the surface of the softer enclosing rock. In limestone rocks the cracks are usually partly filled with crystallized carbonate of lime. Lines of fracture are not, therefore, for purposes of denudation, necessarily lines of weakness, unless it happen that on opposite sides of the fault hard and soft rocks come together, when of course the softer rocks will wear away more rapidly, and generally originate a straight valley.

Again, in an excessively contorted country, such as the Alps, it is, I believe, impossible, *in consequence of that contortion*, that there should be gaping fractures now exposed to view. Assuming for the sake of argument the sudden violent contortion of the strata of any great tract of country, we shall see that the contorted rocks *now exposed at the surface*, even if broken, would be most unlikely to gape.

The expression "elevation of mountains" conveys to the minds of many persons the idea that the elevation has been produced by some force acting from below, along a line in the case of a chain, and on a point of greater or less extent when the mountains lie in a cluster, as a whole, more or less dome-shaped. Such forces would stretch the strata; and when they could no longer stand the tension, cracks would ensue, and many lines of valley are assumed to lie in such fractures. But in Wales, the Highlands of Scotland, and more notably in the Alps, the strata now visible have been compressed and crumpled, not stretched, and they occupy a smaller horizontal space than they did previous to the formation of the chain.

Let us suppose a set of strata of (say) 14,000 to 20,000 feet in thickness, like the rocks of North Wales, and let these be spread out horizontally over thousands of square miles. Let these strata, from any cause, be compressed from the right and left so as to be contorted, and occupy a smaller horizontal area than they did before disturbance. Then, at a great depth, where the superincumbent strata pressed heavily on the lower beds, the latter would be crumpled up, cleavage would often supervene, and gaping fractures would be impossible; for, where mere fractures occurred, the walls of the cracks would be pressed more closely together. But nearer the surface, where there was less weight, and at it, where there was none, the beds would extend into larger curves than they did lower down; and where the limits of extensibility were passed, shattering might take place, and yawning chasms might ensue. In all violently contorted countries, however, as in the cleaved rocks of North Wales, for instance, the present surface shows those originally deep-seated contortions that since disturbance have been exposed by denudation; otherwise the rocks would not be cleaved. I therefore do not believe that in any country I have seen, such as Wales or Switzerland, there are any lakes now occupying yawning fractures, consequent in Switzerland on post-eocene or post-miocene disturbances. On the contrary, they lie in hollows of denudation, shortly to be explained, of later date than these disturbances.

Fourthly, again, it may be supposed that the great lakes lie each in an area of special subsidence; but, in reply to this, it is evident that among the unnumbered lakes of Switzerland and the Italian Alps it would be easy to show a gradation in size, from the smallest tarn that lies in a rock-basin to the Lakes of Geneva and Constance. Neither do I see any reason why mere size should be considered the test of subsidence. Disallowing that test, we should require a great number of special subsidences, each in the form of a rock-basin, in contiguous areas. Between the Seidelhorn and Thun, for example, we should require one for the Todten See, several on the plateau on the north immediately under the Seidelhorn, one for the lake at the Grimsel, another for the drained lake at the Kirchet*, and another for the lakes of Brienz and Thun. In Sutherlandshire these areas of special subsidence would be required by the hundred, and in North America by the thousand.

Signor Gastaldi, in a masterly memoir on the composition of the Miocene conglomerates of Piedmont†, considers with reason that the large angular blocks of these strata, many of them far-transported, and some of them foreign to the Alps and Apennines, have been deposited from ice-rafts; and thence he infers the existence of glaciers during a part of the Miocene epoch. But, admitting this, it is evident that the distribution of the post-pliocene glaciers of

* See the "Old Glaciers of Switzerland and North Wales."

† "Sugli elementi che compongono i conglomerati Mioceni del Piemonte." Turin, 1861.

the Alps must, in all details, have been quite different from those of Miocene age, in consequence of the great disturbance that the Alpine rocks underwent after the close of the Miocene epoch, and the subsequent formation of numerous new valleys of denudation. Traces of the long lapse of time between the Miocene and the later Glacial epoch are in other countries but imperfectly preserved in the subdivisions of the Crag, and of other minor formations of still later date. Of the finer gradations that unite these subdivisions few traces have been described. For long before, and during all these Crag epochs and the ages between them, of which we have little trace, and during all the time that elapsed from the close of the Crag until the period of extreme cold came into action, the Alps stood above the sea, and, suffering subaërial denudation, valleys were being formed and deepened. It is possible that, while the mild climates of the Lower Crag epochs endured, there may still have been glaciers in the higher Alps; but at whatever period the later glaciers commenced, those who allow the extreme slowness of geological change will admit that the period was immense that elapsed during the gradual increase of the glaciers, until, in an epoch of intensest cold, the ice abutted on the Jura in one direction, in another spread far beyond the present area of the Lake of Constance, and on the south invaded the plains of Lombardy and Piedmont. During all that time weather and running water were at work modifying the form of the ground under review. But, as I have already explained, these two agents were incapable of scooping out deep hollows surrounded on *all* sides by rocks, and it therefore follows that the lakes first appeared after the decline of the glaciers left the surface of the country exposed approximately as we now see it,—unless we admit, what seems to me impossible, that fractures, formed at the close of the Miocene epoch, remained filled with water until the great glaciers filled them with ice; or believe, with De Mortillet, that the valleys, and lake-hollows were charged with water-borne alluvial or diluvial *débris* before the glaciers ploughed it out *.

Allowing the hypothesis of De Mortillet, the rock-basins must have been twice filled with water; but, according to my hypothesis, they did not exist as lakes till after the disappearance of the glaciers.

But the glacier map of ancient Switzerland shows that the areas now occupied by the great lakes, both north and south of the Alps, have all been covered with glaciers. No tertiary deposit of an age between the close of the Miocene and the commencement of the Glacial epoch lies between the Alps and the Jura; and, had the hollows of the lakes existed prior to the great Glacial epoch, we ought, but for some powerful wasting agent, probably in these hollows, still to find

* See an admirable memoir by G. de Mortillet, "Des Anciens Glaciers du Versant Italien des Alpes." Milan, 1860. Though I had seen his map, I had not seen this memoir when I read my paper; and the passages in which it is mentioned have been added as these pages passed through the press. His theory leaves the difficulty of the first formation of the basins untouched, unless we believe (which I do not) that the Alpine valleys are lines of fracture.

some traces of freshwater deposits, perhaps of the age of part of the Crag. No such relics exist.

The Great Lakes. Lake of Geneva.—The Lake of Geneva is about 45 miles in length by about 12 in breadth, and its delta, once part of the lake, between Villeneuve and Bex, is 12 miles long. The latter and a small part of the banks of the lake beyond the mouth of the river lie in the great Rhone valley, formed of older Tertiary and Secondary rocks. All the rest of the lake is surrounded by the low country formed of the various subdivisions of the Molasse and Nagelfluh. The lake is 1230 feet above the level of the sea, and 984 feet deep towards the eastern end, according to the soundings of De la Beche *. See fig. 1, p. 194.

Geneva itself stands on superficial *débris*; but the solid rock first appears in the river-bed below Geneva, at Vernier, at the level of 1197 feet above the sea—only 33 feet below the surface of the lake, or 951 feet above the deepest part of its bottom. Any one acquainted with the remainder of the physical geography of the country will therefore see that the water of the lake lies in a true rock-basin. The question thus arises, How was this basin formed?

1st. It does not lie in a simple synclinal basin; for, though the Lake of Geneva lies in the great synclinal hollow of the Miocene strata between the Alps and the Jura, it is evident by an inspection of the country that the flexures of that formation are of far greater antiquity than the lake. These flexures have been denuded, and the lake runs in a great degree across their strike.

2nd. For reasons already stated, it is, I believe, impossible to prove that the lake lies in an area of special subsidence, all the probabilities being against this hypothesis.

3rd. It is almost needless to say that the Lake of Geneva is too wide to lie in a mere line of fracture; and I know of no reason why the valley of the Rhone, where occupied by the delta, should be esteemed a line of fault or gaping fissure, any more than many other valleys in Switzerland, which many geologists will consider with me chiefly the result of the old and long-continued subaërial denudation of highly disturbed strata. I could enter on details to prove this point, but they belong rather to the rock-geology of Switzerland than to the matter in hand.

4th. Those who do not believe in the existence and excavating power of great and sudden cataclysmal floods will at once see that the area of the lake cannot be one of mere watery erosion; for ordinary running water, and far less the still water of a deep lake, cannot scoop out a hollow nearly 1000 feet in depth.

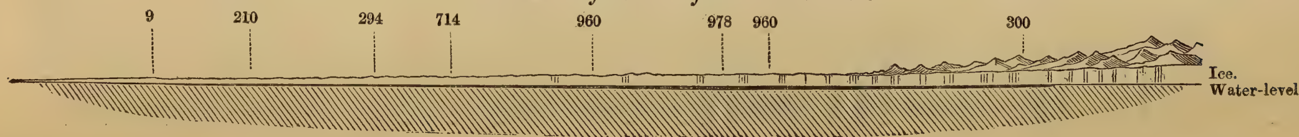
Now, if the Lake of Geneva do not lie in a synclinal trough, in an area of subsidence, in a line of fracture, nor in an area of mere aqueous erosion, we have only one other great moulding agency left by which to modify the form of the ground, namely, that of ice.

When at its largest, the great glacier of the Rhone (No. 1 of the Map, Pl. VIII.) debouched upon the Miocene beds where the eastern end of the Lake of Geneva now lies. The boulders on the Jura, near

* Edinburgh Philosophical Journal, 1820, vol. ii. p. 107, and plate 2.

Fig. 1.—*Outline-map of the Lake of Geneva, showing the principal Soundings in English feet. (After Sir H. De la Beche, F.R.S.)*

Fig. 2.—*Diagram-section of the Lake of Geneva, with Soundings in English feet, and showing the Comparative Thickness of the Ice of the Old Glacier.*



Neuchâtel, at the point on the Map marked B, prove that this glacier was about 2200 feet thick where it abutted on the mountains; and, where it first flowed out upon the plain at the mouth of the valley of the Rhone, the ice, according to Charpentier, must have been at least 2780 feet thick *. Add to this the depth of the lake, 984 feet, and the total thickness of the ice must have been about 3764 feet at what is now the eastern part of the lake, fig. 2 †. I conceive, then, that this enormous mass of ice, pushing first north-west and then partly west, scooped out the hollow of the Lake of Geneva most deeply in its eastern part opposite Lausanne, where the thickness and weight of ice, and consequently its grinding power, were greatest. This weight decreasing as it flowed towards the west, from the natural diminution of the glacier, possessed a diminishing eroding power, so that less matter was planed out in that direction, and thus a long rock-basin was formed, into which the waters of the Rhone and other streams flowed when the climate ameliorated and the glacier retired.

Lake of Neuchâtel.—The basins of the Lakes of Neuchâtel, Bienne, and Morat were, I consider, hollowed out in a similar manner, differing in points of detail. Near the Lake of Neuchâtel, on the flank of the Jura, the fan-shaped end of the Rhone glacier (No. 1) attained its greatest height, swelled in size and pressed on as it was by others that descended from the north snow-shed of the mountains between the Oldenhorn and the great snow-field above Grindelwald. According to estimates based on the highest ice-stranded boulders, the ice rose 2203 feet above the present surface of the lake. The lake is now 1427 feet above the sea, and 480 feet deep; and the Lake of Bienne is 1425 feet above the sea, and 231 feet in depth. The bottom of the Lake of Neuchâtel is thus 947 feet above the sea. Unless the gravel, therefore, on the banks of the Aar, immediately east of the latter, be over 480 feet deep, the hollow of the lake near its immediate bounds is a true rock-basin; for on the north, south, and west it is surrounded by solid Secondary and Miocene rocks. Even if the rock does not rise close to the surface in the river near the lake, still, at Solothurn, strata in place come close to the river-bank on both sides, the river being 1414 feet above the sea. Under any circumstances there must therefore be a long, deep trough between Solothurn and the rocks a little south-west of the Lake of Neuchâtel. How was this basin formed? When the glacier, debouching from the valley of the Rhone, spread out like a fan and pressed forward till it abutted on the Jura, its onward progress was stopped by that mountain; and direct further advance being hindered, the ice spread north-east and south-west, to the right and left, and being as a whole thickest and heaviest above the area where the lake now lies, a greater quantity of the Miocene strata on which it rested must have been ploughed out there than further on towards the north-east and south-west ends of the glacier, towards which

* The Lake of Geneva is 197 feet lower than the Lake of Neuchâtel. The glacier first surmounted the hills between Lausanne and Vevay, and then flowed down the general slope northwards to the Jura.

† This diagram is on a true scale both horizontally and vertically.

the ice, gradually declining in thickness, exercised less grinding power. In this manner I believe the troughs were formed in which lie the three lakes near Neuchâtel; and when the ice finally retreated, the ordinary drainage of the country filled them with water, the cliffs on the south-eastern side of the Lake of Neuchâtel and other changes of the form of the ground having since been produced or modified by watery erosion and the local deposition of silt and alluvial gravel.

The Lake of Thun.—The Lake of Thun is 1825 feet above the sea, and 776 feet deep. Its bottom is therefore 1049 feet above the sea. It is about 10 miles in length, 1½ broad, and its length chiefly cuts across the strike of rocks of Secondary and Miocene age. The Lake of Brienz (about the same size) is more remarkable; for, while its level is 1850 feet above the sea, its depth is more than 2000 feet: so that its bottom is at least between 100 and 200 feet below the level of the sea. Before the formation of the alluvial plain between, these two lakes were probably united; and whether or not this was the case, it is evident, from its great depth, that the Lake of Brienz lies in a true rock-basin. Even if below Thun the rocks do not crop nearer than Solothurn, the Lake of Thun still lies in a rocky hollow more than 600 feet deep, both hollows having, I believe, been deepened by the great old glacier of the Aar (No. 2 in the Map), the ice of which was so thick, that above Brienz it overflowed into the valley of Sarnen by the Brunig, about 1460 feet above the Aar below Meyringen, and sent off a branch which scooped out the hollows of the Lakes of Lungern and of Sarnen on its course towards Alpnach on the Lake of Lucerne.

The Lake of Zug.—The Lake of Zug is about 9 miles long, from 1 to 2½ wide, 1361 feet above the sea, and 1279 feet deep; and its bottom is therefore only 82 feet above the sea. The whole is surrounded by Miocene strata, the strike of which the lake cuts across, and its great depth clearly shows that it lies in a rock-basin.

The Lake of Lucerne.—The Lake of the Four Cantons (Lucerne) ramifies among the mountains and extends its arms in various directions. In its lower part, the branches that run N.E. to Kussnach and S.W. towards Gestad lie partly in the strike of the Miocene and older strata; but for the most part it runs across the average strike of the Eocene and Secondary rocks, between banks, sometimes precipitous, that rise in noble cliffs sometimes more than 2000 feet above the water. Its height is 1428 feet above the sea, and its recorded depth 853 feet; but the shape of the banks and the round number of 800 French feet make it likely that it may contain deeper gulfs than have yet been plumbed. If not, then its bottom is 575 feet above the sea; and those acquainted with the shape of the ground by Lucerne will easily be convinced that the lake lies in an actual rock-basin. The steepness of the walls of this lake more resembles the sides of a rent than those of any of the basins yet described, and the re-entering angles of rock opposite curving bays have been cited as evidences of fracture, one side being supposed to fit into the other. But in most cliffy valleys of aqueous erosion there are necessarily such re-entering angles, from the common action of running water; and, in Switzerland, ere these valleys were filled with ice, they existed in some shape, and were drained by rivers that deepened them and gave them a general form preparatory to the flow of the ice that largely modified their outlines. I should no more consider the re-entering angles a sign of gaping fracture in these valleys than I would the bends of the Welsh valleys or of the tortuous Moselle. But even if at first sight one were inclined to believe the space between the opposite cliffs between Brunnen and Flühlen to be an open fracture, if we take a moderate average slope for each side, say of 65°, and produce it below the water, we get a depth, ere the lines meet, of between 7000 and 8000 feet—a very improbable depth for the original hollow of the lake. But it may be said that the fracture has been much widened by degradation, the line of the break merely giving a line of weakness, along which the surface-drainage might widen the valley. If, however, we only take an angle for the sides of the lake giving a moderate depth, the necessity for a fracture does not exist, and we recur to some process of mere erosion for the scooping of the hollow in which the water lies, that process having, I consider, been the long-continued grinding of the ice of the great glacier No. 3 of the Map.

The Lake of Zurich.—The Lake of Zurich runs from N.W. to S.E., across the average strike of the Miocene strata, which are much disturbed towards its eastern end. It is bounded by high hills, much scarred by the weather, on which the different Miocene strata often stand out in successive horizontal steps. The Linth Canal and the Wallen See lie in an eastern prolongation of this valley, which is still further extended to the valley of the Upper Rhine at Sargans. The lake is about 25 English miles in length, by $2\frac{1}{4}$ wide in its broadest part. A great moraine partly dams it up at its outflow at Zurich; and a second forms the shallow at Rapperswyl, where the lake is crossed by a long wooden bridge. The general level of the water is 1341 feet above the sea, and only about 639 deep; and the bottom of the lake is therefore 702 feet above the sea. The limestone rocks at Baden, on the Limat, are 1226 feet above the sea; and the lake therefore lies in a true rock-basin, though it is probable that the old moraine at Zurich accounts for the retention of the water of the lake at its precise level. The long hollow was in old times entirely filled by the great glacier (No. 4 in the Map, Pl. VIII.) which descended from the mountains between the Todi and the Trinserhorn, through the valley of the Linth, to Baden.

The Wallen See.—The Wallen See lies in a deep valley, whose cliffy slopes of Secondary rocks rise from 2000 to 3000 feet, and in the Leistkamm 4500 feet above the surface of the lake. The lake itself is 1391 feet above the sea; and from the great steepness of its banks it may be inferred that it is exceedingly deep, but none of the authorities I have consulted give its soundings. A large branch from the great Rhine glacier (No. 5 on the Map) joined that of the valley of Glarus and Zurich through this wide gorge, and ground out the hollow of the Wallen See.

The Lake of Constance.—The Lake of Constance, the largest sheet of water in Switzerland, is about 50 miles in length, by about 15 in breadth at its broadest part. It is entirely surrounded by Miocene strata, often considerably disturbed, and forming great hills towards the S.E., which in a remarkable manner evince all the signs of long-continued erosion by running water,—conveying the impression that chiefly by that means all the deep valleys of the district have been worn since the close of the Miocene epoch. This lake lies 1298 feet above the sea; and, its depth being 912 feet, its bottom is only 386 feet above the sea. The falls of the Rhine are 1247 feet above the sea; and the lake therefore lies in an unmistakeable rock-basin, the whole of which was once overflowed by the deep and broad-spreading glacier of the Upper Rhine valleys (No. 5 of the Map), which stretched far northward beyond the lake into Baden and Wurtemberg. Being of greatest thickness where it entered the region of the lake, by its enormous weight and grinding power it scooped out, in the soft rocks below, the wide hollow now filled with water.

The Italian Lakes.—If we now turn to the Italian side of the Alps, we shall find the same phenomena prevailing in the Lakes of Maggiore, Lugano, and Como, the only important lakes I have yet had an opportunity of seeing south of the great chain. To each of these the same reasoning applies, modified only in detail; and I shall therefore briefly pass them over.

The most westerly, the Lago Maggiore, lies in a winding valley, 40 miles long, excavated in gneissic and jurassic rocks, which rise on either side in lofty mountains. The surface of the lake is 685 feet above the level of the sea, and near the Borromean Islands it has the enormous depth of 2625 feet; so that its bottom is 1940 feet lower than the sea-level. It must, therefore, be enclosed all round by rocks, unless we suppose the narrow passage at Arona, near its outlet, to be as deep as its deepest part, or that the alluvial deposits of the Ticino and the Po are more than 1940 feet deep—an assumption no one is likely to make.

Of all the Alpine lakes, that of Lugano is the most irregular in form,—in the language of M. Desor, stretching its arms like a great polyp among the mountains in all directions *. Its surface is 938 feet above the level of the sea, and its depth 515 feet. Its bottom is therefore only 410 feet above the sea-level, and the shape of the surrounding ground renders it impossible to believe that it is not entirely surrounded by rocks.

The Lake of Como, the hollow of which has been scooped out gene-

* See memoirs "De la Physionomie des Lacs Suisses" (extrait de la 'Revue Suisse,' 1860) and "Quelques Considérations sur la Classification des Lacs, à propos des bassins du revers méridional des Alpes," by E. Desor. The opinions of M. Desor and my own do not agree on the question of the origin of the lake-basins of the Alps. His views are well expounded in the above-named memoirs. It was in conversation with my friend, in 1860, that I first proposed what I consider the true solution of the question, and to this conversation I presume he alludes in the latter memoir, p. 13,—"On a prétendu que les lacs étaient l'effet de l'affouillement des glaciers qui auraient labouré le sol sur lequel ils s'avançaient," &c.

rally in the same set of rocks as the other two lakes, is 700 feet above the sea, and 1929 feet deep; and its bottom is therefore 1229 feet below the level of the sea. On the borders of these lakes the rounded rocks and the well-known glacier-stranded boulders, high on the mountain-sides, attest that these deep valleys were filled to the brim by a vast system of glaciers (Nos. 6 and 7 of the Map, Pl. VIII.) that flowed southerly from the snow-shed that runs from the eastern side of Monte Rosa, by the Rheinwald-horn, to the top of the valley of the Adda,—a system of glaciers so large that, like that of Aosta and Ivrea (No. 8 of the Map), further west, they protruded their ends and deposited their moraines far south on the plains of Piedmont and Lombardy.

The glacier of Ivrea (No. 8 on the Map), when it escaped from the valley of the Doire, deposited a moraine at its side, east of the town of Ivrea, rising in mere *débris* 1500 feet above the plain, and spreading out eastward in a succession of fan-shaped ridges miles in width. The vastness of this mass gives a fair idea of the huge size of the glacier, and of the great length of time it must have endured; and just as this glacier hollowed out the little rock-basins in which lie the tarns that nestle among the large *roches moutonnées* between the town and the moraine *, so, deep as the hollows of the great Lakes of Maggiore and Como are, I believe they also were scooped out by the grinding power of long-enduring ice, where, under favourable circumstances, the glaciers were confined between the mountains, and therefore thicker than the glacier of Ivrea where it debouched on the plain. Diagrams illustrative of this subject should be drawn on a true scale; otherwise, height, depth, and steepness being exaggerated, the argument becomes vitiated. I have not the data for giving an actual outline of the bottom of the Lago Maggiore; but a line drawn from the upper end of the lake to the required depth near the Borromean Islands gives *an angle only of about* 3° *in a distance of about* 25 *miles*, and from thence to the lower end of the lake (12 or 13 miles) *of about* 5°. The depths of Maggiore and Como do not, in my opinion, militate against my view; for, if the theory be true, depth is a mere indicator of time and vertical pressure in a narrow space. It is interesting, and confirmatory of this view, that the deepest part of the Lago Maggiore is just at the point where the enormous glacier of the Val d'Ossola joined the great ice-stream that was formed by the united glacier-drainage of the valleys above Bellinzona and Locarno. Where these glaciers united, there the lake begins; and where the ice was on the largest scale near the Borromean Islands, there the lake is deepest.

Summary with regard to the Alpine Lakes.—And now, in reviewing the subject of the origin of the lakes of Switzerland and North Italy, I would remark—

1st. That each of the great lakes (see Map) lies in an area once covered by a vast glacier. There is, therefore, a connexion between them which can scarcely be accidental.

* There are other well-known lakes dammed up by the moraine of this great glacier.

2nd. I think the theory of an area of *special subsidence* for each lake untenable, seeing no more proof for it in the case of the larger lakes than for the hundreds of tarns in perfect rock-basins common to all glacier-countries, present or past, and the connexion of which with diminished or vanished glaciers I proved originally in 'The Old Glaciers of North Wales.' In the Alps there is a gradation in size between the small mountain-tarns and the larger lakes.

3rd. None of them lie in lines of *gaping fracture*. If old fractures ran in the lines of the lakes or of other valleys, and gave a tendency to lines of drainage, they are nevertheless, in the deep-seated strata, exposed to us as close fractures now, and the valleys are valleys of erosion and true denudation.

4th. They are none of them in simple synclinal basins, formed by the mere disturbance of the strata after the close of the Miocene epoch: nor,

5th, Do they lie in hollows of common watery erosion; for running water and the still water of deep lakes can neither of them excavate profound basin-shaped hollows. So deeply did Playfair, the exponent of the Huttonian theory, feel this truth, that he was fain to liken the Lake of Geneva to the petty pools on the New Red Marl of Cheshire, and to suppose that the hollow of the lake had been formed by the dissolution and escape of salts contained in the strata below.

6th. But one other agency remains—that of ice, which, from the vast size of the glaciers, we are certain must have exercised a powerful erosive agency. It required a solid body, grinding steadily and powerfully in direct and heavy contact with and across the rocks, to scoop out deep hollows, the situations of which might either be determined by unequal hardness of the rocks, by extra weight of ice in special places, or by accidental circumstances, the clue to which is lost, from our inability perfectly to reconstruct the original forms of the glaciers.

7th. It thus follows that, valleys having existed giving a direction to the flow of the glaciers ere they protruded on the low country between the Alps and the Jura, these valleys and parts of the plain, by the weight and grinding power of ice in motion, were modified in form, part of that modification consisting in the excavation of the lake-basins under review.

In connexion with this point, it is worthy of remark that glaciers, many of them very large in the modern sense of the term, on the south side of the Vallais (excepting those of Mont Blanc), and the large glaciers on the south side of the Oberland, all drain into the Lake of Geneva; those on the north of the last-named snow-field, also large glaciers, are drained through the Lakes of Brienz and Thun. These, among the largest existing glaciers of the Alps, are only the shrunken tributaries of the greater glaciers that in old times filled and scooped out the basins of the lakes. The rest of the lakes, as already stated, are in equally close connexion with the old snow-drainage of glacier-regions on the grandest scale,—all of them, excepting those of Neuchâtel, Bienne, and Morat, lying in the direct course of glaciers filling valleys that extend right into the heart of the mountains.

8th. Most of the lakes are broad or deep according to the size of the glaciers that flowed through the valleys in which they lie, this general result being modified according to the nature of the rock and the form of the ground over which the glacier passed. Thus, the long and broad Lake of Geneva, scooped in the Miocene lowlands, is 984 feet deep, and over its area once spread the broad glacier of the Rhone. Its great breadth and its depth evince the size of the glacier that overflowed its hollow. The Lake of Constance, lying in the same strata, and equally large, is 935 feet deep, and was overspread by the equally magnificent glacier of the Upper Rhine. The Lakes of Maggiore and Como, deepest of all, lie in the narrow valleys of the harder Secondary rocks of the older Alps; and the bottom of the first is 1992 feet, and the latter 1043 feet, below the sea-level. Both of these lie within the bounds of that prodigious system of glaciers that descended from the east side of the Pennine Alps and the great ranges north and south of the Val Tellina, and shed their moraines in the plains of Piedmont and Lombardy. The depth of the lakes corresponds to the vast size and vertical pressure of the glaciers. The circumstance that these lakes are deeper than the level of the sea does not affect the question, for we know nothing about the absolute height of the land during the Glacial period.

The Lakes of Thun and Brienz form part of one great hollow, more than 2000 feet deep in its eastern part, or nearly 300 feet below the level of the sea. They lie in the course of the ancient glacier of the Aar, the top of which, as *roches moutonnées* and striations show, rose to the very crests of the mountains between Meyringen and the Grimsel.

The Lake of the Four Cantons is imperfectly estimated at only 884 feet in depth; but here we must also take into account the great height and steep inclines of the mountains at its sides. The Lake of Zug, 1311 feet deep, lies in the course of the same great glacier, the gathering-grounds of which were the slopes that bound the tributaries of the Upper Reuss and the immense amphitheatre of the Urseren Thal, bounded by the Kroutlet, the Sustenhorn, the Galenstock, the St. Gothard, and the southern flanks of the Scheerhorn.

The lesser depths (660 feet) of the Lake of Zurich were hollowed by the smaller but still large glacier that descended the valley of the Linth.

This completes the evidence.

Lakes of the Northern Hemisphere generally.—I shall now make a few remarks on the bearing of this subject on the glacial question generally.

It is remarkable that in Europe and North America, *going northward*, lakes become so exceedingly numerous, that I have been led to suppose the existence of some intimate connexion between their numbers and the northern latitudes in which they occur.

Let any one examine the map of North America, and he will find that, from the Atlantic coast to the St. Lawrence, through New Hampshire, Vermont, the north of the State of New York, Maine, Nova Scotia, New Brunswick, Gaspé, and Newfoundland, the whole continent is strewn with lakes. North of the St. Lawrence and the great lakes, as far as the Arctic Ocean, the same sprinkling of unnumbered lakes over the entire face of the country is even more remarkable; and it is a curious circumstance that a large part of this vast area is so low and undulating, that some of its lakes drain two ways—towards the North Sea and the Gulf of Mexico, or towards the North Sea and the North Atlantic. This vast country, about as far south as lat. 40°, shows, almost universally, marked signs of the strongest glacial action, in the *moutonnée* forms, polish, and constantly recurring striation of the rocks. I have only seen a few of the above-mentioned lakes south of Lake Ontario; but I have closely questioned that able observer, Dr. Hector, who has examined the country north and west of the great American lakes, and he informs me that, though unable to account for it, he was struck with the circumstance that so many (he thought he might say *all*) of the smaller lakes are in *rock-basins*. I connect this circumstance with the universal glaciation of the country, still evinced on the grandest possible scale by every sign of ancient ice. These signs, I now believe, are far too universal and unvarying in their general directions to have been produced merely by floating ice, though in part of the glacial history of the continent floating ice has undoubtedly left large traces. But the lake-basins could only, I believe, have been scooped out by true continental glacier-ice, like that of Greenland; for the lakes are universal in all the ice-worn region *.

On the eastern side of the Atlantic, Wales, Cumberland, many parts of Ireland, the North Highlands, and some of the Western Isles are also dotted with unnumbered lakes and tarns. All of these are well-glaciated countries, both high and low; and for Wales and many parts of Scotland, I can answer that by far the greater proportion of these lakes lie in rock-basins of truly glacial origin †.

* Since this memoir was written, I have conversed on the subject with Sir Wm. Logan, Director of the Geological Survey of Canada, who not only agrees in my views with respect to the origin of American lakes in general, but also believes that the great American lake-basins may have been scooped out by the same means. They are all true rock-basins, in areas occupied by comparatively soft rocks surrounded by harder strata. Given sufficient time, I see no difficulty in this view, to which I inclined while writing this paper, but refrained from stating it, considering that most readers would think it too strong, and thus that in general opinion I might damage the whole theory. Sir William says that the arrangement of the strata proves that the great lakes do not lie in areas of special subsidence.

† See 'The Old Glaciers of North Wales.' When I published my account of these glaciers, I was too timid to include the Lakes of Llanberis, Llyn Ogwen, Llyn Cwellyn, and some others of the larger lakes in this category. I now feel convinced that they are true rock-basins, and also that the shallower pools of Llyn Llegeirin, Llyn Felin-y-nant, and others in Anglesea had the same origin. The horizontal striations far up the side of Carnedd Dafydd, by Llyn Ogwen, were probably made by a glacier of immense thickness during the first great glacier-period, preceding the deposition of the stratified drift.

Loch Lomond and Loch Katrine, probably, like the greater lakes of Switzerland, are of the same kind, being merely large cases of glacier-erosion, though in the case of the former it may be that the alluvial deposits on the banks of the Leven prevent its being invaded by the tide. Its islands are mere *roches moutonnées* *.

In the lowlands of Scotland numerous examples of the same kind of rock-basins occur, some of them certain, others doubtful because of the surrounding drift, which indeed in some cases may be the sole cause of the retention of the water. Notable examples of both kinds occur in the lowlands of Fife and Kinross, and of true rock-basins in the Cleish and Ochil Hills, as for instance Loch Glow, Dow Loch, and the two Black Lochs, and more doubtfully Loch Lindores.

I have not yet had an opportunity of visiting the Scandinavian peninsula, which, geologists are aware, is, through all its length and breadth, one of the most wonderfully glaciated countries in the world. On the west, descending from the great chain, striated *roches moutonnées* plunge right under the deep fiords; and on the east, in Sweden, all between the mountains and the Baltic, round the Gulfs of Bothnia and Finland, and up to the North Sea, the whole country is covered with a prodigious number of lakes, just like North America, the Lewes, and the North Highlands of Scotland. The intense glaciation which all of these countries have undergone, their similarity, and what I believe to be the intimate connexion of such crowded lakes with the movement of ice, induce me to believe that in Sweden also a great number of the lake-hollows must be true rock-basins scooped out by the passage of glacier-ice into the Baltic area. Furthermore, as the glaciated sides and bottoms of the Norwegian fiords and of the saltwater lochs of Scotland seem to prove, each of these arms of the sea is merely the prolongation of a valley down which a glacier flowed, and was itself filled with a glacier; for the whole country was evidently, like the north of Greenland, moulded by ice. In parts of Scotland, some of these lochs being deeper in places than the neighbouring open sea, I incline to attribute this depth to the grinding power of the ice that of old flowed down the valleys, when possibly the land may have been higher than at present †. It may, however, only arise from unequal deposition of detritus. If the former view be admitted, raise the land so as to lay bare the surrounding ocean-bottom, and in some respects of levels and depth they become approximately the counterparts of the deeper narrow lakes of Switzerland and North Italy, glaciers bounded by mountains having flowed through both, and debouched upon the plains beyond.

The Glacial Theory.—Furthermore, considering the vast areas over which the phenomena described are common in North America and Europe, I believe that this theory of the origin of lake-rock-basins

* When the lake was low, I have seen in Loch Lomond ice-striated suraces of rock just above the water, the striations running in the direction of the length of the lake.

† But this is not essential, unless the lochs are so deep that the ice must have been floated up before reaching the deeper parts.

is an important point, in addition to previous knowledge, towards the solution of the glacial theory; for I do not see that these hollows can in any way be accounted for by the hypothesis that they were scooped by floating ice*. An iceberg that could float over the margin of a deep hollow would not touch the deeper recesses of the bottom. I am therefore constrained to return, at least in part, to the theory many years ago strongly advocated by Agassiz, that, in the period of extremest cold of the Glacial epoch, great part of North America, the north of the Continent of Europe, great part of Britain, Ireland, and the Western Isles†, were covered by sheets of true glacier-ice in motion, which moulded the whole surface of the country, and in favourable places scooped out depressions that subsequently became lakes.

This was effected by the great original glaciers (probably connected with the origin of the *unstratified* boulder-clay) referred to in my memoir on the glaciers of North Wales‡, but the magnitude of which I did not then sufficiently estimate. The cold, however, continued during the depression of North Wales and other districts beneath the sea, when they received the *stratified* erratic drift; and glaciers not only did not cease at this time of depression, but were again enlarged during the emergence of North Wales and other countries, so as to plough the drift out of many valleys. These enlarged glaciers, however, bore no comparison in size to the great original sheets of ice that converted the North of Europe and America into a country like North Greenland. The newer development of glaciers was strictly local. Amelioration of climate had already far advanced, and probably the gigantic glaciers of Old Switzerland were shrinking into the mountain-valleys.

Finally, if this be true, I find it difficult to believe that the change of climate that put an end to this could be brought about by mere changes of physical geography§. The change is too large and too universal, having extended alike over the lowlands of the Northern and the Southern Hemispheres. The shrunken or vanished ice of mountain-ranges is indeed equally characteristic of the Himalaya, the Lebanon, the Alps, the Scandinavian chain, the great chains of North and South America, and of other minor ranges and clusters of mountains like those of Britain and Ireland, the Black Forest, and the Vosges.

* I do not in any way wish to deny that much of the glaciation of the lower countries that came within the limits of the Drift was effected by floating ice on a large scale, which must have both polished and striated the rocks along which it ground. I have, with other authors, described this in various memoirs. But the two sets of phenomena are distinct.

† The Lewes is covered by small lakes.

‡ Quart. Journ. Geol. Soc. vol. xviii. p. 371.

§ It has been suggested to me by Dr. Sibson that the prodigious waste of the Alps by the gradual disintegration and diminution of the upper snow-fields, witnessed by the great moraines of North Italy and other phenomena, must have tended to lessen the glaciers. This is true, but, as he also believes, it is not of itself enough to account for the shrinking of the ice into the higher valleys where it is now alone found.

MARCH 19, 1862.

Elliot Square, Esq., Gresham House, London; Ernest Shelley, Esq., Avington House, Winchester; Edward Romilly, Esq., 14 Stratton Street, Piccadilly; The Right Hon. Edward Cardwell, Esq., M.P., 74 Eaton Square; George W. Stevenson, Esq., C.E., F.S.A., Halifax; George W. Hemans, Esq., C.E., 32 Leinster Gardens, Bayswater; and Harvey Buchanan Holl, M.D., Woodgate, Malvern, were elected Fellows.

The following communications were read:—

1. *On the* SANDSTONES *and their associated Deposits in the* VALE *of the* EDEN, *the* CUMBERLAND PLAIN, *and the* SOUTH-EAST *of* DUMFRIESSHIRE. By Professor R. HARKNESS, F.R.S.L. & E., F.G.S.

CONTENTS.

§ 1. THIS memoir refers to an area which commences a little south of Kirkby Stephen, in Westmoreland, and extends N.N.W. for 50 miles, reaching the lower portions of the valleys of the Esk and Annan in Dumfriesshire. In an east and west direction, this area varies greatly in breadth; but, measured from Castle Carrock on the east, to the sea at Allenby on the west, the extent is about 30 miles. It occupies the whole of the Cumberland plain, except a small portion of the parish of Aikton; and, in Westmoreland, it occurs on both sides of the Vale of the Eden. The district under consideration exceeds 800 square miles.

The strata which occur in this area consist of sandstones of two distinct positions and characters, separated from each other by a well-developed series of shaly beds, in some localities containing a considerable amount of gypsum; and calcareous layers are also sometimes found associated with the shaly deposits.

The arenaceous strata of Cumberland and Westmoreland have already attracted the attention of geologists. Those contiguous to the Penine chain are referred to by Dr. Buckland *. Those of the western side of the area have been alluded to by Prof. Sedgwick, and their boundaries in this portion of the north of England have been defined †.

These deposits, as they occur at Kirkby Stephen, have been noticed by Prof. Phillips ‡.

Mr. Binney has also described the nature and age of some of these

* Geol. Trans., 2nd Series, vol. iv. p. 105 *et seq.*
† Ibid. vol. iv. p. 383 *et seq.* ‡ Ibid. vol. iii. p. 9.

deposits in his memoir "On the Permian Beds of the North-west of England*."

In these several memoirs, detached localities are principally treated of. The object of this communication is not only to point out the several forms of rocks which occur in the area under consideration, but also to indicate the relative ages of the sandstones and the gypsiferous shales; and reference will also be made to the fossils which these latter afford.

§ 2. *Section near Kirkby Stephen.* (Fig. 1.)

Wharton Park, immediately south of Kirkby Stephen, is the most southerly limit of the rocks referred to. Here the beds seen in the Eden consist of a breccia composed of angular fragments of light-grey limestone, cemented together by a fine-grained dark-red sandstone.

Fig. 1.—*Section of Eden Valley, south of Kirkby Stephen, near Stenkrith Bridge.* Length 1½ mile.

5. Upper sandstone.
4. Upper breccia (60 feet).
3. Red clay (15 feet).
2. Lower breccia.
1. Carboniferous rocks.

This rock, locally termed "hard brockram," has a thickness in Wharton Park (from information received from a quarry-man) of 60 feet. Its aspect at Stenkrith Bridge, near this, has been described by Professors Sedgwick and Phillips, and also by Mr. Binney,—the latter pointing out the superposition of this "hard brockram" on an underlying mass of a softer nature, known as "rotten brockram," the latter resting on soft red sandstone.

The recent cuttings of the South Durham Railway, at the Kirkby Stephen Station, have exposed a section showing distinctly the relations of the two "brockrams." The foundations of the bridge here rest upon the "rotten brockram," dipping east at a low angle. Succeeding this is a series of red sandy clays, about 15 feet thick. Upon the sandy clays the "hard brockram" is seen extending to Stenkrith Bridge, and having a thickness of about 60 feet. These three deposits conform to each other; and a little below Stenkrith Mill, the "hard brockram" is overlain conformably by thin-bedded red sandstones.

* Memoirs of the Literary and Philosophical Society of Manchester, vols. xii and xiv.

At the old saw-mill at Kirkby Stephen the "hard brockrams" are also well seen, but they are much dwarfed in thickness, and show that they are rapidly thinning out. They repose on the sandy clays, which continue northward on the east side of the Eden, in the form of an escarpment; and at the Brewery, to the west, the "rotten brockram" again occurs.

Northward from this, no trace of the "hard brockram" (which is an extensively used and durable building-stone) is seen.

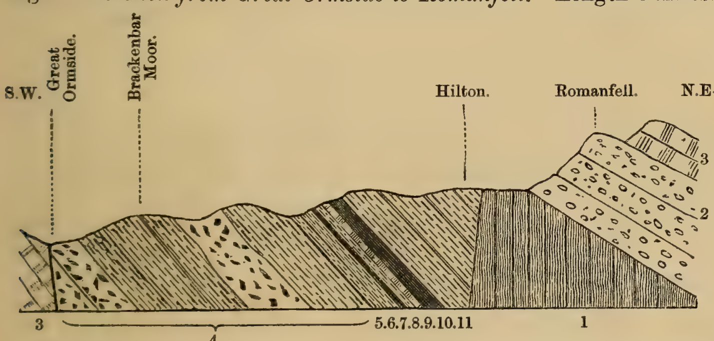
The lower or "rotten brockram" has a different mineral nature from the "hard brockram;" it consists of *yellow* limestone fragments, imbedded in a matrix of light-coloured sandstone; and it is more persistent in its occurrence. As it is seen in the Bela Water and the neighbourhood of Brough, it has been described by Mr. Binney, who has also pointed out the great abundance of soft sandstones which are associated with it.

Deposits of a like nature occupy the country north of Brough, the "rotten brockram" being seen west of Warcop; and to the east of this, under the western escarpments of Romanfell, the upper thin-bedded sandstones have been extensively worked.

§ 3. *Section from Great Ormside to Romanfell.* (Fig. 2.)

The section showing most satisfactorily the sequence of the sandstones and the accompanying strata in the north-west of England is one traversing the Vale of the Eden, from Great Ormside on the west to Romanfell on the east.

Fig. 2.—*Section from Great Ormside to Romanfell.* Length 5 miles.



11. Upper sandstones (700 feet).
10. Red clays (80 feet).
9. Limestone (7 feet).
8. Dark-coloured sandstone (6 feet).
7. Grey shale (3 feet).
6. Thin-bedded red sandstone (50 ft.).
5. Plant-beds (20 feet).

(5–11: Fossiliferous series.)

4. Lower sandstones (2000 ft.).
3. Carboniferous rocks.
2. Old Red conglomerate (500 feet).
1. Lower Silurian schists.

Professor Sedgwick notices the brockrams as they occur at Little Ormside, and at Burrels, a mile N.W. of Great Ormside *.

* Geol. Trans. 2nd Series, vol. iv. p. 386.

In Gill Beck, a small brook N.W. of Great Ormside, deposits appertaining to the Carboniferous rocks occur. Below these, in the brook, breccias are seen, succeeded by red sandstones, having an E.N.E. dip at 10°, inclining towards the Eden. East of this river, and west of the Appleby road, ridges of sand occur, as seen in the cutting of the Eden Valley Railway, resulting from soft decomposing sandstones. At Coupland Mill, immediately east of the high road, in the course of the stream, red false-bedded flaggy sandstones manifest themselves. These have a dip and nature similar to the flaggy beds which are wrought near Penrith. False bedding gives to these sandstones an apparent W.N.W. inclination, but the true dip is E.N.E. at a low angle.

East from Coupland Mill is an extensive moor, called Brackenbar, along the western and northern margin of which a stream, called Hilton Beck, flows. This stream exposes a beautiful section of the higher beds of the inferior sandstones and breccias. Above the false-bedded sandstones of Coupland Mill, a thick mass of soft deep-red-coloured sandy beds is seen. These are also greatly false-bedded, and have upon them strata of a harder nature, in which yellow breccias make their appearance in great profusion, conforming to the low E.N.E. dip of the sandstones.

These breccias occur under the same circumstances as those seen in the Bela Water; but they are rarely so thick as those of the latter, and the interstratified sandstones are usually less false-bedded. In their higher beds these sandstones become lighter in colour, and are conformably succeeded by some very interesting strata. These latter consist of cream-coloured, thin-bedded, arenaceous layers, with thin, grey, shaly strata; and a few thin beds of limestone, well marked by their distinct jointings; the limestone is of a brownish colour in its interior, but weathers yellow. The strata, although well seen in the brook-course, are better exposed on the face of a small cliff seen below the Appleby guide-post on the south side of the stream. These yellow, thin-bedded strata have a thickness of about 20 feet. They have a remarkable resemblance to the *marl-slate* of Midderidge, Durham, and *they afford fossils.*

The brook-course shows the following conformable succession above the yellow beds:—1st, very regular, thin-bedded, red sandstones, about 50 feet thick; 2nd, grey shale, imperfectly seen, having a thickness not exceeding 3 feet; 3rd, thin-bedded, soft, dark-red sandstones, 6 feet; 4th, a thin-bedded, compact, brownish-grey limestone, with drusy cavities filled with small crystals of calc-spar. The limestone becomes darker in colour, and semicrystalline in its upper layers; and papery bands of black shale separate the strata. This limestone, which afforded no trace of fossils, does not appear to exceed 7 feet in thickness.

A series of red clays overlies conformably the limestone. The thickness of this, which is *probably* 80 feet, cannot be exactly made out, as débris masks the junction of this clay with the upper sandstones. These latter, with associated clay-beds, form the bed of the brook to beyond the village of Hilton, and they also dip E.N.E. at 10°.

At the smelt-mill, above the village, the dip of the upper sandstones is reversed; but here they are contiguous to the great Penine fault. On the opposite or east side of the fault, Lower Silurian rocks are seen dipping N.N.W. at 50°; and on the west side of Romanfell these have upon them Old Red Sandstones, about 500 feet in thickness, dipping east, and passing regularly under the base of the Carboniferous series of Warcop Fell.

The section from Great Ormside to Romanfell affords means for ascertaining the thickness of the inferior sandstones and breccias. The dip of these averages 10° E.N.E.; and the distance from their western margin to the spot in Hilton Beck where the yellow series occurs is about two miles, measured across the dip. This would give a thickness of nearly 2000 feet to the inferior strata. The next series, including the yellow sandstones below and the clays above, with the intervening deposits, has a thickness of about 160 feet; and the upper sandstones are here about 700 feet in thickness.

§ 4. Reference has already been made to the occurrence of the breccias at Burrels. These are also seen on the east side of the Eden, immediately below Appleby; and at Bongate, an eastern extension of Appleby across the river, the false-bedded sandstones also occur. At Hungrigg, a mile E.N.E. from Appleby, the higher members of the breccia are seen, having here been extensively worked for their limestone fragments; and a short distance from this eastwards the clayey zone comes on.

No traces of the breccias occur north of Hungrigg; and with this thinning out of the coarse portion of the inferior series, we have a greater development of the sandstones proper.

To the north of Hungrigg no section can be obtained comparable to that across the Eden from Ormside to Romanfell, but many exposures of rock are seen which exhibit the sequence of the several strata.

At Long Marton, three miles north of Appleby, in the stream above the bridge, the inferior sandstone occurs, being the higher portion of the series. The clay-beds also were formerly wrought on the south side of the village, at Haa Plaister Scar, for the gypsum which they here afford; and the upper sandstones are seen in the streams between Dufton and Knock. At Stamphill, a mile N.W. of Long Marton, the red clays and gypsum were also formerly worked; and at Townhead, a quarter of a mile N.E. of Kirkby Thorpe, a good exposure of these now occurs, for here they are worked to a considerable extent. At this spot a mass of gypsum, called "Haa Plaister," about 9 feet thick, is seen resting on bluish clay, the gypsum itself being capped by about 7 yards of boulder-clay.

The level country W. and N.W. from this affords no sections until we reach Cliburn, where the false-bedded flaggy sandstone has been noticed by Prof. Sedgwick*. From Cliburn this extends northward; and, forming Whinfell, it here exhibits its normal false-bedded character well developed. East from Whinfell this sand-

* *Op. cit.* p. 386.

stone is seen at the bridge over the Eden, on the highway from Appleby to Penrith, to a slight extent. Near this is Crowdundle Beck, separating Cumberland from Westmoreland, in which we have a fine section of the argillaceous series. This extends from Acorn Bank to beyond Newbiggin, and is devoid of gypsum. It exhibits the same direction and angle of dip as at Hilton Beck, and is also succeeded by the upper sandstones, which are extensively worked at Crowdundle quarry. The same sandstone is also seen at Culgaith, and forms the escarpment known as Culgaith Peel; and immediately below it, on the opposite side of the Eden, the argillaceous series are well exhibited, forming Haa Plaister Scar, on the property of Winderwaith.

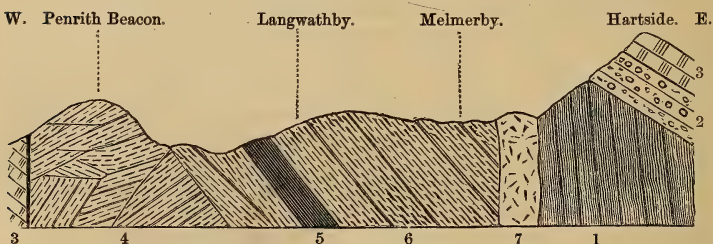
The section at Winderwaith is as follows:—The upper portion red clays, 12 feet thick, beneath which are greenish-grey clays with thin gypseous bands, 9 feet; red and grey clays and thin gypsum, 4 feet; a bed of fibrous gypsum, 2 inches,—the thickest seen, resting upon 6 inches of clay, passing downwards into an argillaceous sandstone.

Down the Eden on the east side, the argillaceous series forms a well-marked escarpment; and on the west side of the river the inferior sandstone is occasionally seen. The latter is, however, very well exhibited in the Eamont, a short distance above its junction with the Eden, for about a mile and a half. In this section the false bedding is so abundant that on account of it no idea could be arrived at concerning the arrangement of the inferior sandstones.

§ 5. *Section from the West of Penrith to Hartside.* (Fig. 3.)

West of Penrith, the junction between the Carboniferous rocks on the W. and the sandstone deposits on the E. is not apparent.

Fig. 3.—*Section from the West of Penrith to the Penine Chain.* Distance 10 miles.



7. Trap-rock.
6. Upper sandstones.
5. Red clay.
4. Lower sandstones (false-bedded, 5000 feet).
3. Carboniferous rocks.
2. Old Red conglomerate.
1. Silurian schists.

At Newton Raigny and Catterlen, a purple grit of the Carboniferous series has been noticed by Prof. Sedgwick*. This grit is seen in the

* *Op. cit. note*, p. 387.

Petterill, about half a mile below Newton; and there is reason for inferring that the red sandstone does not extend further than a mile west of Penrith. East of this place the sandstone is amply developed on Penrith Beacon Hill. Soft sandstones, nearly in the condition of sand, form the lowest beds here. Harder rocks succeed these, having a false-bedded and flaggy nature, the false bedding inclining westward, and the beds having sometimes a light colour.

The same rocks occur at Cowrigg quarry, about a mile and a half E. from Penrith. Soft beds again succeed these, as seen on crossing over the Beacon Hill; and at Snittersgill, a mile and a half below Langwathby Bridge, on the west side of the Eden, the higher beds of the inferior sandstones occur with a false-bedded W. dip. On the east side of the river the ridge of the argillaceous strata is seen striking N.N.W., the road from Langwathby to Hartside crossing this between the village and Whinskill Bridge, where the upper sandstones make their appearance with an E.N.E. dip at 10°. These continue to beyond Melmerby, and are well seen in the Rake Beck, three-quarters of a mile E. from this, where they come abruptly against a mass of trap occupying the line of the Penine fault. East of this, Lower Silurian rocks, overlain by Old Red Sandstones, passing upward to the Carboniferous series, occur. The rocks here have been alluded to by Dr. Buckland*.

The section from Penrith to Hartside, with the exception of the traps, has a great affinity to that from Great Ormside to Romanfell. In the former, however, there is a greater development of the inferior sandstones, and a total absence of the breccias, which are so abundant in the latter. The *flaggy strata* which occur between the soft sandstones are much more extensive in the former than in the latter, and equal the total thickness of the inferior sandstones as seen between Great Ormside and the plant-beds. Measured along the dip, which averages 10°, the lower sandstones of the Penrith section extend more than five miles; and from this it would appear that the total thickness of this portion of the rocks here would be nearly 5000 feet.

§ 6. North from the line of the last section, numerous exhibitions of rocks appertaining to all the three groups are seen. The lower sandstones form the ridges which occur on the east of the Lancaster and Carlisle Railway, and are extensively marked on Bowscar and at Brownrigg in Plumton, where, in a quarry affording flags remarkably like those of Corncockle and Dumfries, footprints similar to those of the Scotch localities have been found.

Impressions of the same nature have been also noticed by Mr. Binney and the author on the flaggy beds near Penrith, but these are not so distinct as the impressions at Brownrigg. On Lazonby Fell the same flaggy beds, with the false-bedded westerly dip, are also very abundantly wrought, and, affording very superior flags, these are often sent to great distances.

East from this range of hills we have also, in the Valley of the

* Geol. Trans. 2nd Series, vol. iv. p. 112.

Eden, the inferior sandstones. They occur at Forge Mill, immediately opposite to Lacy Caves, where they are intersected by a felstone dyke; at Scatterbeck, and in the brook near Lazonby village, they are also seen; they form Blaze Fell, and Great Barrock; and east from these we have them well exhibited in the Eden, immediately above Armathwaite Mill, where they are intersected by the trap-dyke which runs from the Carboniferous rocks at Renwick, in a N.W. direction to Petterill Crooks, near the Wreay Station on the Lancaster and Carlisle Railway. East from Armathwaite, the inferior sandstones are found at Napestone, and amongst these are hard coarse flags like those of Templand quarry near Corncockle.

Below Armathwaite Bridge the inferior sandstones are confined to the west side of the Eden. They are worked at Little Barrock quarry, near the Wreay Station; but here they have a yellow colour, and no flaggy beds.

Their most N.E. exposure is in the course of a small stream flowing into the Petterill, known as Howgill Beck, on the west side of the Carlisle road, near Carleton Hill. Only a small portion of the higher beds appear here, consisting of red sandstones dipping W., succeeded by nearly horizontal layers passing conformably under the marls and gypsums of the argillaceous series, which here dip N. at a low angle.

The western margin of the inferior sandstones also affords some sections. As occurring in Ive-gill, they have been described by Prof. Sedgwick*. Here the upper part of the stream is through these rocks, which dip N. at 20°.

Below these, purple Carboniferous grits are seen; and closely contiguous to these grits the red sandstones exhibit reversed dips, and also a thin bed of breccia composed of fragments of the Carboniferous grits. The Carboniferous rocks extend down the stream to near High-head Castle, where the inferior red sandstones are again seen, and where their occurrence is mentioned by Prof. Sedgwick. Well-marked northern inclinations obtain here, and continue to near the junction of Raw Beck, below which the sandstones again appear, and continue with the same inclination to Stockdalewath, where, for a short distance, Carboniferous rocks again occur.

The inferior sandstone, however, soon again makes its appearance, forming the brook-course to below the bridge at Througholme, where it passes conformably under the argillaceous series, which occurs about 200 yards below Througholme Bridge, dipping N. at 10°, and is about 100 feet in thickness.

Below the argillaceous series, on the east side of the stream, Carboniferous rocks again appear, and extend south-eastward to Broadfield, where they were formerly worked for lime, as referred to by Prof. Sedgwick†. From Broadfield they extend still further in the same direction to Roughten Gill, a mile north of Southwaith Station, where they are wrought for the ironstone-nodules which they contain.

* Geol. Trans. 2nd Series, vol. iv. p. 406. † *Op. cit.* p. 391.

The rocks seen in Ive-gill have the same general arrangement as that which obtains in the Valley of the Eden, the only difference being in the *direction* of the dip. This change from E.N.E. to N. is a gradual one, as is well shown in the strike and dip of the argillaceous series.

Following the argillaceous series along its strike from Haa Plaister Scar, on the Eden, we find it exhibiting the following modifications:—

At Langwathby it seems to consist solely of red clays. At the farm of Lang Meg and her Daughters, near Lacy Caves, it consists of gypsum and clays, the former having been wrought here. About a mile and a half northwards, at Glassonby Beck, red clays alone occur; and at Ravens Beck, east of Kirk Oswald, where a good section is seen, the same features are manifested. In the river Croglin, between Dale and the Nunnery, argillaceous beds are the sole constituents of this series. Here, below the argillaceous strata, a fine section of the inferior sandstones is seen in the course of the Croglin, and, above these, the upper sandstones are worked at Sevie quarry.

North of the Croglin, on the Armathwaite road, at Cross House, there are remains of a quarry in the argillaceous series, from whence gypsum was formerly obtained; but here the beds are thin, and not profitable, being irregular in their occurrence. The next locality which affords an exposure of the argillaceous series is the Haa Beck, at Ainstable. The strata here are only partially seen, but they seem exclusively clay-beds. On the west side of the Eden, at High Stand, gypsum is now extensively worked, the section of the quarry affording the following beds:—The lowest (passed through in sinking a well below the floor of the quarry) consist of 8 feet of fine-grained purple sandstone, with thin layers of fibrous gypsum. Above these are three beds of gypsum, with a total thickness of 20 feet, the whole dipping N.E. at an angle of 5°. Similar gypseous strata are wrought at Carleton Hill, three miles N.W. from High Stand, near the Carlisle high-road. Here the gypsum is about 18 feet thick, irregular in its upper surface, and succeeded by indurated clay 3 feet in thickness, upon which rests a shaly sandstone 15 feet in depth. Here the strata have a low N. dip.

On the east side of the argillaceous series, near High Stand, on the banks of the Eden, the upper sandstone is seen dipping N. at 20°. At Wetheral Pastures we have also this sandstone dipping in the same direction at an angle of 10°. At Corby the dip of this sandstone is N.N.W.; and from thence it extends eastward to beyond Castle Carrock, where, in the Gelt, it is seen in close proximity to the Penine fault.

From this the fault runs N. to Lanercost, occurring immediately below the bridge. From Lanercost its course is N.N.W.; and it is again seen at Penton Linns, on the Liddel, as described by Professor Sedgwick *.

§ 7. In the neighbourhood of Carlisle we see the upper sandstones in

* *Op. cit. note*, p. 385.

the course of the Caldew, both below and above Dalston, the dip here being N.N.W. at 10°. No trace of the argillaceous series is seen in this river; and the only evidence it affords of the inferior sandstones is at the bridge near Rose Castle, above which light-coloured rocks of Carboniferous age occur.

West from the Caldew, in Chalk Beck, a good exposure of the upper sandstones and the argillaceous beds appears. The former, which dip N.W., have afforded the Romans materials for the construction of the western portion of Hadrian's Wall; and the latter seem to repose upon a breccia, to the south of which occurs the fault separating the red sandstones from the Carboniferous rocks. The strata here, and also those which occur near this at Westward, have been described by Mr. Binney in the memoir before alluded to.

West of these localities the *upper sandstones* strike W.S.W., abutting directly against the Coal-measures of West Cumberland. At Maryport these upper sandstones are seen in near proximity to the Coal-measures. They are also well developed in the cliffs north of this place, where they exhibit the N.W. dip they usually assume in the west part of the Cumberland plain.

On the English shore of the Solway these upper sandstones are not well seen; there is, however, every reason to infer that they occupy the whole of the flat area of N. Cumberland, except the portion covered by Lias referred to by Mr. Binney * (see fig. 4).

The Scotch shore of the Solway, especially E. of Annan, affords these upper sandstones. They also, in Scotland, occupy the southern halves of the parishes of Canobie, Half Morton, and Kirkpatrick Fleming, the greater portion of the parish of Annan, the southern part of Cummertrees, and also the whole of Dornock and Graitney.

The Scotch area of upper sandstone has for its northern boundary the same fault which in Cumberland separates it from the Carboniferous formation; but in Dumfriesshire this fault has a direction nearly E.N.E. and W.S.W.

§ 8. In Dumfriesshire, besides the fine section in the Esk, S. of Knotty Holm, the upper sandstones are seen in Half Morton, and at Cove, in Kirkpatrick, on the west side of the Caledonian Railway. They are also very extensively worked in the neighbourhood of Annan. Their general dip shows that they trough under the Solway, and become united with their equivalents on the south side of the Firth: see the section from Kirkpatrick to the Chalk Beck limestones showing their arrangement (fig. 4).

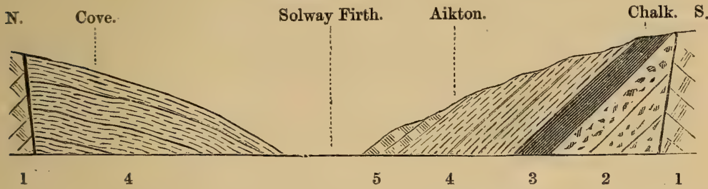
Little has been said concerning the lithology of the inferior and the upper sandstones.

There is a well-marked difference in this respect between them. In the former the particles are more angular, often exhibiting shining facets; the colour is also brighter than that of the upper sandstones, and there is an absence of the interstratifying clay-beds which usually accompany the latter. These latter are more compact

* Quart. Journ. Geol. Soc. vol. xv. p. 549.

in their composition, and the faces of the strata exhibit features which are not seen on the lower series, consisting of beautiful ripplings, desiccation-cracks, rain-pittings, and pseudomorphs of salt—features accompanying the upper sandstones throughout the area where they present themselves.

Fig. 4.—*Section across the Cumberland Plain to Dumfriesshire.* Distance 15 miles.



5. Lias.
4. Upper sandstone.
3. Red clay.
2. Breccia.
1. Carboniferous rocks.

§ 9. *Organic Remains.*

Reference has been made to the occurrence of fossils in the yellow beds at Hilton Beck. The strata affording these form the lowest portion of the argillaceous series, and have, as before stated, a great affinity to the marl-slates of Midderidge. The remains consist principally of Plants, specimens of which were, through the kindness of Sir Charles Lyell, submitted to Professor Heer, who determined their general Coniferous character. The remains consist usually of leaves and wood, and in one instance of a *cone*. This, Sir Charles Lyell suggests, is of some importance, especially if the strata be Palæozoic, since the absence of *cones* in Coal-strata induces botanists to regard the *Coniferæ* of the Carboniferous epoch as having a *taxoid* character, "and, like a great majority of the *Coniferæ* of the southern hemisphere, as berry-bearing, and not cone-bearing."

Through the kindness of Mr. Wood of Richmond, I had an opportunity of examining the marl-slate of Midderidge, and was furnished by him with fossil plants from this locality, which are remarkably like the fossils from the Hilton beds. Besides the remains of coniferous leaves, this locality affords ferns referable to *Neuropteris* and *Sphenopteris*. Of the latter, one form seems nearly akin to *S. erosa* (Morris), a species from the Russian Permians *. Remains are found which appear allied to *Weissites* (Göppert), resembling that figured by Geinitz ('Die Versteinerungen des Zechsteingebirge und Rothliegenden oder des permischen Systemes in Sachsen,' tab. viii. fig. 8). A form having the aspect of *Caulerpites selaginoides* (Sternb.) occurs here; and, with this, leaves identical with those of the Saxon Zechstein, as figured by Geinitz (tab. viii. figs. 11, 12, 13), are found. Detached leaves, resembling *Cupressites Ullmanni*, Brongn.,

* See 'Russia and the Ural Mountains,' plate C. fig. 3.

and others attached to stems akin to *Voltzia Phillipsii* (Lindley and Hutton), are also seen.

These plant-remains are usually in the state of carbonaceous markings; sometimes, however, they occur not *imbedded*, but *enclosed* between the laminæ; and when in this condition, their preservation is very imperfect.

A few traces of animals have also been found here, but, as yet, these have been seen only in the condition of casts. Crinoid stems, of small size, which seem identical with the casts of *Cyathocrinus ramosus*, are among them. Brachiopodous shells, which in size and general aspect resemble *Terebratula elongata*, Schloth., present themselves, and also other bivalves which are too imperfect to allow of their relations being determined.

Although the fossils obtained at Hilton are as yet comparatively few, they conduce to the conclusion that the strata which afford them are at the base of the Zechstein portion of the Permians, and that the overlying beds, including the red clays, must be regarded as the representatives in the N.W. of England of the higher members of this formation; while the thick mass of underlying sandstones and breccias is the equivalent of the Rothliegende, which attains its greatest development in this part of England.

§ 10. *St. Bees.*—Reference to strata which are seen on the north-east side of St. Bees Head, Whitehaven, and which have been long regarded as Permian, still further corroborates this conclusion.

Here, at Barrow Mouth, reposing on purple sandstones of the Carboniferous age, is a deposit of breccia only 3 feet in thickness, representing the higher members of the inferior sandstone.

Magnesian limestone, which is worked on the side of the hill, occurs above the breccia. This limestone, the base of which is not here seen, contains Permian *Lamellibranchiata*. On the shore it reposes on the breccia, and its thickness at this spot is about 11 feet, being much thinner than on the hill, and indicating a rapid thinning out.

Red marls, with interstratified gypsum, about 30 feet in thickness, succeed the limestone, upon which the fine-grained red sandstones with interbedded clays of St. Bees Head occur,—these latter being *in every respect* identical with the upper sandstones of Eastern and Northern Cumberland.

The absence of the magnesian limestone, which we have seen is thinning out, would give us here the most common mode of occurrence in this county of the argillaceous series and the upper sandstones. These Permians of St. Bees have been described by Prof. Sedgwick*, and also by Mr. Binney in the memoir so frequently referred to.

§ 11. The Permians of Cumberland, especially their lower members, have an interesting bearing on the isolated Permian patches scattered over portions of the South of Scotland, and which, in Dumfriesshire, afford footprints.

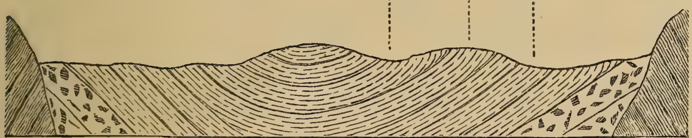
* Geol. Trans. 2nd Series, vol. iv. p. 395.

In their mineral nature these Scottish Permians have a great affinity to the Rothliegende of the N.W. of England, and especially that portion which is seen in the Ormside and Hilton section.

The Corncockle area exhibits the lowest beds of the Scotch equivalents at several spots where these abut against the Lower Silurians. These lowest beds are breccias made up of fragments of the surrounding Lower Silurians. One locality in this area, Dalton Hook, shows the inferior sandstones in proximity to the Carboniferous rocks. Here the breccias abound in limestone-fragments, have the aspect of the lower breccias of Burrels, and, like these latter, were formerly wrought for the limestone which they contain.

Above the lower breccias the sandstones, with impressions as seen at Corncockle, occur; and any section taken across this part of Annandale would exhibit the arrangement seen in fig. 5, which is an extension of that given by Sir Wm. Jardine *.

Fig. 5.—*Section across the Permian Strata of Annandale.*
Distance 8 miles.



3. Sandstone, with Fossil Footprints at Corncockle Muir.
2. Permian breccia. 1. Silurian rocks.

The Annandale Permians do not show a full series of the Rothliegende: in order to see the other members, it is necessary to have recourse to the Nithsdale areas. The one which best exhibits this is seen in the district around Dumfries (fig. 6), extending from a

Fig. 6.—*Section of the Permian Strata of the southern part of the Valley of the Nith.*

4. Peat. 3. Permian breccia. 2. Sandstone with Footprints.
1. Lower Silurian rocks.

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* Ichnology of Annandale, p. 16.

mile E. of the Nith to about two miles W. thereof. In this section the lowest strata, well seen at Craig's Quarry, are red sandstones with the same footprints as those of Corncockle, upon which, after passing through false-bedded sandstone, the thick mass of breccia forming a trough through which the Nith flows, and which extends to the Silurian hill W. of Dumfries, is seen.

The sections of Annandale and Nithsdale collectively furnish the following groups which compose the Permians of this part of Scotland:—first and lowest, breccias; second, a thick series of sandstones, some of the strata of which are somewhat incoherent, and some flaggy, with footprints; and third and highest, a thick mass of breccias. This sequence shows such an analogy to the inferior sandstones of Westmoreland as to justify the conclusion that in Scotland, so far as is yet known, the Rothliegende portion only of the Permians is exhibited.

Another important circumstance connected with the Scottish Permians is the position of the footprints. Like those occurring in the neighbourhood of Penrith, which consist of *Chelichnus Duncani*, these impressions appear to mark the *middle* portion of the Rothliegende—a position probably below that portion of the inferior sandstone represented in the East of England, but which has very likely its equivalent in the well-developed Rothliegende of Saxony.

No allusion has been made to the geological age of the upper sandstones of the N.W. of England and the S.E. of Dumfriesshire. Like similar strata in the S.E. of Durham, they succeed the Zechstein representatives of the Eden valley, and might therefore be regarded as Triassic.

As Mr. Binney has noticed the occurrence of Liassic strata in North Cumberland, near the margins of the Solway Firth, which exhibit themselves in such a position as to lead to the conclusion that they repose in the trough formed by the upper sandstones, the Triassic age of these arenaceous deposits, with clay-beds, becomes highly probable *.

Note.—In a memoir published in the 6th vol. of the Quart. Journ. of the Geol. Soc., having reference to the sandstones of the Vale of the Nith, I allude to them as appertaining to the same age as those of the Cumberland area, referring the whole to the Trias. This opinion I adopted in consequence of its being then a generally received one among geologists. Subsequently, in another memoir (vol. xii. p. 266), I stated the reasons which induced me to alter this opinion, and to regard these deposits as belonging, for the most part, to the Permian age.

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2. *On the* Date *of the* Last Elevation *of* Central Scotland. By Archibald Geikie, Esq., F.R.S.E., F.G.S., of the Geological Survey of Great Britain.

That the central districts of Scotland, together with the greater part of the British Islands, have undergone a movement of upheaval within

* Quart. Journ. Geol. Soc. vol. xv. p. 549.

a comparatively recent geological period is a fact which has long been familiar to the geologist. A line of raised beach, with shells of living species still in a perfect state of preservation, fringes many parts of the coast, at a height of from 15 or 20 to upwards of 40 feet above the present sea-level. This difference of elevation may point either to different periods of upheaval or to one great upward movement which varied in intensity in different parts of the island. For facts so well known it is only necessary to refer here to the papers of Mr. Smith of Jordan Hill, Mr. Maclaren, Mr. Chambers, and others who have described the evidence which different parts of the Scottish coast-line furnish as to a recent rise. The object of the present communication is to inquire how far we have data for ascertaining the time at which at least the later stages of this rise took place.

Ever since the publication, in 1838, of Mr. Smith's great paper on the last changes of level in the British Islands*, the belief has been universal that no alteration of the relative position of sea and land has taken place within the last two thousand years, the coast-line being the same now as it was at the time of the Roman invasion. I shall have occasion, in a subsequent part of this paper, to examine the evidence on which such a belief is founded. With regard to the centuries prior to the Christian era, Mr. Smith remarks that probably no change of level has taken place within the human period†. For this statement, however, he adduces no other foundation than that mounds known as British tumuli, along with vitrified forts, exist close to the margin of the present high-water mark. The discovery of canoes in an elevated part of the old alluvium of the Clyde, and of other antiquities in that of the Forth, tended to throw some doubt on Mr. Smith's assertion. Mr. Chambers, in his volume on 'Ancient Sea Margins' (pp. 18–22), published in 1848, refers with hesitation to the possibility of these canoes having been in use prior to the last shift of the land, and the same view was entertained by other geologists; but in October 1850 he published an account of some antiquities found in the Carse of Gowrie which he conceived to have been brought by an abnormal inundation within the historical period, and he then acknowledged his belief that those of Glasgow had been similarly imbedded, and that consequently they afforded no evidence in favour of a change of level since Scotland had been tenanted by man‡.

Such was the state of the question when, in the spring of last year (1861), I obtained evidence which seemed to show that a portion of the coast of the Firth of Forth had been elevated not only within the human period, but even since the first years of the Roman occupation§. This observation involved so wide a departure from

* Edin. New Phil. Journ. xxv. p. 385; and Mem. Wern. Soc. vol. viii. part i.

† Mem. Wern. Soc. vol. viii. p. 58.

‡ See Edin. New Phil. Journ. vol. xlix. p. 233.

§ Edin. New Phil. Journ., new series, vol. xiv. p. 107. Since this paper was written, more recent excavations have shown the existence of mediæval preconceived opinions, and bore so closely on questions of the deepest moment regarding the antiquity of man, that I felt the necessity of examining other parts of the coast with the view of ascertaining how far the movement may have been general over the central districts of Scotland. It seemed to me advisable also to make a search through such archæological volumes as treat of our maritime antiquities, in order to see whether any antiquary had detected proofs of physical changes. The results of these inquiries are now communicated to the Society.

The Firths of Clyde, Forth, and Tay are each bordered with a strip of flat land, varying in breadth from a few yards to several miles, and having a pretty uniform height of 20 or 25 feet above high-water-mark. This level terrace is the latest* and on the whole the most marked of the raised beaches. It must have been formed when the land was from 20 to 30 feet lower than at present, and evinces an upheaval which was nearly uniform over the whole of the central valley of Scotland. What, then, was the date of this upheaval?

The discovery of human remains in the sands and clays of the raised beach affords the only ground for an answer to this question. From these strata canoes, stone hatchets, boat-hooks, anchors, pottery, and other works of art have been from time to time exhumed on both sides of the island. These remains are usually claimed by the antiquary. He arranges them in his museum according as they belong to the Age of Stone, of Bronze, or of Iron. He speculates from them as to the character of the early races, and from the indications which they may afford he compiles his prehistoric annals. But the geologist, too, has an interest in them. To him they are true fossils, as much as the footprint of a Reptile, the track of a Crustacean, or the tube of an Annelide. He deals with them as he deals with other evidence of the former presence of animal life. The circumstance of their occurrence, the nature of the material in which they lie imbedded, the indications which they may afford of former diversities of surface, whether of lake or river, land or sea, their association with the bones of animals now rare or extinct, and then

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pottery in the sands and silt of the section described by me as occurring at Leith. Attempts have been made to show that the deposit in which these fragments occur is merely artificial ground. Since this idea was suggested I have several times visited the sand-pit, both alone and in company with observers of greater experience than myself, and have been unable to alter the opinion I originally formed as to the true aqueous origin of the upper silt and sand. A hasty inspection might lead one to confound these beds with an unconformable artificial earth which overlaps them, and to class together the contents of two very different formations. The occurrence, however, of pottery, to which Mr. Franks of the British Museum can hardly assign a higher antiquity than 700 years, seems to show that the upper parts of this series of strata have been re-assorted in more recent times than I had supposed. But the subject requires further investigation, and until this is given, I am unwilling to depart from my original conclusion.—July 18, 1862.

* There are occasional traces of a later terrace, as along the Clyde at Glasgow, but these may for the present be disregarded.

their intrinsic character as illustrations of various stages in the onward march of human progress,—all these are points of view from which the geologist claims to study such remains. The antiquities of man have thus a geological as well as an archæological interest. The day, indeed, is perhaps not far distant when archæology will form well-nigh as integral a part of geological science as palæontology does now. This conviction must, at least, be my apology for bringing before you some parts of a subject which is not usually held to come within the scope of the Geological Society.

Along the margin of the Clyde at Glasgow, the raised beach extends as a level terrace of varying width, its surface lying about 26 feet above high-water-mark. This plain, when sections are cut through it, is found to consist of alluvial clay, silt, and sand, with layers of shells—the deposits of an ancient estuary. Its presence so high above the limits of even the extremest spring-tides or the highest recorded river-floods can only be accounted for by an actual upheaval of the land. No transient flood, of what magnitude soever, could deposit well-stratified laminæ of fine silt and mud in regular succession to a height of 26 feet above the ordinary level of the estuary. The bed of the river, along with the surrounding country, must therefore have been raised; and hence any remains which may occur contemporaneously imbedded in these alluvial deposits must have been involved in the same upheaval. If it can be shown that human works of art lie beneath some of the undisturbed silt-beds, it will follow that the elevation has been witnessed by man.

Human remains have been especially abundant in the alluvium of the Clyde. There is comparatively little variety, however, in their character, inasmuch as they have been almost entirely connected with the primitive navigation of the river. Within the last 80 or 90 years the hulls of no fewer than eighteen canoes have been exhumed, some of them even from under the very streets of the city*. The most important discoveries took place during the progress of those great excavations by which the harbour of Glasgow was widened and deepened. Twelve canoes were then obtained, the whole of which came under the notice of the antiquary, who in 1856, under the signature of J. B., communicated an account of them in the third volume of the work entitled ‘Glasgow, Past and Present.’ With only one exception, they were all formed of single oak-trees. Two had evidently been scooped out by the action of fire; others had been hollowed with a rough implement, such as a stone axe; while several were cut beautifully smooth, evidently with metal tools. Hence a gradation could be traced, from a pattern of extreme rudeness to one showing considerable mechanical ingenuity. The average depth beneath the surface of the ground at which the whole were found was about 19 feet, or about 7 feet above the level of high water†. They all lay

* For the details of the Glasgow canoes I am indebted to an interesting paper in ‘Glasgow, Past and Present,’ vol. ii., written, I believe, by that zealous antiquary, Mr. Buchanan.

† The canoe found at an earlier date, on the site of the Tontine Hotel, lay about 21 or 22 feet above high-water-mark in the river.

at a distance of more than 100 yards back from the margin of the Clyde as it existed before the alterations began, and were chiefly imbedded in a thick bed of finely laminated sand.

Most of the Clyde canoes were formed out of single oak-stems; but two of them were built of planks. Of these the more elaborately constructed was discovered on the property of Bankton, in 1853. A large oak had been cut longitudinally into a mere strip, as the back-bone of the boat, from which a long keel was formed underneath by being simply *left standing out*, while the back-bone was pared away, so that the keel appeared a mere longitudinal projection from the lower plane of the same strip. Strong transverse ribs were inserted for the skeleton of the back. These were clothed outside with deals about 8 inches broad, and they overlapped each other precisely as in modern clinker-work. The stern was formed of a thick triangular-shaped piece of oak, fitted-in exactly like those of our day. Again, the prow had a neat cutwater, rising about a foot above the gunwale, and giving it rather an imposing effect, not unlike, on a very small scale, the beak of an antique galley. The length of this curious vessel was 18 feet; width at the waist 5 feet, and at the stem $3\frac{1}{2}$ feet. When discovered, it was lying *keel uppermost*, with the prow pointing straight up the river. It had probably been capsized in a storm. The planks were fastened to the ribs, partly by singularly shaped oaken pins, and partly by what must have been nails of some kind of metal. The perforations where nails had been were uniformly square, and the marks of their broad heads driven home by smart blows deeply into the wood were very perceptible. None of the nails themselves were, however, to be seen; but several of the oaken pins were left. They were round, thicker than a man's thumb, and ingeniously formed. The pin, after being rounded, had been sliced in two, and a triangular-shaped tongue inserted; so that, when driven into the deal, the pin would firmly hold its place*.

In addition to these canoes, a polished celt of greenstone, a thin piece of lead perforated with nail-holes, and a plug of cork in the bottom of one of the vessels have also been discovered. Such are the remains of human workmanship which have been found in the elevated silt-beds of the Clyde. Do they of themselves afford any indication of the probable period during which this elevation was effected?

At the outset it must be borne in mind, that the occurrence of these canoes in the same upraised silt by no means proves them to be synchronous, nor even to have belonged to the same archæological period. The relative position in the silt from which they were exhumed could help us little in any attempt to ascertain their relative ages, unless they had been found vertically above each other. The varying depths of an estuary, its banks of silt and sand, the set of its currents and the influence of its tides in scouring out alluvium from some parts of its bottom and redepositing it in others are circumstances which require to be taken into account in all calculations as to the relative position of different parts of the bed of the stream in any

* Glasgow, Past and Present, pp. 565–6.

former period. Hence mere coincidence of depth from the present surface of the ground, which is tolerably uniform in level, by no means necessarily proves contemporaneous deposition. Nor would such an inference follow even from the occurrence of the remains in distant parts of the very same stratum. A canoe might be capsized and sent to the bottom just beneath low-water-mark; another might experience a similar fate on the following day, but in the middle of the channel. Both would become silted up on the floor of the estuary; but as that floor would be perhaps 20 feet deeper in the centre than towards the margin of the river, the one canoe might actually be 20 feet deeper in the alluvium than the other; and on the upheaval of the alluvial deposits, if we were to argue merely from the depth at which the remains were imbedded, we should pronounce the canoe found at the one locality to be immensely older than the other, seeing that the fine mud of the estuary is deposited very slowly, and that it must therefore have taken a long period to form so great a thickness as 20 feet. Again, the tides and currents of the estuary, by changing their direction, might sweep away a considerable mass of alluvium from the bottom, laying bare a canoe that may have foundered many centuries before. After the lapse of so long an interval, another vessel might go to the bottom in the same locality, and be there covered up with the older one, on the same general plane. These two vessels, found in such a position, would naturally be classed together as of the same age, and yet it is demonstrable that a very long period may have elapsed between the date of the one and that of the other. Such an association of these canoes, therefore, cannot be regarded as proving synchronous deposition; nor, on the other hand, can we affirm any difference of age from mere relative position, unless we see one canoe actually buried beneath another.

Hence the only evidence that remains is that which may be afforded by the character of the antiquities. It is usual to speak of the canoes which have been from time to time exhumed in Scotland as of an extremely rude construction, and as the relics of a very barbarous people. They are described along with the stone implements of the Stone Period, standing thus as far back in the past as the antiquary can place them *. But it is manifest that most of the Glasgow canoes cannot be spoken of as works of extreme rudeness. One or two of them, indeed, were certainly primitive enough in their construction; but the Bankton boat could not have been built by a race of savages. It is, indeed, impossible to avoid the conviction that the rough-hewn, fire-burnt oak-trunks must have belonged to an earlier time than that of the smoothly cut canoes, and that these again date further back than the regularly built boat of Bankton. The first class may be a relic of the Stone, the two latter of the Bronze Period, if, indeed, the boat came not within the Period of Iron. We seem to see, in the various stages of mechanical skill shown in these primitive vessels, a record of the gradual progress of

* See Dr. Wilson's 'Prehistoric Annals of Scotland,' chap. ii.

advancement from a state of comparative barbarism to a kind of semi-civilization.

It is plain that the islanders who built this primitive fleet were not only acquainted with the use of metal, but that before they could have cut out the more highly finished canoes they must have been long familiar with its use. They must have had serviceable metal tools wherewith they could saw an oak through cleanly and sharply at its thickest part, make thin oaken boards and planks, and plane down a large tree into a smoothly cut and polished canoe. They had advanced, too, to a high degree of mechanical ingenuity. We are told, for instance, by the antiquary whose account of the discovery of these canoes has been cited, that one of them had its open stern so broad that the builder seems to have been unable to procure a board large enough to fill it. In this dilemma he took two boards, fitted them into the usual grooves, and inserted between them, along their vertical line of junction, a thin lath of oak, which dovetailed them together and made them water-tight.

What may have been the nature of the metal out of which these aboriginal tools were fashioned has not yet been ascertained. The square metal nails too, although the marks of their heads were still visible, had themselves wholly disappeared. If they were made of bronze, we cannot assign to the canoes in which they were used a date older than some part, it may have been a very late part, of the Bronze Period. If it can be shown that the metal employed was iron, the age of the antiquities must, in accordance with the received archæological chronology, be brought still further down towards the present time.

Two of the canoes were built, not out of a single oak-stem, but of planks. That of Bankton, already described, had its deals fastened to strong ribs, like a modern boat; its prow was turned up "like the beak of an antique galley," and its whole build suggests that the islander who constructed it may have taken his model, not from the vessels of his countrymen, but from some real galley that had come from a foreign country to his secluded shores. Nor is this the sole ground for inferring that, at least at the time indicated by some of these canoes, the natives of the west of Scotland had some communication with a more southern and civilized race. How otherwise are we to account for the plug of cork? It could only have come from the latitudes of Spain, Southern France, or Italy. By whom, then, was it brought? Shall I venture to suggest that the old Briton who used it was not so ignorant of Roman customs as antiquaries have represented him, and that the prototype of the galley-like war-boat may have come from the Tiber to the Clyde?

But whether such a suggestion be accepted or not, it is abundantly evident that the elevation of the bed of the estuary, by which the canoes have attained an altitude of sometimes 22 feet above high-water-mark, cannot be assigned to the rude ages of the Stone Period, but must have taken place long after the islanders had become expert in the use of metal tools *.

* To the conclusion stated in the text, the only objection with which I am

If now we cross the island to its eastern coast, we shall find the shores of the Firth of Forth bordered with a belt of upraised alluvial deposits similar to those of the estuary of the Clyde. This belt reaches its greatest extent on the south side of the Firth, where it expands into a broad plain, known as the Carse of Falkirk, the surface of which appears almost a dead flat, with a general height of about 20 or 25 feet above high-water-mark. From Stirling the same plain extends westward along both sides of the sinuous river for a distance of 16 or 18 miles. This upper part is called the Carse of Stirling. When these carse-lands are cut through by drains, they are found to consist of fine dark silt, with layers of sand, and of shells belonging to species that still live in the adjoining estuary. Layers of peat, with great numbers of oak-stems, occur in the silt; and many parts of the plain, especially above Stirling, are at this moment covered with a thick stratum of peat-moss. The occurrence of finely laminated silt, and layers of marine shells, at a height of 20 or 25 feet above the present high-water, and over many square miles of ground, implies a rise of the land to about the same extent as that indicated by the silt-beds of the Clyde *.

That this elevation has taken place within the Human period is proved by the existence of human remains at various localities, imbedded in the upraised alluvium. In the year 1819, on the carse-land of Airthrey, near Stirling, the skeleton of a whale was found imbedded in the silt fully a mile back from the river-bank, and at a height of nearly 25 feet above the high-water-mark of spring-tides. At Dunmore, on the south bank of the estuary, a few years later, a second whale was disinterred from a stiff clay at a height of 23 or 24 feet above high-water-level. Again, in 1824, a third whale-skeleton was exhumed from under a covering of peat-moss and clay at Blair-Drummond, which lies seven miles higher up the valley than Airthrey. Beside the bones, both at Blair-Drummond and at Airthrey, lay a piece of perforated deer's horn, unmistakeably a work of human fashioning †. They were, in short, two harpoons, one of them having still partially attached to it the fragments of the wooden handle by which it had been wielded. The circumstances under

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acquainted is a casual remark by Mr. Smith, of Jordan-hill, in his paper on the "Last Changes of Level in the British Islands," Mem. Wern. Soc. vol. viii. p. 58, to the effect that some British tumuli and vitrified forts have been formed with a regard to the present level of sea and land. Now, in the first place, we know absolutely nothing of the age of the vitrified forts. Dr. Wilson, indeed, in his 'Prehistoric Annals of Scotland,' p. 413, discusses them along with the strongholds of the *Iron Period*. Again, the date of tumuli, I imagine, must be fixed, to a large extent, if not entirely, by the nature of the antiquities found within them. A mere mound of earth or stones may surely belong to any conceivable period of human history. The custom of raising cairns over dead bodies or on the scenes of suicide and murder is still prevalent in some parts of Scotland.

* For an account of the alluvium of the Forth, see Blackadder, Mem. Wern. Soc. vol. v. p. 424; also, Chambers's Ancient Sea Margins, p. 131; New Statistical Account of Scotland (Stirlingshire).

† For accounts of these whales, see Edin. Phil. Journ. i. 393; Mem. Wern. Soc. iii. 327; Edin. Phil. Journ. xi. 220, 415; Mem. Wern. Soc. v. 437, 440. See also Wilson's Prehistoric Ann. of Scot. p. 33; Owen, Brit. Foss. Mamm. p. 542.

which these remains were found leave no possibility of doubt that the land here has been upraised at least 24 feet, and that this upheaval has been witnessed by man. The horn weapons do not indeed indicate an advanced state of civilization ; yet they unquestionably prove the presence of a human population perhaps contemporary with that which built the ruder canoes of the primitive fleet of Glasgow.

In the elevated alluvial plains of the Forth, canoes similar to some of those of the Clyde have also been found. One was dug up on the Carse, not far from Falkirk, from a depth of 30 feet. Early in the last century, too, a flood of the River Carron, which flows through the carse, undermined a part of the alluvial plain, and laid bare what was pronounced at the time to be an antediluvian boat. It lay 15 feet below the surface, and was covered over with layers of clay, moss, shells, sand, and gravel. Its dimensions were greater than those of any other canoe yet found in Scotland; for it reached a length of 36 feet, with a breadth of 4 feet. "It was described by a contemporary newspaper as finely polished and perfectly smooth, both inside and outside, formed from a single oak-tree, with the usual pointed stem and square stern *."

These features seem to harmonize well with those of the more perfect of the Clyde canoes, and to justify the inference that they were produced by the employment, not of stone, but of metal tools.

But in the Carse of the Forth an implement of metal has actually been found, and one formed not of bronze, but of iron. It was an iron anchor, dug up a little to the south-east of the place from whence the Dunmore whale was obtained. The exact depth at which it lay is not given; it was probably about 20 feet above high-water. "The flanks were much decayed; but the beam, which was of a rude square form, with an iron ring, was tolerably perfect. It hung many years in the old tower near Dunmore, but was at length stolen †." Pieces of broken anchors have also been found below Larbert Bridge and near Camelon ‡.

Putting together, therefore, the archæological evidence to be gathered from the contents of the elevated silt of the Forth, the inference, I think, can hardly be avoided, that not only was the upheaval effected subsequent to the first human immigration, but that it did not take place until the natives along the banks of the Forth had learnt to work in metal, and until vessels sailing over that broad estuary had come to be moored with anchors of iron. There is some additional evidence, however, from another class of works of art, which will more appropriately be discussed in a subsequent part of this paper.

The Firth of Tay, like the estuaries already described, is bordered with a flat plain, which on the north side expands into the broad tract of country known as the Carse of Gowrie. Its general

* Prehistoric Ann. of Scot. p. 32.

† Edin. Phil. Journ. xi. p. 416.

‡ Nimmo's 'History of Stirlingshire,' 2nd edit. p. 74; Chambers's 'Ancient Sea Margins,' p. 160.

elevation above the level of high water is about the same as that of the raised beaches of the Forth and Clyde. Like these also, it consists of clay, sand, gravel, and layers of shells, and proves an upheaval of from 20 to 30 feet. The analogy holds still further; for the old alluvial deposits of the Tay furnish evidences that the rise has been effected within the Human period.

Mr. Robert Chambers* has pointed out that along the Carse of Gowrie many of the hillocks and eminences which rise above the general level of the plain bear names in which the Celtic word *inch* (island) occurs; such are Inchyra, Megginch, Inchmichael, Inchmartin, Inchsture,—"as if a primitive people had originally recognized these as islets in the midst of a shallow firth." But, besides these names, the Carse is still full of traditions that represent the sea as having once advanced inland a long way from the present margin of the Forth. Time out of mind, it has been a popular belief in this district that the Flaw Craig, a cliff which overlooks the Carse between Kinnaird and Fingask, bore the remains of a ring to which ships were fastened when the sea ran at the base of the hill. Mr. Chambers adds that, a few years before the appearance of his volume on 'Ancient Sea Margins,' "there was a man living who alleged that he had seen this ring in his youth, as he climbed bird-nesting along the face of the crag. So also it is told that the rock on which Castle Huntly stands, in the centre of the Carse, once had rings fixed to it, for mooring the boats formerly used in sailing over the surrounding waters†." These circumstances all conspire to indicate that the rise of the Carse of Gowrie above the limits of the sea is a comparatively recent event. If there were no other evidence, however, such traditional beliefs would hardly be worth the serious attention of the geologist; but they acquire a peculiar significance from the fact that they are fully borne out by the character of the antiquities from time to time exhumed from the clay and sand of this great plain.

Between sixty and seventy years ago a small anchor was dug up, not many feet beneath the surface, on a piece of low ground near Megginch‡. Mr. Chambers refers to another anchor as having been met with in casting a drain below the Flaw Craig§. But the most important and the most carefully investigated relic yet discovered in this district was an iron boat-hook, found in 1837 by some workmen on the farm of Inchmichael‖. It lay imbedded under eight

* 'Ancient Sea Margins,' p. 18. † Ibid. pp. 19, 20.

‡ New Stat. Acc. Scotland, Perth, x. p. 378.

§ 'Ancient Sea Margins,' p. 19.

‖ Mr. Chambers, in the work already cited, briefly alludes to this relic; but he subsequently made it the subject of a very careful investigation, and published the results in a paper (Edin. New Phil. Journ. 1850, p. 233), from which the particulars above given are quoted. From the fact of the implement being iron, he admitted that it must have belonged to no very remote period, and that the rise of the land, if at least this boat-hook were to be taken as evidence, must have been greatly more recent than any one had imagined. To such a conclusion he demurred, and accordingly he endeavoured to account for the position of the boat-hook by some other means than an elevation of the Carse. For this purpose he supposed that the vessel in which it was used may have been swept inland feet of stratified gravel, at a distance of a mile from the margin of the Firth. The surface of the ground was about 3 feet higher than the level of the surrounding part of the Carse, or about 28 feet above high-water-mark; so that the height of the boat-hook above the upper limit of the tide was fully 20 feet. "The relic itself," says Mr. Chambers, "was in no respect uncommon. It was pronounced by Rear-Admiral Sir Adam Drummond of Megginch to be such an instrument of its kind as would be used in a man-of-war's launch or a mercantile boat of 3 or 4 tons." It is now preserved in the Museum of the Scottish Antiquaries at Edinburgh.

No river-flood or violent inundation will account for the position of this interesting relic. The gravelly ridge in which it occurs is surrounded by the finely stratified silt of the flat Carse, and belongs, like all the other similar mounds of the district, to the ordinary slow deposits of the estuary. The inference therefore appears to me irresistible that, when this boat-hook was in use, the sea was beating upon these islets of gravel, and depositing around them the dark mud on which the fertility of the plain now depends. Hence the elevation of this part of the coast of Scotland must have been effected since the introduction of iron into the country. And thus all the traditions of the district, the names of its rising-grounds, and the character of its antiquities contribute each their independent testimony to the fact that a large accession of land has been gained from the sea within a comparatively recent, if not actually within the historical period. The historical period dates in Scotland from the year 80 of our era, when Agricola first led the Roman legions across the Tweed. Is there, then, any evidence to connect the elevation of the Scottish coast-line with the time of the Roman occupation?

Mr. Smith of Jordan Hill was the first to assert that since the Antonine Wall was built (about A. D. 140) there could have been no change in the relative position of sea and land, inasmuch as the ends of the wall were evidently constructed with reference to the existing level*. This statement has been the foundation of all the

during some of the great floods recorded in history. Such an explanation I believe to be not only unlikely, but even impossible. The effects of a storm must be comparatively slight in so sheltered an estuary as that of the Tay. We can hardly conceive the sea rising upwards of 28 feet above high-water-mark, and flowing for more than a mile inland. Still less can we believe that, if it did so rise, it could deposit 8 feet of sediment over the surface of the Carse. The effect of great floods is not to renovate the land, but to waste it; and the result of a violent inundation of the Tay would be to sweep away the surface-soil and carry it out into the estuary. Lastly, if we could suppose any sediment to have been deposited by such a sea-flood, it would not have been in the form of stratified gravel, but of fine mud and silt; for the rush of water coming from the sea could only carry with it the fine muddy sediment of the estuary, and in crossing the Carse it could get nothing but clay to tear up and re-deposit. No geologist can doubt as to the origin of those gravelly mounds or *inches* of the Carse. Most assuredly they are not the result of violent inundations, but of the mingling currents of the river and the sea, when the bed of the estuary stood at least 25 feet lower than it does now. As they rose, and the channel shallowed, only the finest silt gathered round their margins, forming now the rich alluvial soil of the Carse.

* Mem. Wern. Soc. viii. p. 58, and Edin. New Phil. Journ. vol. xxv. for 1838, p. 385.

subsequent geological arguments as to the long period at which the British Isles have been stationary. If it be true, then we must allow that the upheaval, of which the evidence has been adduced in the present communication, is referable to a period certainly previous to the Roman invasion. If the statement be erroneous, the other alternative remains, that the upward movment may have been wholly or in part effected after the Roman invasion.

After carefully examining both extremities of the wall, and reading the narratives of the various antiquaries who have treated of the Roman remains in Scotland, I have no hesitation in affirming that not only is there no evidence that the wall was constructed with a regard to the present level of the land, but there is every ground for believing that it was built when the land was at least 20 feet lower than it is at present. To begin with the east end,—from the Avon west of Borrowstounness eastward to Carriden the ground rises from the old coast-line as a steep bank, the summit of which is from 50 to 100 feet above the sea; between the bottom of this abrupt declivity and the present margin of the Firth there is a narrow strip of flat ground, about 200 yards broad, on which Borrowstounness is built, and which nowhere rises more than 20 feet above high water. It is a mere prolongation of the Falkirk Carse, already described, and beyond doubt formed the beach when the sea broke against the base of the steep bank. Now the Roman Wall was carried, not along this low land bordering the sea, but along the high ground that rose above it. The extremity at Carriden, therefore, instead of having any reference to the present limit of the tides, actually stood on the summit of a steep bank overhanging the sea, above which it was elevated fully 100 feet. If the land here were depressed 25 feet, no part of the wall would be submerged. The only change on the coast-line would be in the advance of the sea across the narrow flat terrace of Borrowstounness and Grange, as far as the bottom of the abrupt declivity

The western termination of the Antonine Wall stood on the little eminence called Chapel Hill, near West Kilpatrick, on the north bank of the Clyde. Between this rising-ground and the margin of the river lies the Forth and Clyde Canal, the surface of which is 20 feet above high-water-mark, and the base of the hill at least 5 or 6 feet higher. Hence the wall terminated upon a hill, the base of which is not less than 25 feet above the present level of the sea. In making the canal, a number of Roman antiquities were found at various depths in the alluvium: these seem to have been part of the ruins from the fort above. If we admit that the wall was constructed previous to the last elevation of the land, we see a peculiar fitness in the site of its western termination. The Chapel Hill must in that case have been a promontory jutting out into the stream, and at high water the river must have washed the base of the Kilpatrick Hills—a range of heights that rise steeply from lower grounds, and sweep away to the north-east. Hence, apart altogether from considerations dependent upon the strategic position of the hills which were infested by the barbarians, we obtain an obvious reason why Lollius

Urbicus ended his vallum at Old Kilpatrick. He carried it, in fact, as far westward as he could carry it, and placed its last fort on a promontory which commanded the passage of the Clyde. He thus drove the natives to the necessity of making their incursions by crossing further down in the more open and exposed part of the river below Dumbarton. The Antonine Wall, therefore, yields no evidence in favour of the land having remained stationary since the time of the Romans. On the contrary, it appears to indicate that since its erection the land has actually risen.

I have examined the sites of the Roman harbours along the east coast of Scotland, without obtaining any proof of a stability of level. Inveresk and Cranund, the chief seaports, tend to confirm the opinion that since the Romans left the country the coast of the Forth has not merely been silted up, but has actually been upraised 20 or 25 feet above its previous level. The position of the remains of a harbour mentioned by Sir Robert Sinclair as having existed fully five miles from the present sea-margin, in the valley of the Carron, near Camelon (the old Statio ad Vallum), along with an anchor dug up at the same place, likewise go to corroborate this conclusion*. But for this part of the evidence I may be permitted to refer to the paper in which attention was first called to this subject†.

Several antiquaries have referred to the difference between the present aspect of the Scottish coast-line and that which it must have had in some places when seen by the Romans. This evidence is that of men who had no geological bias, but who drew their inferences chiefly from a consideration of the present position of the antiquities which they described. So far as it goes, therefore, it is not without its value, adding as it does another collateral confirmation to the proofs in favour of a recent rise of the land. Thus Horsley, sagaciously observing the disposition of the ground at the western end of the Wall of Severus, and the necessity of defending this point with care, concludes that the Roman engineers could never have allowed so long a space to intervene between the sea-shore and the end of the wall, as that which now separates them. The Solway Firth, he says, "must have reached much higher, both southward and northward, than it does now;" for, as the wall stands at present, a body of men might easily march unperceived round its end. He also states that, although now so far removed from the sea-margin, this rampart of Severus extends further seaward than the earlier one of Hadrian. How far the change may have been due to a silting up of the estuary, or to an actual elevation of the land, can only be determined by a careful examination of the locality.

Horsley's observations along the Solway prepared him for the detection of similar phenomena along the other Scottish estuaries.

* Sibbald, Histor. Inquir. pp. 34 and 41. See also Gordon's 'Itinerarium Septentrionale,' pp. 23, 29; and Stuart's 'Caledonia Romana,' pp. 177–8. Buchanan wrote that in his time ruins of the Roman Camelon resembled those of a modern city; and that its ditches, walls, and streets were then apparent (Hist. Scot. lib. i.).

† Edin. New Phil. Journ., new series, vol. xiv. p. 107.

"There is good reason to think," we find him remarking, "that both the Solway Firth and the Firths of Clyde and Forth were formerly deeper, and that the tide has flowed further up than it does now;" and thus that "the land seems to have gained here *."

General Roy, about the middle of last century, made the Roman antiquities of Scotland the subject of careful study, when they remained much more perfect than they do now, after a hundred years of advancing agriculture. He surveyed with a military eye the sites of the forts, camps, ramparts, and highways which the legionaries had left to mark their presence. "With regard to the position of these forts," he says, "the Romans seem to have been guided by the same general principles which now-a-days would direct in the execution of works of a like nature. A high and commanding situation hath therefore been their choice, from whence the country could be discovered to a considerable distance all round, but especially towards the north—the quarter from which they were to expect the enemy,—contriving, as often as circumstances would permit, that a river, morass, or some difficult ground, by way of obstruction and additional security, should extend at some little way along their front. Thus we find that the forts toward the right occupied the heights which overlook the shores of the Forth, the low carse-lands of Falkirk, and the banks of the Carron." He was convinced that these low lands could not have existed then in their present condition. "If," he remarks, "the Falkirk Carses were not entirely overflown in the time of the Romans, it is probable at least that they were then salt-marshes, subject in some degree to temporary inundations in high spring tides †."

Nimmo, in his 'History of Stirlingshire,' published in 1777, after alluding to the tradition of a harbour having existed on the inner edge of the Falkirk Carse, below Larbert Bridge, and to the fact that pieces of broken anchors had been found in that neighbourhood within the memory of people then living, contends that there was "reason to believe that the firth flowed considerably higher in former ages than it does at present ‡."

Lastly, Mr. Stuart, the most recent writer who has treated specially of the Roman antiquities of Scotland, is still more explicit. He declares his belief that "the whole of this lower district (towards the mouth of the Carron) had in all likelihood been covered by the sea when the Roman forces occupied the Wall of Antonine. It is likewise probable," he adds, "that the entire plain between Inner-avon and Grahamstown (that is, the whole of the Falkirk Carse) was at the same period subject to the influx of the tide, which may even have penetrated the deeper hollows of the Carron as far up as Dunipace §."

* Horsley's 'Britannia,' pp. 157, 160.

† 'Military Antiq.' book iv. chap. iii. sect. 2.

‡ 'Hist. Stirlingshire,' Edinburgh, 1777, p. 63.

§ 'Caledonia Romana,' Edinburgh, 1845, p. 177.
I have not deemed it necessary to increase the length of this communication by controverting the alleged Roman origin of certain roadways and other traces

Putting together all the evidence which the antiquities yet discovered along the Scottish coast-line afford as to the date of the last upheaval of the country, we are led to infer that this upheaval must have taken place long after the first human population settled in the island—long after metal implements had come into use, after even the introduction of iron; and reviewing the position and nature of the relics of the Roman occupation, we see no ground why the movement may not have been effected since the first century of our era; nay, there appear to be several cogent arguments to make that date the limit of its antiquity.

Although lines of raised beach, or marine littoral deposits, may be traced round the greater part of the Scottish coast-line, I am not aware that remains of art have been found imbedded in any of them, except in the districts described in the preceding pages. The elevation of the land appears to have been general over the whole of the central districts of Scotland between the Firth of Clyde and the Firths of Forth and Tay. Whether or not the movement extended northwards into the Highland districts, or southwards into England, must be determined by future observation. In the mean time, we seem at last to have a date for one of the latest, but not least important, changes which have affected a part of the British Isles.

April 2, 1862.

Charles Longman, Esq., Shendish, Hemel Hempstead, and Thomas Wyles, Esq., Allesley Park College, Coventry, were elected Fellows. Baron Sartorius von Waltershausen, Professor at the University of Göttingen, and M. Pierre Merian, late Professor and Rector of the University of Basel, were elected Foreign Members.

The following communications were read:—

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of art found along the present coast-line at a height of less than 20 feet above high-water-mark. The causeway of logs, for instance, which crossed a part of the Kincardine Moss, in the Carse of Stirling, is commonly spoken of as Roman; but this is mere conjecture. The bronze vessel found in the same moss, and cited by some writers as a Roman camp-kettle, is most certainly of ancient British workmanship. (See Dr. Wilson's 'Prehistoric Annals,' p. 247.) It is quite possible, indeed, that Roman masonry may be found at a lower level than 20 feet above the present high-water-mark, just as in our own day piers and other pieces of stone-work are constructed which the tide covers twice every twenty-four hours. It does not appear, however, that anything of the kind has yet been described. In short, so far as I am aware, there are no remains of Roman buildings which would be submerged by a depression of the land to the extent of 20 or 25 feet; and there seems, therefore, to be no archæological evidence to contradict the conclusion that the land has been actually raised to that extent since the beginning of our era, while the evidence which does exist, whether of antiquaries or of antiquities, tends materially to confirm that conclusion.

1. *On some Remains of* Chiton *from the* Mountain-limestone *of* Yorkshire. By James W. Kirkby, Esq.

[Communicated by Thomas Davidson, Esq., F.R.S., F.G.S.]

The remains of *Chiton* noticed in the present paper were sent to me for examination about two years ago by Mr. H. J. Burrow, of Settle, with permission to describe them should it appear to me desirable to do so. Not being able to identify any of them with species already described, I agreed to draw up a short account of them, so as to make their discovery known. My delay in doing this is mainly due to an expectation of the discovery of additional materials; but as this expectation has not been realized, it will be well, perhaps, not to withhold their description any longer; for though the plates already known may probably give but a very imperfect idea of the species to which they belong, they certainly seem of sufficient importance to allow of their being brought before the attention of palæontologists.

There are eight plates in the collection, four of which are posterior plates, and the others intermediate; and, notwithstanding the smallness of their number, they appear to belong to four species. That so many species should be represented by so small a number of plates, all from one locality, seems, I must confess, somewhat remarkable; but the differences of the characters of the plates are such as to render it scarcely possible for them to belong to less than the number of species named.

The specimens were found in the Lower Scar Limestone, in the vicinity of Settle, and apparently near the base of that subdivision of the Mountain-limestone of Yorkshire; but I here rely solely upon the observation of Mr. Burrow, whom it may be well to quote. He states, "The exact position of the bed in which the Chitons occur is rather difficult to determine, though it certainly belongs to the Lower Scar Limestone of Phillips. So far as I can judge, the bed is nearer the bottom than the top of the Lower Scar Limestone; but, from the bed only occurring in one place, and then where the strata have been disturbed, I hardly dare venture to make a guess at the thickness of the limestone above it. The place where the bed crops out is on the very edge of the Craven fault, by which, not a hundred yards from the spot, the Millstone-grit is thrown down to a level with the Lower Scar Limestone. The only place where the specimens occur is a field within a hundred yards of a very beautiful little waterfall, called Scaleber Foss."

"The matrix is a dark, hard limestone, and abounds in fossils. Among others are *Orthoceras Goldfussianum*, De Kon., *O. Muensterianum*, De Kon., *Cyrtoceras Unguis*?, De Kon., an abundance of beautifully preserved *Goniatites striatus*, var. *crenistria*, Phillips, and several other species of *Goniatites*, *Orthoceras*, and *Nautilus*; also *Patella imbricata*, a *Buccinum*, *Cypricardia trapezoidalis*, De Kon., a large *Pecten*, and other *Conchifera*, some in great abundance. The principal Brachiopods are *Rhynchonella angulata*, *Terebratula hastata*, and *Spirifera cuspidata*."

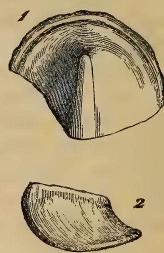
As the following descriptions only refer to the features of the plates discovered, which can only give but imperfect ideas of the species to which they belong, I have thought it better to leave two unnamed, so that those who follow in helping to work out the characters of the species may have their share of the honour (if there be any) of giving them names.

1. Chiton Burrowianus, spec. nov. Figs. 1 & 2.

A nearly perfect posterior plate and a fragment of an intermediate one represent the present species.

Posterior plate rather more than semicircular marginally, depressed posteriorly and laterally; median elevation moderate, angulation obtuse; dorsal area comparatively long, flatly rounded, terminating posteriorly in a blunt, depressed apex; shell thick, surface apparently worn, lines of growth faint; length $\frac{1}{2}$ inch, breadth $\frac{2}{3}$ inch.

Figs. 1 & 2.—*Posterior Plate of* Chiton Burrowianus.
(Enlarged one-third.)



1. Upper view.
2. Lateral view.

The fragment of the intermediate plate is on the same piece of limestone as the one described. It shows the apex, most of the dorsal and small portions of the lateral areas. The apex is acute and depressed; dorsal area rounded and arched longitudinally; lateral areas slope rapidly, almost at a right angle; shell thick, surface similar to that of the posterior plate, and size proportionally the same.

The near position of these plates, and their similarity of size, surface, and shell-thickness lead me to consider them to belong to one individual, hence to the same species.

As a slight acknowledgment of the value of Mr. Burrow's researches in palæontology, particularly of his discovery of four Chitons new to science, I gladly adopt his name for the present species.

2. Chiton coloratus, spec. nov. Figs. 3–6.

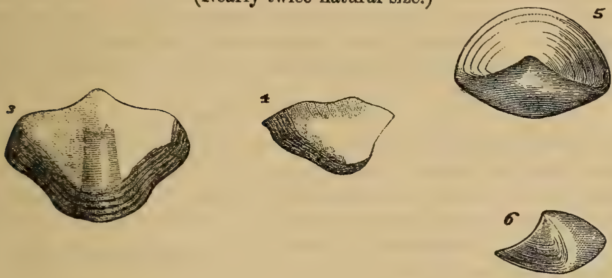
Under this name I include an intermediate and a posterior plate, which, from their size and general character, appear to belong to one species.

The intermediate plate is one-fourth wider than long, and much longer medianally than at the extremity of the lateral areas, as both anterior and posterior margins trend inwards as they proceed from the median line to the lateral extremities; angulation of the plate more obtuse than a right angle, though more acute centrally than laterally; dorsal area (?) raised a little above the general surface; lateral areas obscure; later lines of growth well marked; anterior portion of the plate and dorsal area coloured black, the colour following the contour of the margin and the raised dorsal area; shell strong, length $\frac{6}{10}$ inch, breadth $\frac{1}{2}$ inch.

The posterior plate resembles that of many recent Chitons; it is wider than long, has a semicircular posterior margin, an anterior margin obtusely angulate, a depressed apex almost centrally placed; shell strong, and its surface marked by a few coarse lines of growth.

Figs. 3–6.—*Plates of* Chiton coloratus.

(Nearly twice natural size.)



3. Intermediate plate.
4. Lateral view of the same.
5. Posterior plate.
6. Lateral view of the same.

The intermediate plate possesses considerable interest on account of its colour-marking; the colour is very evident; the uncoloured surface is grey, which is the tint of the matrix. That this is truly the remains of the original colour I can scarcely doubt, considering the symmetry observed in its arrangement, which cannot be ascribed to the accidents of fossilization.

Both plates belong to the ordinary type of *Chiton*. The intermediate plate, from its comparatively great median length, is probably the second, or perhaps the penultimate, of the series. *C. gemmatus*, De Kon., perhaps approaches the nearest to this species among the fossil forms, particularly in the general outline of its intermediate plates.

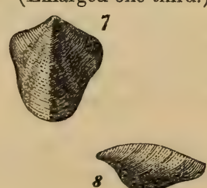
3. Chiton? Spec. nov. Figs. 7 & 8.

A shield-shaped plate, much wider behind than before, strongly keeled medianally, sloping rapidly on each side and anteriorly; apex prominent, pointed, and slightly depressed; two faint lines diverge from the apex to the antero-lateral margin, being apparently analogous to the lateral sulcations that bound the dorsal areas of many Chitons; lateral areas evident, small; surface rather coarsely granulated, granulations arranged somewhat concentrically after the manner of the lines of growth; lines of growth faintly marked, regular; shell rather strong; length $\frac{4}{10}$ inch, breadth $\frac{7}{20}$ inch.

The only plate known to me that has

Figs. 7 & 8.—*Plate of* Chiton?

(Enlarged one-third.)



7. Upper view.
8. Lateral view.

any resemblance to the present one is described by Baron de Ryckholt under the name of *Chitonellus Barrandeanus*; but, so far as may be judged from De Ryckholt's figure of the plate, the relationship does not appear to be specific.

The general form of this plate, its great elongation, and the merging of the anterior into the lateral margins are features that belong rather to *Chitonellus* than to *Chiton* proper. Not knowing, however, anything of the form or development of the apophyses, or rather of that portion of the plate which was imbedded in the mantle, I have doubtfully retained the species in the genus *Chiton*.

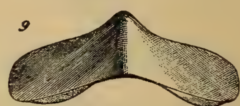
4. Chiton. Spec. nov.? Figs. 9 & 10.

An intermediate plate, short, very transverse, obtusely angulated; anterior margin concave; apex projecting, but not acute; median line arched; dorsal area obscure, lateral areas not large; apophyses wide, semilenticular; surface apparently worn; length $\frac{1}{5}$ inch, breadth $\frac{6}{10}$ inch.

Figs. 9 & 10.—*Intermediate Plate of* Chiton, sp.?

(Nearly twice nat. size.)

9



10

9. Upper view. 10. Lateral view.

There is no mistaking the type of *Chiton* to which the present plate belongs. Its form is that of the intermediate plates of many recent species of the common type. Had it occurred in Permian strata, it would most undoubtedly have been referred to *Chiton Loftusianus*, King, to the middle plates of which it bears great resemblance. It would, of course, be premature to identify it with that species at present, upon the strength of a knowledge of a single plate; and it would be just as premature to say positively that they are distinct, upon the strength of their being found in different formations, particularly as several species of *Mollusca* are already known to be common to the faunæ of both periods.

Besides the preceding plates, there is a cast of a patelliform shell among Mr. Burrow's specimens that may possibly be a plate of a *Chiton* or *Chitonellus*. It is $\frac{3}{4}$ inch long, rather convex, and slightly flanged marginally; and a posterior plate of an undoubted *Chiton* rests upon one side of it. I do not describe it with the other plates, because I cannot detect traces of apophyses, nor satisfy myself as to its shell-structure, nor yet perceive anything conclusive of its relation to this family.

These species appear to be the first Chitons that have been observed in Carboniferous strata in England. In the equivalent rocks of Belgium Chitons have been known to occur since 1843, when Professor De Koninck described two species in his 'Description des Animaux Fossiles du terrain Carbonifère de Belgique,' pp. 321–323.

Two years after this, in 1845, Baron de Ryckholt described ten new species from the same formation, in a paper that appeared in the 'Bulletins de l'Académie Royale de Bruxelles' (tome xii. no. 7). In 1847 the same author noticed another species, which he referred to *Chitonellus*, in the 'Bulletins de l'Académie Royale de Belgique' (tome xxiv. p. 63). Lastly, a species was described by Mr. W. H. Baily, of the Geological Survey, in 1859, from the Carboniferous Limestone of Ireland, in the 'Dublin Natural History Review,' vol. viii., and 'Journ. Geol. Soc. Dublin,' vol. viii. p. 167.

The latter author has also recently published an annotated translation of an old though interesting paper by Professor De Koninck, on two Silurian species of this genus, in which is given a short sketch of all that had been done in the palæontology of the *Chitonidæ* up to the date of publication of the paper; the sketch being accompanied by a list of fossil Chitons from the Lower Silurian to the Upper Tertiary, and Mr. Baily having increased its value by adding to it the results of recent discoveries. Both in this list, however, and in the one originally published by De Koninck, several of De Ryckholt's species are considered but varieties of those described by De Koninck, or altogether ignored; hence, instead of eleven, only three of De Ryckholt's species are allowed in these lists. It is quite possible that Professor De Koninck may be right, to some extent, in considering certain of De Ryckholt's species to be only varieties of his own, but, so far as may be judged from the descriptions and figures of the forms described by the latter author in his valuable paper in the 'Bulletins of the Royal Academy of Brussels,' I see no reason for adopting so sweeping a criticism as that which De Koninck has virtually passed upon De Ryckholt's species; for, though I have had but slight opportunities of examining specimens from Belgium, there seems evidence enough in the figures of De Ryckholt to show that other forms, besides the three allowed by De Koninck, possess peculiar characters of specific value. I include therefore, in the following list of the Carboniferous species of this family, all those described as such by Baron de Ryckholt; it being, in my opinion, only fair to that palæontologist to acknowledge his species until we have shown them to be unworthy of such distinction.

List of Chitones *from the Carboniferous Rocks.*

1. Chiton priscus, *Münster.*
2. —— gemmatus, *De Koninck.*
3. —— concentricus, *De Kon.*
4. —— Tornacicola, *De Ryckholt.*
5. —— Scaldianus, *De Ryck.*
6. —— Nervicanus, *De Ryck.*
7. —— Mempiscus, *De Ryck.*
8. —— Mosensis, *De Ryck.*
9. —— Viseticola, *De Ryck.*
10. —— Legiacus, *De Ryck.*
11. Chiton Eburonicus, *De Ryck.*
12. —— Sluceanus, *De Ryck.*
13. —— Turnacianus, *De Ryck.*
14. —— Thomondiensis, *Baily.*
15. —— Burrowianus, *Kirkby.*
16. —— coloratus, *Kirkby.*
17. ——?, spec. nov.
18. —— spec. nov. (?).

*19. Chitonellus Barrandeanus, *De Ryckholt.*

* The *Chitonellus cordifer*, which Professor De Koninck doubtfully referred to this family, has been shown by Baron De Ryckholt to belong to the *Crinoidea.*

2. *Description of Specimens of* Fossil Reptilia *discovered in the* Coal-measures *of the* South Joggins, Nova Scotia, *by* Dr. J. W. Dawson, F.G.S., &c. By Professor Owen, F.R.S., F.G.S.

[Plates IX. & X.]

The following specimens were transmitted to the Museum of the Geological Society by Dr. Dawson, in a series of boxes and parcels, most of which are numbered according to a list accompanying them, and have been submitted, by his desire, to my inspection. The descriptions will follow in the order of that list.

"Box No. 1.—*Hylonomus Lyelli*, Dawson."

This specimen is imbedded in a portion of a thin layer of carbonaceous matter, measuring six inches by four inches. It consists of scattered parts and impressions of vertebræ, ribs, limb-bones, and part of a cranium crushed, including part of a maxillary bone with teeth (Pl. IX. figs. 1–5). Not any of the bones are entire: all the long bones, even the ribs, are hollow; and the cavity is enclosed by a compact wall of almost uniform thinness throughout each bone, indicative that such cavity was not properly a medullary one, in the sense of having been excavated by absorption after complete consolidation of the bone by the ossifying process, but was posthumous, and due to the solution of the primitive cartilaginous mould of the bone, which had remained unchanged by ossification in the living species. I conclude, therefore, that these hollow long bones (and, indeed, the bodies of the vertebræ seem only to have received a partial and superficial crust of bone) were originally solid, and composed, like the bones in most *Batrachia*, especially the Perennibranchiates, of an external osseous crust, enclosing solid cartilage. The body of the vertebra (figs. 1 & 2) is chiefly represented by a downward growth of the base of the neural arch (*n*); and in the best-preserved specimen there seems to be a distinct inferior plate (*c*), with a median longitudinal channel on the lower surface,—such vertebræ belonging to the dorsal region: the cylindrical cavity of the centrum was doubtless occupied by the notochord. The neural arch developes a short, broad diapophysis (*d*), to which the rib articulates: it also has zygapophyses both before (*z*) and behind (*z′*), and a moderately long truncate spine (*n s*), slightly expanding in the fore-and-aft direction to its summit. The ribs are of various lengths, the shorter ones straight, the longer ones slightly bent; the best-preserved of these have an expanded end, slightly notched (fig. 3), but none show a distinctly bifurcate extremity. Those limb-bones, metapodials or phalanges, which have their articular end preserved, show it to be flattened (fig. 4),—not fashioned for a condyloid or trochlear joint with articular cartilage and synovial membrane, but adapted for a simple ligamentous union, as in the digits of the Salamanders, Turtles, *Amphiume*, and *Proteus*. One end of some of these bones shows a short longitudinal impression at the middle. The surface of some of the larger long bones shows longitudinal striation, indicative of a fibrous structure like that of the bones in some fishes. The maxillary fragment in the slab, No. 1, which Dr. Dawson supposes to belong to another individual of *Hylonomus*, is figured of twice the natural size in Pl. IX. fig. 5. The bone, in respect to its proportions as to length and depth, to the number, size, and shape of the teeth it contains, and to the indications of sculpturing of the outer surface, resembles the maxillary and dentary bones of *Archegosaurus*. A series of twenty-four teeth occupies a part of the alveolar border, *a*, 6 millimeters (nearly 3 lines) in extent; but impressions and fragmentary traces of others beyond show that there were at least 40 teeth in a row on one side of the upper jaw. There is an indication of the lower border of the orbit *o*, above the hinder third of this series. The teeth increase gradually in length as they approach this part; their crowns are slender, subcompressed transversely, pointed, but not sharply, with evidence of alternate shedding. They are partially anchylosed to shallow alveolar depressions on the border, towards the inner side, of the jaw-bone. Their enamelled surface is smooth, and shows a whiter colour than the bone itself.

"Box No. 2.—*Hylonomus aciedentatus*, Dawson."

This contains two portions of shaly carbonaceous matter. In one is imbedded the major part of a maxillary bone (Pl. IX. fig. 6), with the inner side exposed, which is smooth, and demonstrates the fixation of the teeth not to be as in the pleurodont lizard, but according to the acrodont type; the sockets, however, are shallow, and the simple bases of the teeth are partially anchylosed thereto, as in *Archegosaurus* and *Labyrinthodon*, and that of the largest tooth (being exposed by removal of the inner alveolar wall) shows the fossa due to the matrix of the successional tooth. The teeth are not so bent as to indicate which is the front or which the hind end of this maxillary bone. The teeth are the smallest at both ends, gradually increasing as they recede from one end, and rapidly from the other, near to which are four or five teeth, four times the length of the terminal ones of the series. I suspect this to be the fore part of the bone. The proportions and shape of the crown are much as in the *Hylonomus Lyelli*; but there seems to be a greater variety of length in the teeth of *Hylonomus aciedentatus*. In both species the dentition indicates a small insectivorous or vermivorous reptile.

A second portion of coal-shale, in box No. 2 (marked 5 *a*), contains the impression, with a small portion of one end, of a dentary bone of the lower jaw, which held a series of at least 40 teeth (Pl. IX. fig. 7*a*). These, in size and proportion, agree with those of *Hylonomus Lyelli*, in No. 1. The teeth very gradually decrease from the middle to the two ends, especially to the anterior one. In the number, proportions, and close arrangement of the teeth, this dentary bone agrees with that of the *Archegosaurus*. Lizards have not so many teeth.

A third portion of coal (5 *a*), in box No. 2, contained the slender-pointed end of a jaw-bone, with a close-set series of about 25 teeth in an extent of 13 millimeters, or 6½ lines (Pl. IX. fig. 9). These teeth increase from the pointed end of the bone to about the tenth tooth, and thence continue with little difference of size: the crown expands slightly beyond the implanted base, before narrowing to the rather blunt-pointed end. The outer surface of the jaw-bone shows a striated or strio-punctate pattern of sculpture.

A fourth portion (5 *b*) included parts of the bones of a short natatory fore limb (Pl. IX. fig. 10). The humerus (*h*) has an expanded proximal end, with three ridges, two of them more extended than the other; the shaft of the bone is rather bent. This bone has been dislocated from the radius (*r*) and ulna (*n*), beyond which are evidences of three, if not four, digits; these progressively increase in length to the fourth (*iv*), of which, and of the third, impressions and parts of three successive phalanges are shown. These are slightly expanded at their flattened articular ends, at which the longitudinal impressions may be seen in two instances; but the joints were syndesmotic, as in *Archegosaurus* and modern aquatic batrachian reptiles; and the humerus and antebrachium are short in proportion to the manus, although not to such a degree as in *Archegosaurus*.

The group of dermal scutes includes some (Pl. IX. fig. 13 *b*, *c*) which are nearly perfect, of an oval form, smooth on the inner surface, with a low longitudinal ridge, half the length of the scute, on the outer surface; the external layer is of ganoid hardness; the internal structure is cellular. They indicate the nature of the covering of one of the species of *Hylonomus*.

"Box No. 3.—*Hylonomus Wymanni*, Dawson."

The remains of foot-bones (Pl. IX. fig. 11) in one of the portions of coal-shale in this box show a tridactyle structure, with more slender proportions than in the *Hylonomus aciedentatus*; but the phalanges have the same flat joints and incomplete ossification, a thin external crust of bone enclosing a cavity which had been occupied by cartilage: they much resemble the phalanges of the Axolotl.

A second portion contains a series of six or seven crushed neural arches of vertebræ (Pl. IX. fig. 12), of a length twice their breadth, with horizontal zygapophyses—the spines probably broken away. In the proportion of length to breadth, these vertebræ resemble those of *Proteus**. There is no evidence of an ossified centrum in any part of this series; but there are some elongated vacuities, which seem to represent the unossified parts of centrums, partially cased by thin bone. The impressions, with filmy remains of bones of a second series of six vertebræ, of similar slender proportions, are preserved in the same portion of coal.

Pl. IX. fig. 13 *a* represents one of the largest specimens of a rib, partly in bone, partly in impression, with an expanded, slightly notched head, as in the ribs of the Axolotl, but of greater length and more curved than in any modern naked Batrachian: it is hollow, as in the shorter specimens, with a thin outer crust.

* Cuvier, Ossemens Fossiles, v. pt. ii. pl. xxvii. fig. 14.

Near the specimen, and near the jaw of *Hylonomus* (fig. 7*a*), are specimens of the dermal scutes. They are oval, flattened, smooth and slightly concave on the inner side, with parallel curved striations on the outer surface.

Pl. IX. fig. 14 is the dentary bone, with very small, equal, close-set teeth, eleven being in the extent of 2 millimeters; they best accord in character with those of the upper jaw of *Hylonomus Lyelli* (fig. 5), to which species I believe this lower jaw to belong.

Pl. IX. fig. 15 is part of an upper jaw, with teeth less closely arranged, and very small in proportion to the breadth of the bone. It is of a *Hylonomus*, and exhibits on the outer surface of part of the bone the pits and radiating furrows which characterize the outer sculpturing of the skull-bones of *Archegosaurus*.

"Parcel No. 4.—Jaw of a Reptile, supposed to be new."
Hylerpeton Dawsoni, Ow. (Pl. IX. fig. 16).

This specimen consists of the left ramus of a lower jaw, which has been dislocated from the crushed head, of which the fore end of the left premaxillary (*p*) is preserved, terminating near the middle of the series of the teeth of the more advanced mandible. A fragment of the left maxillary (*m*), which has been separated from the premaxillary, overlaps the hinder mandibular teeth. The fore part of the mandible is wanting. The teeth in the remaining part are larger and fewer, in proportion to the jaw-bone, than in *Hylonomus* or *Dendrerpeton*. They have thicker and more obtusely terminated crowns; they are close-set where the series is complete at the fore part of the jaw, and their base appears to have been anchylosed to shallow depressions on the alveolar surface. The shape of what is preserved of the upper jaw affords the only evidence, and not very decisively, that the present fossil is not part of a fish. It inclines the balance, however, to the reptilian side; and, accepting such indication of the class-relations of the fossil, it must be referred to a genus of *Reptilia* distinct from those it is associated with in the Nova-Scotian coal, and for which genus I would suggest the term *Hylerpeton*.

A small part of the external surface of the dentary bone shows a longitudinally wrinkled and striate or fibrous character. The outer bony wall, broken away from the hinder half of the dentary, shows a large cavity, now occupied by a fine greyish matrix (*x*), with a smooth surface, the bony wall of which cavity has been thin and compact. We have here the mark of incomplete ossification, like that in the skeleton of *Archegosaurus*. The crushed fore part of the right dentary bone, with remains of a few teeth, is below the left dentary, and exemplifies a similar structure. The teeth slightly diminish, though more in breadth than length, towards the fore part of the series: here there are nine teeth in an alveolar extent of 10 millimeters, or nearly 5 lines. The portion of jaw, figured of twice the natural size, in fig. 17, shows the anchylosis of the base of the teeth in a shallow groove or alveolus: the base of the teeth is longitudinally fissured, but the fissures do not extend upon the exserted crown. In their general characters, the teeth manifest at least as close a resemblance to those of *Ganocephala* as of *Lacertia* or any higher group of *Reptilia*; whilst their mode of implantation, with the structure and sculpturing of the bone, weigh in favour of its relations to the lower and earlier order of the cold-blooded Vertebrates.

"No. 5.—Skin and dermal plates of *Hylonomus* (?), probably *H. Lyelli.*"

The specimen so marked shows three oblong plates (Pl. X. *a*, *b*, *c*, fig. 2), with a slightly concave surface, finely striate transversely, and with one margin free, obtuse, and well defined. Continuous with this is a granulate surface, like shagreen, of small, close-set, subelliptic scales or tubercles (*d*).

Another portion of coal-shale shows a layer, and an impression of a continuous part of the same layer, of integument (Pl. X. fig. 1) which has been defended by similar small and subimbricate scales. From their state of preservation, these were probably bony or ganoid. I do not know the evidence in proof of their belonging to *Hylonomus*.

Pl. X. fig. 3 is a portion of the bones of the cranium, including the frontal and parts of the prefrontal, postfrontal, parietal, postorbital, and supertemporal bones of probably a *Hylonomus*. They show the skull to have been broad and much depressed: the superorbital border (*o*) is formed by the pre- and post-frontals. In most of the bones, and especially the supertemporal plate, *s*, the outer surface is sculptured according to the pattern shown in the skull of *Archegosaurus*.

Pl. X. fig. 4 is a portion of a jaw, with small equal teeth having the characters of those of *Hylonomus*, and with a sculptured external surface like that in Pl. X. fig. 3 and in Pl. IX. fig. 15.

Passing over the interesting examples of probably the food of the small reptiles, shown in No. 5 (*Pupa vetusta*, Dawson) and No. 7 (*Xylobius sigillarius*, Dawson), I come to

"No. 8. Loose specimens of *Dendrerpeton Acadianum*, Ow. (a nearly complete skeleton)."

The chief addition to the evidence already recorded of the characters of this reptile* are, 1st, the incompletely ossified conditions of the endoskeleton, manifested even in the slender ribs, which have their cavities filled with matrix, as formerly with the primitive cartilage; 2nd, the shape of the head (Pl. X. fig. 5 *a*); 3rd, the superficial markings of the cranial bones (fig. 6) and scutes; 4th, the batrachian type of the ilium, and probably of the pelvis, fig. 7.

The skull (Pl. X. fig. 5 *a*) is broad, depressed, obtusely rounded anteriorly, rather Labyrinthodontal than Archegosaural in shape; although, in the species of both these early types of batrachian air-

* Quart. Journ. Geol. Soc. vol. ix. p. 64, &c.

breathers, there is such a known range of variation as to detract from the value of the character of the degree of obtuseness of the muzzle. Unfortunately, the occipital part of the skull, which would have afforded the test of the mode of its articulation with the atlas, is wanting. The Labyrinthodonts have a pair of condyles, as in *Rana*: the *Ganocephala*, like *Lepidosiren*, show no bony joint between the basi-occipital and atlas.

The under surface of the bones forming the roof of the skull is exposed in this specimen. As in *Archegosaurus* and *Hylonomus*, the frontal (11) is separated from the orbital border (o, o) by the union of the post- (12) and pre- (14) frontals. The temporal fossæ were roofed over with bone; and these cranial bones show their external surface, fig. 6, to be sculptured with the beautiful and characteristic pattern exhibited in the supertemporal plate of the specimen of *Hylonomus*, fig. 3. This pattern may be seen on the cranial bones of some ganoid fishes, and on those of *Archegosaurus* and *Labyrinthodon*. The orbits in *Dendrerpeton* are circular, divided by a bony tract of more than their own diameter: they seem to have been midway between the two ends of the skull; but the hinder part of this is not complete in the specimen. The small nostrils are not midway between the orbits and the muzzle, but nearer the latter. The few teeth preserved at this part of the skull show the plication of the base due to the entering folds of the cement, and yield, on a transverse section (fig. 5 *b*), the same approach to the labyrinthic character as in *Archegosaurus*. Their bases are confluent with the alveolar depressions: there are no tusks as in *Labyrinthodon*.

A short straight bone, uniting with two other divergent ones, appears to be the ilium; and I regard the specimen Pl. X. fig. 7 as part of the pelvis of *Dendrerpeton*: the ossified part of each of these bones is a thin outer crust. The ilium, by its shortness and straight subcylindrical rib-like form, agrees with that in *Archegosaurus* and in modern Perennibranchiate reptiles. In *Labyrinthodon* the ilium expands in some measure according to the Crocodilian type of the bone.

The short proportions and simplicity of shape and structure of the limb-bones combine, with the above-mentioned characters, to demonstrate the Ganocephalous nature of this Nova-Scotian reptile of the Coal-period.

Dendrerpeton, like *Hylonomus* and *Archegosaurus*, shows the affinity (shall we call it?) or analogy to the ganoid fishes, not only in the character of the cranial bones, but in the retention of a covering of the body by ganoid scales: these are elliptic, smooth on their inner surface, with a slight indication of a ridge, about half the length of the scale, on the external surface,—at least, in certain of the scales, and probably those along the back.

The genus *Hylonomus* also, although with more minute and simple teeth, had the skin defended by similar elliptic or suboval ganoid scales. Much remains to be determined as to the structure of the skull: nevertheless such cranial bones as have been obtained (Pl. X. figs. 3, & 5*a*, 6) exemplify the Ganocephalous sculpturing; while the arrested state of ossification of the endoskeleton and the characters of the limb-bones sustain the reference of the genus to the order *Ganocephala*.

After careful scrutiny of all the specimens confided to my inspection by Dr. Dawson, I have not met with decisive evidence of a member of any of the orders of *Reptilia* represented by species of the Oolitic or later series of deposits. Some, as (*e. g.*) *Baphetes*, may be Labyrinthodont, but the rest are Ganocephalous; and *Baphetes* may possibly belong to this lower group of palæozoic air-breathing Vertebrates.

DESCRIPTION OF THE PLATES.

Plate IX.

Fig. 1. *Hylonomus Lyelli*, dorsal vertebra, three times magnified: side view.
Fig. 2. ———————, dorsal vertebra, three times magnified: transverse section.
Fig. 3. ———————, one of the longer ribs, twice nat. size; the end showing the hollow.
Fig. 4. ———————, metapodial and phalangial bones, twice nat. size.
Fig. 5. ———————, upper maxillary and part of orbit, twice nat. size.
Fig. 6. Part of upper maxillary and teeth of *Hylonomus aciedentatus*.
Fig. 7*a*. Impression and remains of the dentary bone of the lower jaw of *Hylonomus aciedentatus*, and of a scute, three times magnified.
Fig. 8. Part of the dentary bone of a young, or small kind of *Hylonomus*, three times magnified.
Fig. 9. The anterior end of a jaw-bone of *Hylonomus*, twice nat. size.
Fig. 10. Bones of the fore limb of *Hylonomus*, three times magnified.
Fig. 11. Bones of a foot of *Hylonomus Wymanni*, twice nat. size.
Fig. 12. Series of (caudal?) vertebræ of *Hylonomus Wymanni*, twice nat. size
Fig. 13. Rib (*a*) and two scutes (*b* and *c*) of *Hylonomus*, twice nat. size.
Fig. 14. Right dentary part of lower jaw of *Hylonomus Lyelli*, twice nat. size.
Fig. 15. Part of the upper jaw and teeth of a *Hylonomus*, three times magnified.
Fig. 16. Parts of upper and lower jaws of *Hylerpeton Dawsoni*, nat. size.
Fig. 17. Small part of jaw of *Hylerpeton*, showing the mode of implantation of the teeth; twice nat. size.
Fig. 18. A group of the scutes of *Hylerpeton* (?); twice magnified.

Plate X.

Figs. 1 & 2. Dermal scutes and markings of the skin of *Hylonomus*?
Fig. 3. Portion of the frontal and contiguous cranial bones of a *Hylonomus*, twice nat. size.
Fig. 4. Part of the lower jaw of apparently the same species of *Hylonomus*.
Fig. 5 *a*. Inner surface of upper part of the skull of *Dendrerpeton Acadianum*, nat. size. 5 *b*, magnified section of base of tooth.
Fig. 6. Outer surface of supertemporal bone of *Dendrerpeton Acadianum*, twice nat. size.
Fig. 7. Ilium and parts of pubis and ischium of *Dendrerpeton Acadianum*.

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3. *On the* Occurrence *of* Mesozoic *and* Permian Faunæ *in* Eastern Australia. By the Rev. W. B. Clarke, F.G.S.

Since I forwarded my remarks on the "Relative Positions of certain Plants in the Coal-bearing Beds of Australia," which were published in the Quarterly Journal, vol. xvii. pp. 354–362, I have received, from a friend who is engaged, under my direction, in exploring the

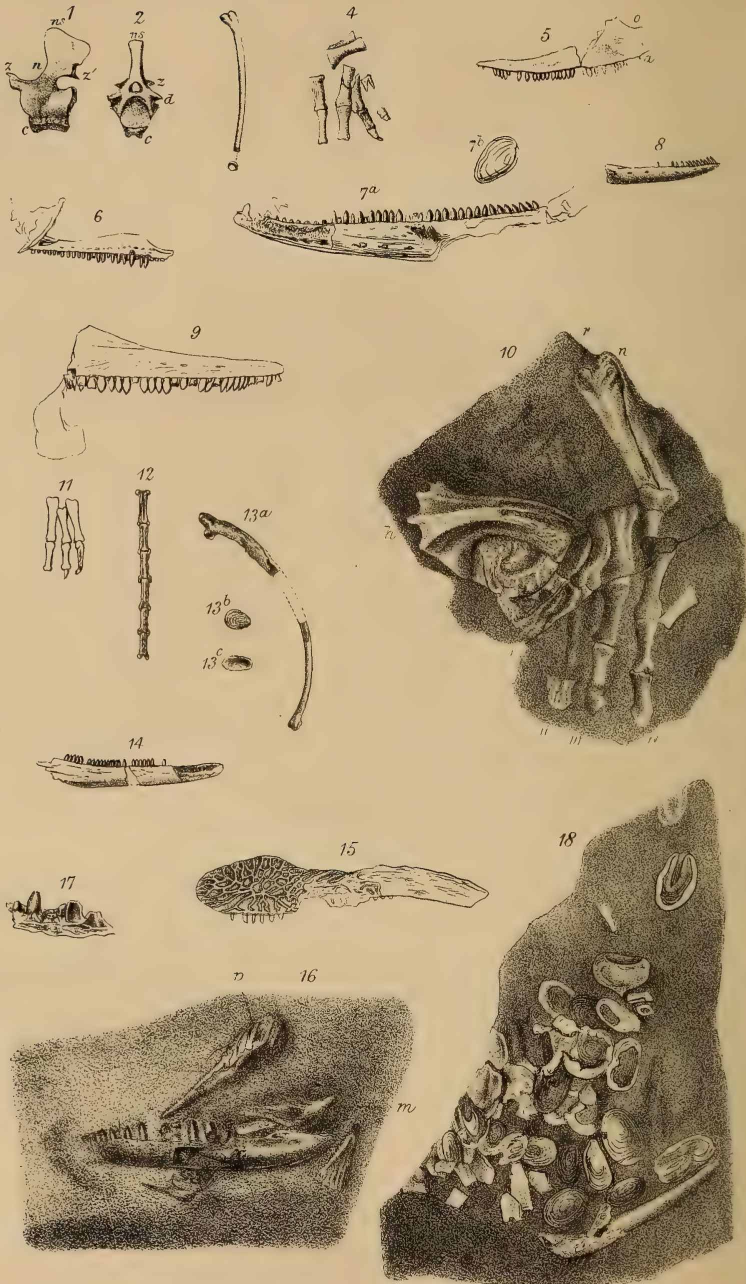
Description of Specimens of Fossil Reptilia *discovered in the* Coal-measures *of the* South Joggins, Nova Scotia, *by* Dr. J. W. Dawson, F.G.S., &c. By Professor Owen, F.R.S., F.G.S.

Appendix.—Dr. Dawson, of Montreal, on receiving the paper on Fossil Reptilia discovered at the South Joggins, printed in the 71st Number of the Society's Quarterly Journal (August 1862), observed that some of the specimens referred to in that paper must have been displaced from their respective boxes before Professor Owen described them, and that, therefore, he was misled by the labels on some of the boxes as to the nature of their contents. Dr. Dawson has therefore suggested some corrections for the paper in question, which, with Professor Owen's sanction, are here enumerated. The Professor accepts the interpretation of specific characters and distinctions arrived at by Dr. Dawson through a study of the rich materials which that gentleman has collected and worked out, in preference to the opinion which Prof. Owen himself may have formed from the selection of specimens submitted to him, and under the circumstances in which they reached him.

Page 238, line 11, *for* This specimen *read* The second specimen.
„ 239, lines 1 and 2, *dele* which Dr. Dawson supposes to belong to another individual of *Hylonomus*.
„ „ lines 19 to 36 inclusive, transpose to p. 238 *above* line 11, and *under* Box No. 1. &c.
„ „ lines 32 to 35 inclusive, *dele the sentence commencing* The proportions, &c., and ending *Hylonomus aciedentatus*.
„ „ line 35, *dele* In both species.
„ „ line 37, *for* A second *read* The first.
„ „ line 46, *for* A third *read* A second.
„ 240, line 6, *for* A fourth *read* A third.
„ 241, line 8, *add* It was probably placed by mistake in this box.
„ „ after line 13, *insert* Pl. IX. fig. 8 is the lower jaw of *Hylonomus Wymanni*. Its teeth somewhat resemble those of *H. Lyelli*, but are fewer and more obtuse. As in all the species of *Hylonomus*, they are much longer toward the anterior end of the jaw.

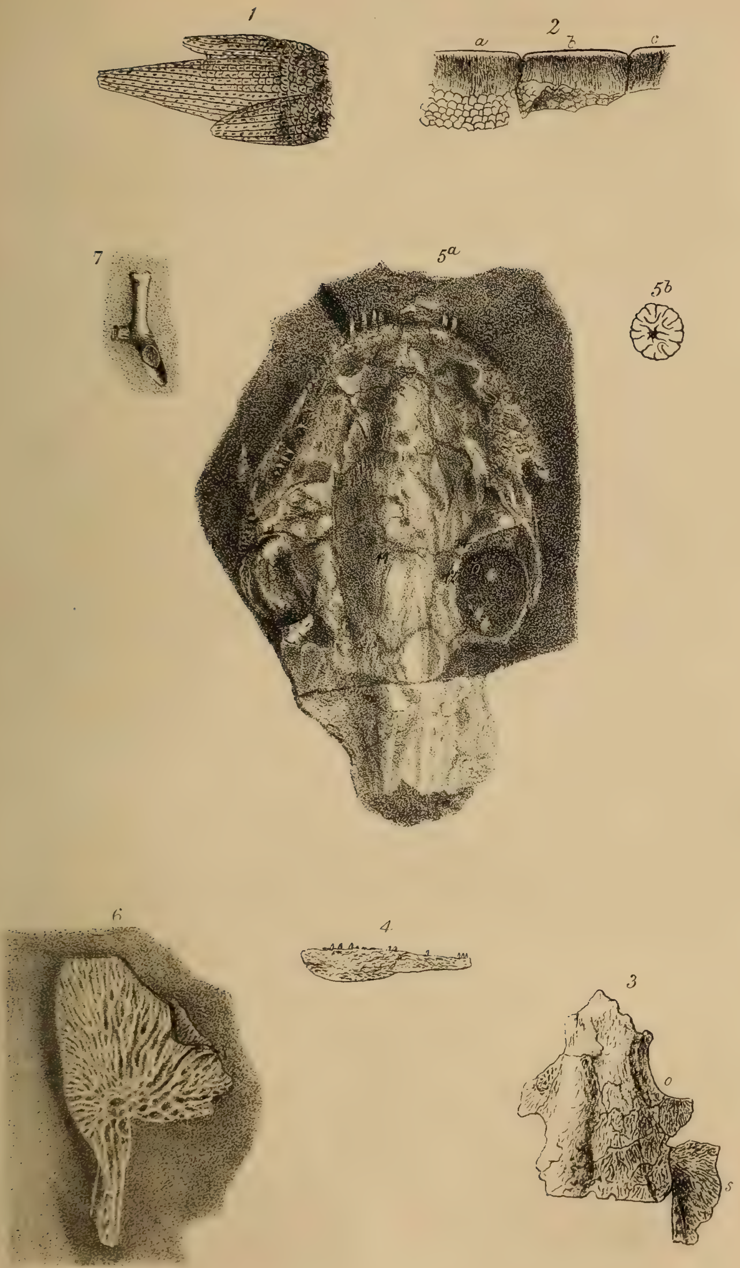
Page 244, Description of the Plates.

Pl. IX. Fig. 6, for *aciedentatus* read *Lyelli*, twice the natural size.
„ Fig. 8, *dele* a young, or small kind of: after *Hylonomus* insert *Wymanni*.
„ Fig. 9, after *Hylonomus* insert *aciedentatus*.
Pl. X. Fig. 3, after *Hylonomus* insert *Lyelli*.



J. Dinkel lith. W. West imp.

REPTILIAN REMAINS FROM NOVA SCOTIA.



J. Dinkel lith.

W. West imp.

REPTILIAN REMAINS FROM NOVA SCOTIA.

country between the Balonne and Maranoa Rivers (now a portion of the new colony of Queensland), a collection of fossils which will serve, to a certain degree, to meet the remark I made at p. 361, respecting "the want of good unmistakeable deposits in which the animal remains will leave no further room for doubt." Mr. W. P. Gordon, a young squatter on Wollumbilla Creek, one of the branches of the "Yahoo River" of Leichhardt, was requested by me to search his neighbourhood and the Fitzroy Downs for fossils; and he has been enabled to send me a very goodly collection. The specimens are accompanied by the pale sandstones of the Creek, and hard red conglomerates and quartzites from between Wollumbilla and the River Amby of Mitchell, including a tract on Fitzroy Downs nearly halfway to Mount Abundance.

On receiving them, I reported at once to Sir Henry Barkly, the Governor of Victoria, who has taken a deep interest in the little matters of difference in opinion between Prof. M'Coy and myself respecting the Coal-epochs, that I had obtained Mesozoic evidence (enumerating many of the genera), and that I should be obliged if he would submit them to Prof. M'Coy, to whom I wished them referred, because I considered it was due to Mr. M'Coy on all accounts (specially as he had examined my collections of 1844, sent to Cambridge) that I should lay before him such new facts as I could obtain, whichever way the evidence from them might turn.

Accordingly Mr. M'Coy has very obligingly examined the specimens, and reports that he considers them "not younger than the base of the Great Oolite, and not older than the base of the Trias."

On this occasion, the departure of the mail, after an interval of only 24 hours for correspondence, prevents me from doing more than announcing this discovery to the Geological Society, naming the principal genera determined by Mr. M'Coy, without any particular arrangement, but numbered as they stood on my own lists when I broke the fossils out of the matrix.

The rock in which they occur is a bright calcareous grit, passing into an imperfect limestone, which decomposes into a soft chalky- or greensand-looking substance.

1. Gigantic Serpulæ.
2. Pentacrinus.
3. Monotis (? Lias).
4. Pectines (? Lias).
5. Lingulæ.
6. Myacites.
7. New species of Aviculæ, of the section *Meleagrina*.
8. Lima.
9. Turbo.
10. Natica.
11. Rhynchonellæ.
12. Monotis (? Saliferian).
13. Pectines (? Muschelkalk).
14. Myophoria, a typical new species (? Muschelkalk).

15. Lamellibranchiate bivalve of a new genus, between *Modiola* and *Pachydomus*.
16. Mæonia or Astartilla.
17. Lamellibranchiate bivalve of a new genus.
18. Avicula.
19. Small Orthoceras (?).
20. Belemnites, like *B. giganteus*, and proposed by Mr. W. B. Clarke to be termed *B. Barklyi*.
21. Arca.
22. Nucula.
23. Modiola-like shell.
24. Fossil Wood.
25. Lamelliferous Coral (very like a fossil from the Wianamatta beds, N. S. Wales).
26. Fossils, very like fish-teeth, but considered by Mr. M'Coy to be the spines of the suckers of probably No. 20.
27. ? Scalpellum.
28. Sponge.
29. Belemnites (like *B. paxillosus*).
30. Dentalium.

There are several other fossils, not yet examined, besides the above. There are three casts of, probably, *Eurydesma* or *Astartilla*. These come from Fitzroy Downs, about 13 miles N.W. from Wollumbilla. Professor M'Coy considers them to be of different age from the preceding.

Moreover I submitted to him three Permian fossils, which I have long had in my cabinet, from the Mantuan Downs, 200 miles north of Wollumbilla, and which he has confirmed as such, viz., two very like *Productus calva*, Sow. (I have another in my collection which I believe to be identical with that species), and one allied to *Aulosteges* or *Strophalosia*, by which latter name I have marked it. These, being shells which belong to the Magnesian Limestone, indicate the Permian epoch.

I have had also lately some fossils which were found on the Dawson River, consisting of *Producta* and columns of *Cyathocrinus*, and are therefore either Permian or Carboniferous.

Any further notice of these Queensland fossils, with their bearing on doubtful opinions, must be deferred.

Mr. M'Coy believes the Wollumbilla fossils to be the marine representatives of the so-called Jurassic Coal-beds of New South Wales. My own opinion is that they represent the marine life of the Wianamatta formation, and are nearer Trias than anything else; and with this the Fitzroy Down fossils and the Red Sandstones of the Amby would well agree in local position and other circumstances. I feel confident, from what I personally know of the region from which they come, that they are altogether above the Coal-beds of the Hunter River and Illawarra, distant about 530 miles, and of which there are representatives, with the Newcastle coal-plants, about 200 miles further N.W. at the junction of the Comet River with the

"Mackenzie" of Leichhardt. I have instituted a search (at my own expense) at the head of the Maranoa River, and shall be able, I hope, to report further discoveries hereafter. These fossils were exhibited in Sydney, and are included in the Catalogue of the New South Wales products for exhibition at London in 1862*.

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4. *On the* Footprint *of an* Iguanodon, *lately found at* Hastings. By Alfred Tylor, Esq., F.G.S., F.L.S.

The occurrence of ichnites or footprints in the Wealden strata has on previous occasions been brought before the notice of the Geological Society by both Tagart† and Beckles‡; and these remains have also been alluded to by Mantell in his 'Geology of the Isle of Wight' (1st edit., 1847, pp. 247, 328).

A notice of the recent discovery of similar impressions may be interesting, and may assist in throwing some light upon their nature and character, as well as lead us to some general observations on the strata in which they are found.

By the earlier observers these footprints were referred to gigantic birds, but subsequently the probability of their being reptilian has been advanced§. This idea is supported by the abundant occurrence of numerous bones of the Iguanodon and other Dinosaurians in the Wealden deposits. By Dr. Mantell's exertions many of these remains were brought before the scientific world; and more lately Professor Owen, in a monograph published by the Palæontographical Society‖, has figured and described, among other fine specimens, the bones of the foot of a young Iguanodon, obtained by Mr. Beckles in the Isle of Wight. This foot has three toes, measures 21 inches in length and 9½ in width, and would form a print or "spoor" similar in outline to that shown by the imprint now exhibited, and by the several other imprints and natural casts of imprints found in the Wealden rocks.

The footprints recently observed near Hastings were upon detached blocks of sand-rock which had fallen in large masses from the upper part of the cliff a little west of Ecclesbourne Glen. About 150 yards of this sandstone in pieces was there exposed on the beach, exhibiting numerous footprints on the ripple-marked surfaces, apparently in a continuous direction.

* These specimens have not reached London, July 20, 1862.—Editor.

† Quart. Journ. Geol. Soc. vol. ii. p. 267.

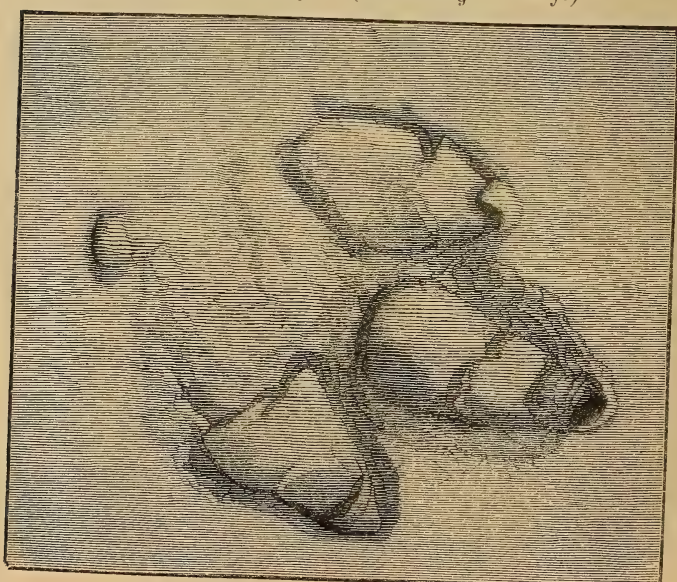
‡ Ibid. vol. vii. p. 117; vol. viii. p. 396; and vol. x. p. 456.

§ In Tagart's Letter, an abstract of which was printed in the Geol. Journ. vol. ii. p. 267. In this letter (dated March 10, 1846) he states that "Dr. Harwood suspects them to be the foot-marks of the Iguanodon." See also Rupert Jones's edition of Mantell's 'Wonders of Geology,' 1857, vol. i. p. 383, and vol. ii. (preface) 1858; and 'Literary Gazette,' N. S. vol. viii. No. 193, March 22, 1862.

‖ 'Monograph on the Fossil Reptilia of the Wealden Formation,' Part iv. 1857.

Natural Imprint of the Foot of an Iguanodon *from the Cliff near Hastings.* (Reduced $\frac{1}{9}$th nearly.)

Cast of the Natural Imprint of the Foot of an Iguanodon *from the Cliff near Hastings.* (Reduced $\frac{1}{9}$th nearly.)



The peculiar interest of the plaster cast now exhibited by Mr. C. S. Mann, of Eltham, taken from one of the best impressions visible on the beach, is, that it represents what I believe to be the footprint of probably the hind foot of an Iguanodon, standing upon a ripple-marked surface of sandy mud sufficiently hard to retain an exact impression. The pressure of the foot has raised the sand surrounding the impression about half an inch above the ripple-mark, at the same time turning over some shells of the genus *Cyrena*, which may be seen in the disturbed mud.

Professor Owen's figure of the bones of the foot of the Iguanodon, above referred to, exhibits phalanges having similar proportions, and similar relative position, to the impressions visible in the newly discovered footprint from Hastings, which measures 24 inches from the toe to the posterior margin of the cup-shaped depression which, I suppose, marks the heel of the Iguanodon, and is 3 inches in diameter and $\frac{3}{4}$ inch deep.

The impressions made by each of the three toes are well defined: the middle one measures 11 inches in total length, 6 inches at the posterior margin, widening to 7 inches, and then tapering down to 2 inches at the depression of its anterior extremity, made by the ungual phalanx, which probably penetrated deeply into the mud. The impression of the dextral or exterior toe is 9 inches in total length, and 6 inches wide, tapering to an obtuse point, 1 inch wide at the claw; that of the sinistral or internal toe is 11 inches long and 5 inches wide, tapering to 1 inch, with an irregular cup-shaped termination as in the right toe.

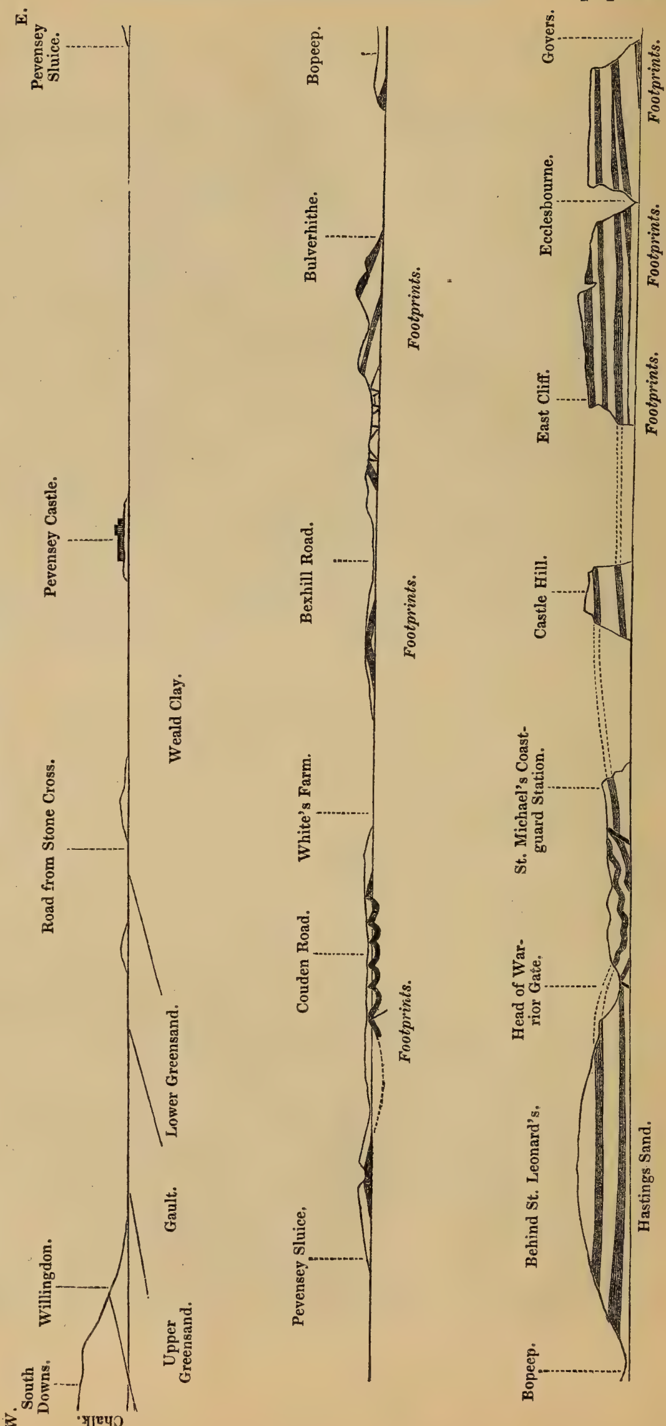
The posterior margin of the impression left by the exterior toe commences at a point very much posterior to that left by the central toe; while the posterior margins of the central and internal toes are more nearly level with each other.

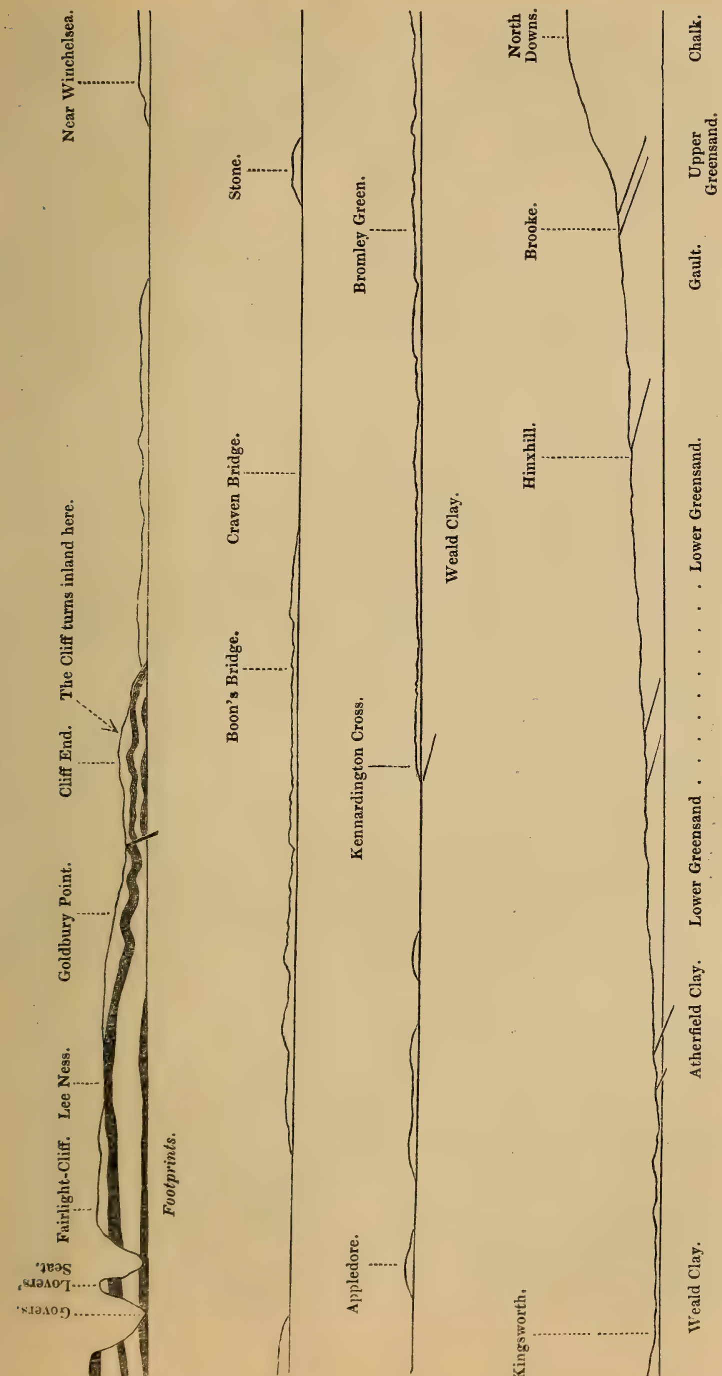
The animal appears to have been walking in a direction nearly at right angles to the ripple-marks, turning his foot a little on one side, so as to give a slightly oblique direction to the footprint. The animal appears in this instance to have left an impression of a resting foot, which is much more distinct than, and also differs in character from, others of the associated imprints, which were apparently made by feet of an animal in continuous motion.

These remains occur in the upper part of the East Cliff, near the junction of the shales (known as "Tilgate Beds") and the Hastings Sand proper, corresponding in position with the strata of other localities in which osseous remains of the Iguanodon have been found.

If, as I am disposed to do, we may really regard these trifid, pachydactylous, and apparently uniserial imprints and casts of imprints as the "spoors" of quadrupeds, and not of bipeds, and if we refer them to the thick-footed, three-toed Iguanodon, we have indications of the tracks of that great reptile at several places and on, at least, two horizons in the Wealden area. The footprints already described by Beckles are, first, from grey sandy shales at and near Couden and Bexhill, west of Hastings. Here the tracks were represented by numerous imprints on the surface of the shales. The foot-

Section along the Coast of Sussex, from the South Downs to the North Downs, showing where Fossil Footprints have been found in the Wealden Beds.




Near Winchelsea.
The Cliff turns inland here.
Cliff End.
Goldbury Point.
Lee Ness.
Fairlight-Cliff.
Lovers' Seat.
Govers.
Footprints.
Stone.
Craven Bridge.
Boon's Bridge.
Bromley Green.
Kennardington Cross.
Appledore.
Weald Clay.
North Downs.
Brooke.
Hinxhill.
Kingsworth.
Chalk.
Upper Greensand.
Gault.
Lower Greensand.
Lower Greensand
Atherfield Clay.
Weald Clay.

prints varied from 8 inches to 27 inches in length, with strides of 18 inches and upwards, in proportion to the size of the feet. These shales are probably on the same geological horizon as those at East Cliff, in which natural casts of similar imprints frequently occur. 2ndly, from the strata of the cliffs at Bulverhithe (including Galley Hill), east of Bexhill. Here also the footprints and their casts are numerous, and sometimes of large size (27 inches long). These track-bearing beds are below the Couden shales, and probably on the horizon of the Castle Rock (Hastings Sand proper) and its underlying shaly beds. 3rdly, Mr. E. Tagart and Mr. Beckles have noticed the occurrence of the track-marks on sandstone slabs at East Cliff. The place of these shales and calciferous sandstones is immediately above the Castle Rock; and they may be called the "Endogenites-shales," as that curious plant is of common occurrence in them, both at this cliff, on Castle Rock, at St. Michael's (Coastguard-station, Hastings), and St. Leonard's. 4thly, Mr. Beckles has discovered similar print-casts in the strata near Lee Ness, 40 feet above the sea-level. These beds are much lower in the series than the Castle Rock, as shown by the long section of the Hastings coast now exhibited, constructed from observations made by Professor Morris, Mr. Rupert Jones, and myself, at various opportunities during several years.

Similar casts of footprints (about 12 inches long) occur in the thin sandstones at Biggs' Farm, near Cuckfield. These were observed by Mr. Hancock, of Tye's Farm; and a specimen is now in the Museum of Practical Geology, Jermyn Street. In this specimen the toes have made isolated prints, as in Mr. Mann's cast, and in some seen by Mr. Beckles, the palm or heel leaving a faint separate depression. The shales near Cuckfield are higher in the series than some of those at East Cliff, and belong probably to the "Wadhurst Clay" of Mr. Drew. As the Endogenites-shale and the Wadhurst Clay may both be represented at East Cliff (see section), some of the foot-marks found on the beach here may have come from the upper (Wadhurst) as well as from the lower (Endogenites) shales. The latter shales, however, certainly bear foot-tracks at Hastings; for where they come to a low level, behind the Castle, at the Waterworks, the sinkings there exposed some specimens in the calciferous sandstone shales.

The relations of the strata are well shown in the long section now exhibited, made on a horizontal scale of 8 inches to a mile, with the vertical heights exaggerated three times. We here see the Hastings Beds, with the overlying Weald clay, arching across the Wealden area, and forming low undulations along the crown of the arch. The passage of some beds of sand-rock into clay is well shown on the east of Hastings (from the East Cliff to Goldbury Point); and the thinning of the Castle Rock on the same line is also shown. The bearings of the same strata to the west, through St. Leonard's to Bexhill, are of considerable interest, as they appear to lose much of their thickness before they pass under the highest part of the Hastings Sand series and the overlying Weald Clay of Pevensey.

The occurrence of the imprints, sometimes on the surfaces of sand-rock, but more frequently on clay-beds, and that probably along definite geological horizons, is suggestive of speculations as to the replacement of clays by sandstones horizontally in delta-deposits; and on this subject, and its connexion with the stratigraphical characters of the Wealden formation, I hope to offer some observations on another occasion.

April 16, 1862.

Thomas McKenny Hughes, Esq., B.A., of the Geological Survey of Great Britain, Jermyn Street, and Edward Petre, Esq., 38 Brook Street, were elected Fellows.

The following communications were read:—

1. *On the Position of the* Pteraspis Beds, *and on the Sequence of the Strata of the* Old Red Sandstone Series *of* South Perthshire. By Professor R. Harkness, F.R.S., F.G.S.

Introduction.—In the 'Quarterly Journal of the Geological Society,' vol. xvii. p. 541, Mr. Powrie mentions the occurrence, for the first time, of *Pteraspis* in the Old Red Sandstone of Scotland, as developed in the neighbourhood of the Bridge of Allan in Perthshire. The specimens obtained by this geologist I had an opportunity of seeing in his possession in the early part of this year. Being under the impression that this area was occupied by that portion of the Old Red Series which is so extensively developed in Fife and Kinross, and which appertains to the upper portion of the series, it occurred to me that either there was something anomalous in the position of these Pteraspidian remains, or that the true horizon of the strata in this portion of the southern margin of the Old Red Sandstone north of the Firths of Forth and Clyde had yet to be determined.

Under this impression, I was induced to examine the district around the Bridge of Allan; and I was also induced to extend my observations north-westward, across the Old Red Sandstone area of this part of Scotland, to the metamorphic rocks of the southern margin of the Grampians, as these occur N.E. of Callander. The result of this has been to ascertain the position of the Pteraspis-beds, and likewise to show a variation in this section from the lithology which usually obtains in the deposits which make up the Old Red Sandstone areas lying to the N.E. of the line of this section.

Commencing at the S.E. margin of the district under consideration, we have, a little to the south of the Bridge of Allan, the great fault which here separates the Carboniferous rocks of Stirlingshire on the S. from the Old Red Sandstones of Perthshire on the N.; and along this line of fault, to the W.S.W., we have that great development of trap-rocks which forms the range of the Campsie Hills. To the E.N.E. this line of fault traverses the country N. of the Ochills, and passing through Perthshire by the Carse of Gowrie, it separates, in the latter area, the lower members of the Old Red Sandstone on the North (as seen at Rossie, Balrudery, and in the neighbourhood of Dundee) from the higher members on the South, as exhibited at Clashbinnie.

Old Red Sandstone Series at the Bridge of Allan.—Immediately N. of this line, in South Perthshire, at the Bridge of Allan, the Old Red deposits make their appearance. The lowest strata which occur here, and which are seen on the road from the village by the well to Wolf's Hole Quarry, on the Westerton estate, consist of conglomerates made up of fragments of trap; and these conglomerates have, as we ascend in the series, deposits of grey sandstones intercalated with them.

These latter dip N.W. at an angle of about 20°, and they gradually become so developed as to exclude the conglomerates which are so abundant beneath them.

These grey sandstones are now worked at Wolf's Hole Quarry; and, as seen here, they are covered by a mass of trap. It is in this quarry that the only recognized specimens of *Pteraspis* have been found in Scotland; and the species appears to Prof. Huxley, who examined the specimens obtained by Mr. Powrie, to be *P. rostratus.* These Pteraspidian remains are by no means uncommon here; but they are usually in an imperfect condition. Besides *Pteraspis,* I have procured from this locality *Cephalaspis*; and Mr. A. Bryson, of Edinburgh, informs me that he also obtained this latter genus from the same locality some years ago.

The grey sandstones are well seen in the course of the Allan above the last-mentioned locality. They form the bed of the river to beyond Kippenross House, and are also seen in ascending the stream to beyond Dunblane; but they gradually change their colour and become purple flaggy sandstones. The north-west dip at the same angle, however, prevails along the course of the Allan, from the Bridge of Allan to above Dunblane.

East of the Bridge of Allan.—In the district which lies on the east side of the Allan Water the same grey sandstones occur, succeeded by the purple beds. At Stonehill Quarry, a mile and a quarter E. from Dunblane, the former are wrought, and these quarries are the source from whence the building-stone of Dunblane is principally obtained. Some of the beds are micaceous and flaggy; and, on the whole, the strata at Stonehill have a great lithological affinity to the Forfarshire flags. I learn from Mr. Page that *Cephalaspis Lyellii* has been found in this quarry. The angle of dip and the direction here also conform to the strata traversed by the Allan Water.

East from Stonehill, and flowing along the northern margin of the Ochills, is a stream called Alt Wharry: this separates the traps on the S. from the grey beds of the Old Red Sandstone on the N.; and the character of the vegetation on these respective rocks well marks the difference in their mineral nature. The former is clothed with a fine green herbage, while on the latter brown benty grasses prevail. These latter cover the surface of Sherra Muir, which, where intersected by the streams flowing into the Allan, affords exhibitions of the rocks of this area.

On Sherra Muir, at Blackford of Burn Ogilvie, the grey beds are wrought, and have the N.W. dip at 20°. The same beds are seen on the east side of Sherra Muir, in the course of the Millstone-burn which joins the Allan near Greenloaning Station; and in this stream we have the sequence of the grey and purple beds well shown. At Balhardie in the brook-course the higher purple strata occur, and are worked; they are flaggy, and have green layers and nodules accompanying them. The rocks here are false-bedded, but the prevailing dip is N.W. at 20°. This locality is on the road from Greenloaning to Dunblane; and to the S.W. thereof we have, in the stream on the road from Dunblane to Kinbuck, the same purple flaggy strata, with the same dip and direction; and these false-bedded sandstones have been partially worked about a mile and a half N.E. of Dunblane, on the east side of the road.

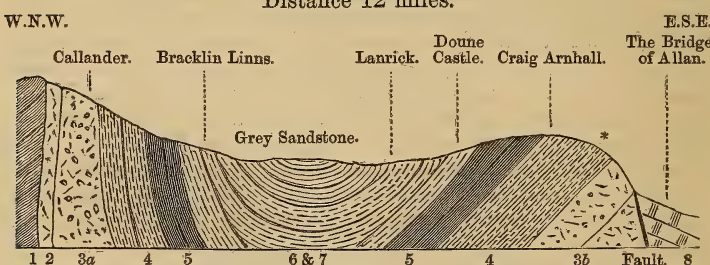
North-west of the Bridge of Allan.—In the country which lies west of the Allan we have strata of a like nature manifested; but in passing north-westward into the area drained by the Teith, we have other and higher strata exposed than those which the Allan Water exhibits. West from the Bridge of Allan, along the escarpment in the north side of the Carse of Leckrop, the grey sandstones are seen; west of this, at Craig Arnhall, these are succeeded by the purple portion of the series, and in the upper parts of these latter intercalated light-purple shales occur. On the north side of the Teith, in Craig Arnhall Wood, the light-purple shales are exclusively seen, and these continue to the Farm of Row. The whole of this series of strata, as seen west of the Bridge of Allan, has the N.W. dip at an angle of about 20°. In passing higher up the Teith these purple shales have interstratified with them thin beds of fine-grained, brown-coloured sandstones, which gradually increase until we find the higher strata entirely composed of the latter. This is the case at Ardoch Burn, which flows past Doune Castle; and of these brown sandstones this stronghold is built. As seen in the stream at Doune Castle, the brown sandstones have in them green laminæ, and are spotted with the same colour; here their dip is W. at 20°. The brown sandstones are also seen above Doune, in the course of the Teith at Deanstown, and about half a mile to the W.N.W. they have been worked. Above Doune Bridge they exhibit N.W. inclinations. Beyond Deanstown, in the course of the Teith, they are seen in the grounds of Lanrick Castle still with a N.W. dip, but at a low angle; and they continue, as seen in the Teith, all through the estate of Lanrick, becoming to the W.N.W. by degrees almost flat. They pass gradually upwards into grey flaggy rocks which, within about four miles of Callander, have become nearly horizontal.

In the course of the Teith, from about four miles below Callander to this place, no rocks are seen in the river; at Callander on the Muir, which is situated on the south side of the river, conglomerates make their appearance, made up for the most part of quartz-fragments. These conglomerates, which are well developed, and which are used for building-purposes at Callander, have a S.E. dip at a high angle. Their relation to the strata dipping N.W., as seen between the Bridge of Allan and Lanrick, is not apparent in the district drained by the Teith; but in the course of the Keltie, which joins the Teith from the N., the connexion of the conglomerates of Callander with the rocks on the S.E. can be well made out.

In the course of the Keltie, about half a mile above the bridge, on the road on the north side of the Teith leading from Callander to Doune, at the Mill Weir, the grey sandstones above referred to are seen; and here they have a horizontal position. On ascending the stream the same strata occur, and become more highly inclined; beneath these upper grey sandstones there are seen brownish-red flaggy strata, conforming to the higher series in dip. The brownish-red flagstones gradually increase in dip to Bracklin Linns, where they become coarser; and some of the beds, in consequence of containing quartz-fragments, put on the aspect of a fine conglomerate. Some of the surfaces of the beds at Bracklin Linns exhibit well-marked ripples, and here the strata dip S.E. at 75°.

Above Bracklin Linns in the course of the Keltie these conglomerates and associated red sandstones also occur, the former prevailing to a greater extent than the sandstone layers; but these beds pass downwards into thin-bedded brown flags, which rest upon a series of fine-bedded, light-purple, micaceous sandstones. Fine conglomerates, with quartz-pebbles, are seen below the purple micaceous sandstones; and under these latter are reddish-coloured shaly sandstones, reposing upon sandstones of a grey colour, and bearing great affinity to the grey sandstones of the Bridge of Allan.

Diagram-section from the Bridge of Allan to Callander.
Distance 12 miles.



8. Carboniferous rocks.
7 & 6. Brown sandstone surmounted by grey sandstone.
5. Purple shale.
4. Grey sandstone passing upwards into red sandstone.
* Place where remains of *Pteraspis* and *Cephalaspis* have been found.
3*b*. Trappean conglomerate.
3*a*. Conglomerate of felstone.
2. Trap-rock.
1. Metamorphic Lower Silurian rocks.

These latter are well seen in the lower portion of a beautiful Linn in the course of the Keltie, about a mile above Bracklin Linns; and here they rest upon brown sandstones with well-developed conglomerates made up of quartz-pebbles, which at this spot have almost a vertical position. The conglomeratic portion of this series becomes more prevalent in the lower members, and finally we have a very great thickness of these latter exclusively occurring. The fragments which enter into the composition of these last conglomerates differ from those in the higher beds of the Old Red Sandstones of the Keltie; for in these lowest conglomerates rounded fragments of felstone almost solely make up this portion of the series; and these fragments vary very greatly in size, some being as much as two feet in diameter. The lower conglomerates, which are devoid of any trace of stratification, are well seen in the Keltie immediately opposite the small farm-house on the east side of the stream. Above these conglomerates, which are nearly a thousand feet in thickness, we come upon a fine exhibition of trap-rocks occupying the line of fault which separates the Old Red Sandstones on the S.E. from the metamorphic rocks of the Grampians on the N.W.

The sequence of deposits, as represented in the course of the Keltie, has a great affinity to that which occurs on the southern margin of the Old Red Sandstone of Scotland north of the Forth and Clyde, as seen in the neighbourhood of the Bridge of Allan and in the course of the Teith. In the former locality we have, however, a much greater development of the conglomerate series which forms the lowest member in both these areas; and in both instances we have these conglomerates succeeded by grey sandstones, the latter at the Bridge of Allan affording Cephalaspidian remains. In the course of the Keltie the grey sandstones are succeeded by purple beds; and the like circumstance marks the superposed beds on the grey sandstones north of the Bridge of Allan. Upon these we have the purple shales of Leckrop, which in the Keltie section are represented by thin-bedded, light-purple, micaceous sandstones; and upon these there are found brown sandstones and conglomerates which are the equivalents of the brown sandstones of the Ardoch, of Doune, and of Lanrick. In the Keltie and in the Teith this portion of the series has reposing upon it the grey flaggy strata which, in the section between the Bridge of Allan and Callander, form the highest beds of the Old Red Sandstones in this part of Scotland.

With reference to the thickness of the strata exhibited in the Keltie,—if we take the distance from the trap-rocks which intervene between the metamorphic Lower Silurian rocks on the N.W. and the spot where, in this stream, the upper grey beds become horizontal, as two miles, measured along the dip, and the average angle of dip as 45° (which is most probably below the mean), then we have, in the course of the Keltie, from the lowest beds of the conglomerate to the highest beds of the upper grey sandstone series, a thickness of more than 7000 feet of strata appertaining to the Old Red Sandstone in South Perthshire. In the arrangement of the mineral matter which forms these Old Red Sandstones we have a much greater affinity to the deposits which represent this series in the N.E. of Scotland, than to those of the extension of the Perthshire deposits as they occur north-eastward in Forfarshire and

Kincardine, since the base in South Perthshire is composed of a conglomeratic mass fully equal in thickness to the lower conglomerates of the country south and east of the Moray Firth. In Forfar and Kincardine the lowest members are composed of Forfarshire flags and inferior red shaly sandstones; but in the district under consideration we have, underneath the representatives of the Forfarshire flags and beds equivalent to the inferior red shaly sandstones, a thick conglomeratic series, differing in the nature of its fragments from the higher conglomerates; and this, both in position and thickness, can only be parallel with the base of the Old Red, as occurring in the countries which margin the Moray Firth.

Organic remains.—Reference has already been made to the discovery of *Pteraspis* by Mr. Powrie in the grey beds at Westertown Quarry, near the Bridge of Allan. This form, I learn from Prof. Huxley, is probably *P. rostratus.* I have also stated that Mr. Bryson has procured from the same locality a specimen of *Cephalaspis.* This specimen has unfortunately been mislaid. From this spot I have likewise obtained, along with remains of *Pteraspis,* the head of a *Cephalaspis.* This specimen is not in a very perfect condition, and the species cannot be satisfactorily made out by Prof. Huxley; it is therefore desirable that the fossils from the Bridge of Allan should be carefully looked after in order that the form of *Cephalaspis* which is associated with *Pteraspis* here may be determined.

No traces of Plants, so far as I am aware, have been found in this neighbourhood, nor are there any remains of Crustaceans.

With reference to the strata which overlie the grey sandstones reposing on the inferior conglomerates, I have seen it stated that the brown sandstones of Doune afford *Cephalaspis Lyellii*; but this is a matter on which I am in doubt, as I can get no satisfactory evidence of the occurrence of this fish in this portion of the Old Red Sandstone area of Scotland.

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2. *On the* Western End *of the* London Basin; *on the* Westerly Thinning *of the* Lower Eocene Beds *in that* Basin; *and on the* Greywethers *of* Wiltshire. By William Whitaker, B.A. (Lond.), F.G.S., of the Geological Survey of Great Britain.

Contents.

Introduction.—The above three subjects are closely akin to one another. The sections that will be described in the first part of this paper show that the "thinning" treated of in the second is greater than has been hitherto thought; and the extent of this latter must much change our notions as to the formation from which have come the greater part of those loose blocks of Greywether-sandstone that, in many places, lie on the surface of Cretaceous and Tertiary beds.

The age of the sands noticed in the third part may also have some bearing on that of the Greywethers.

The data on which a great part of this paper is founded have been in my hands for some time; and the conclusion that I have come to with regard to the age of the Greywethers at the western end of the London Basin has been shortly given in the Geological Survey Memoir on Sheet 13 (p. 48). I have great pleasure in knowing that Prof. Ramsay wholly agrees with my views of the beds in that district, to which this paper chiefly refers. The thinning-out of the London Clay in Marlborough Forest has also been noticed at p. 54 of the above-mentioned memoir.

The new points of this paper, which treats of the *London* Tertiary District alone, are—the proof of the occurrence of the London Clay and the Lower Bagshot Sand further westward than they have been before noticed*; the thinning of the Woolwich and Reading Beds west of Hungerford; the proof that the London Clay thins much more quickly westward from Reading than has been hitherto thought, and that in Marlborough Forest it has thinned out altogether; the inference from the above that further westward, where the Greywether-blocks abound, the Bagshot Beds probably rested at once on the Chalk; the natural conclusion that the greater part of those blocks came from that formation, and the further evidence in support of this theory that *may* perhaps be given by certain sands, as yet of doubtful age, that are found here and there on the Chalk of Surrey and Kent.

I must state, however, that the idea that the Greywethers once formed a part of the Bagshot Beds is not by any means new; but it has of late years been given up in favour of Mr. Prestwich's theory that they for the most part belonged to the Woolwich and Reading Beds. With the data that Mr. Prestwich had, I do not see how he could have come to any other conclusion than the one so ably and logically worked out in the latter part of his paper in vol. x. of the Society's Journal (p. 123); but I think that the further data given in the first part of the present paper, and the conclusions to which I have shown that they lead, in the second part, must lead us back again to the old doctrine that the greater part (not the whole) of the Greywethers are of Bagshot age. The Hertfordshire "pudding-stone" I agree with Mr. Prestwich in referring to the Woolwich and Reading Beds.

Part I.—The first part of this paper refers chiefly to the neighbourhood of Bedwin and Savernake (or Marlborough) Forest, in Wiltshire, mapped in the north-eastern corner of Sheet 14 of the Map

* Except on Sheets 12 and 14 of the Map of the Geological Survey, and in the Memoirs on the former and on Sheet 13. The most western Tertiary outliers in the London Basin (in Sheet 14) have not been hitherto described with any detail.

of the Geological Survey of Great Britain. As that sheet, which was published in 1857, is not illustrated by a memoir, like those descriptive of many of the sheets of later date, and as some changes were made in the mapping of the Tertiary beds in its north-eastern part in 1859, I shall give a short notice of the ten Tertiary outliers that have been there mapped. The country included in the S.E. corner of the sheet to the north (Sheet 34) will also be noticed. Here also the Tertiary beds have been resurveyed, which has made needful some corrections in the next edition of the Memoir illustrating that sheet.

The Tertiary beds that are found in this district are—the "Lower Bagshot Sand," the "London Clay," and the "Woolwich and Reading Beds" (or, for shortness, the "Reading Beds"). It will be convenient to work from the east westward, and to notice all the formations together, as they occur, instead of treating of each separately.

It is well first to state that it would seem that, when Mr. Prestwich examined this district, before the publication of his papers on the Lower Tertiary beds, sections were neither so plentiful nor so clear as when the Geological Survey was in progress (1858–59). Thus Mr. Prestwich says (in 1850), "The first" (that is to say, the most westerly) "point where we meet with some uncertain indications, without sections, of the basement-bed of the London Clay is capping the summit of Bagshot Hill, between Great Bedwin and Hungerford*" (Map 12); and again (in 1853), "In Marlborough Forest the Tertiary beds are so thin, and so disturbed by, or mixed with, drift, that no good section can be obtained†." I shall show that there is London Clay three miles or more to the west of Bagshot Hill, and moreover that the Bagshot Sand ranges still further westward.

Tertiary outliers in Sheet 14 *of the Geological Survey Map*.—At the western edge of the map (14), east of Great Bedwin, there are three patches of the Reading Beds, the middle one capped with London Clay, forming parts of a large and well-marked outlier, the greater part of which is in the map to the east (Sheet 12). There is a section of the Reading Beds in the brickyard at Folly Farm, and northwards there are two other brickyards, the pits in which show the junction of the London Clay and the Reading Beds. An account of these sections will be found at p. 26 of the Geological Survey Memoir illustrating Sheet 12.

At Castle Hill, south of Great Bedwin, there is an outlier of the Reading Beds, probably capped by London Clay at the top of the hill (judging by its height alone, there being no section of the latter formation). This outlier, which is about a mile and a quarter in length from north to south, but nowhere half a mile in breadth, is well marked; the Tertiary beds, for the most part covered with wood, rising sharply from the Chalk. On its eastern side, in a chalk-pit half a mile a little E. of S. of Broil Farm, there may be seen an irregular junction of the "bottom-bed ‡" of the Reading Beds with

* Quart. Journ. Geol. Soc. vol. vi. p. 257. † Ibid. vol. x. p. 85.

‡ For an account of this bed, see Memoir illustrating Sheet 13 of the Map of the Geological Survey of Great Britain, p. 23.

the Chalk. The former, here many feet thick, consists, in descending order, of bluish-grey clay (partly mottled yellow), light-green sandy clay, and light-green sand. I saw no flints in it. South of this there are "swallow-holes*" at the junction of the Reading Beds and the Chalk.

West of Castle Hill there is another outlier, equally well marked, forming the wooded hill that stretches for three-quarters of a mile from the northern end of Wilton Common nearly to Broil, and the top of which consists, without doubt, of London Clay; for at Wilton Kiln, at the southern end of the outlier (where the dip is sharp to the north), whilst in places the brown and light-coloured sands of the Reading Beds are found at the surface, I saw, close by the edge of the wood, and near the middle of the brick-field, about four feet of stiff bluish-grey and brown London Clay, with a line of ironstone containing fossils. The fossils were all casts, and amongst them I made out *Nautilus* (casts of detached chambers), *Calyptræa*, *Fusus* (or *Pleurotoma*), *Cardium*, and *Ostrea*.

On the line of hill to the west of the Bedwins there is a large outlier of Lower Bagshot Sand, London Clay, and Reading Beds, forming the high ground from Chisbury Barrow to the south-eastern part of Tottenham Park, a distance of about two and a half miles nearly N.E. and S.W. The outlier is from a quarter to three-quarters of a mile in breadth; its boundary is for the most part well marked, and along it there are many swallow-holes, especially within a radius of half a mile from Stoke Farm to the west of Great Bedwin. At the southern end, near the Chalk escarpment, the dip is fairly sharp; but it soon lessens northward, and the beds become flat or nearly so: perhaps, indeed, the direction of the dip may have changed from north to south at the northern end of the outlier; but not having any datum-heights by which to judge, I cannot say with certainty. Down the northern flank of the hill just south of Stoke Farm deep drains were made in January 1859, and I was fortunate enough to see part of the work in progress. The following beds were cut into, beginning at the bottom of the hill, and taking them in ascending order:—

1. *Chalk* (and the reconstructed bed described in Quart. Journ. Geol. Soc. vol. xvii. p. 527).
2. *Reading Beds.*—Variously coloured mottled plastic clay, with a little sand.
3. *London Clay.*—Stiff blue and brown mottled clay, not plastic, with large rounded flints at the lower part (basement-bed). Higher up the clay is sandy.
4. *Lower Bagshot Sand.*—Brown and buff sand, partly clayey.

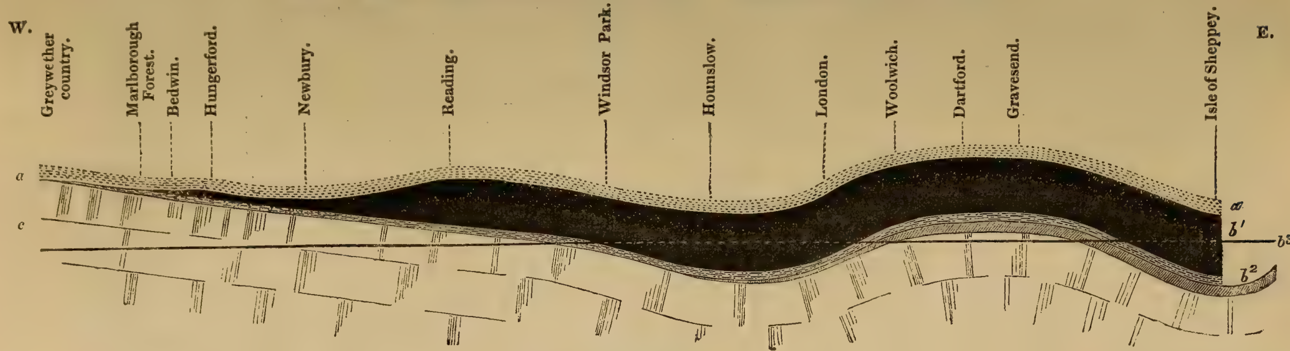
* For an account of these underground water-courses, see a paper by Mr. Prestwich, Quart. Journ. Geol. Soc. vol. x. p. 227; and also the Memoir illustrating Sheet 13 of the Map of the Geological Survey, p. 24. In the latter their frequent occurrence near the junction of the Tertiary beds and the Chalk is noticed.

This section shows that *neither the London Clay nor the Reading Beds are here more than from* 12 *to* 15 *feet thick, and therefore that the Bagshot Sand is only* 25 *or* 30 *feet from the Chalk.* In the London Clay there were many pieces of ironstone, as at Wilton Kiln; and in one of them I found a cast of an *Ostrea.* This formation covers the Reading Beds over a great part of the outlier; but the patch of Bagshot Sand, the boundary of which is partly marked by a slight rise of the ground, only stretches about a third of a mile both northward and southward of Stoke Farm. On the south-west of the farm, I saw a deep and long ditch, freshly cut, in the sand; and along the road, a quarter of a mile north-east of the farm, sand is again shown. Further northwards the beds are much hidden by pebble-gravel (drift) and by wood. At Chisbury Barrow there is a section along the road-cutting up the southern side of the hill, showing sands, with a little clay, from the top of the Chalk up to the gravel that caps the hill. These must altogether be some 40 or 50 feet in thickness. As I have shown that, in another part of the outlier, the Reading Beds are not more than 15 feet thick, it seems unlikely that here they should be three times that thickness; I should conclude, therefore, that the sands of Chisbury Barrow do not belong wholly to that formation; but rather that the upper beds, which in look are like those above the London Clay at Stoke Farm, are also like them in age, that is to say, are a part of the Lower Bagshot Sand, *which formation therefore here rests directly on the Reading Beds, the London Clay having thinned out.* I should not have ventured, however, to colour those beds as Lower Bagshot on the Geological Survey Map, had not such a step been confirmed by a section in an outlier further west, where a thin pebble-bed, representing the basement-bed of the London Clay, is all that separates the Reading Beds from an overlying mass of sand.

A little west of the large outlier just described are three smaller outliers of the Reading Beds. Tottenham House stands on one, from below which the Chalk rises sharply to the south; another caps the Chalk over a great part of Bedwin Common, but is much hidden by a clayey drift; and between these two there is a small patch, barely separated from the first.

Further westward is a more important outlier, stretching from the house at the western end of Terrace Hill in a north-westerly direction for a mile and a quarter. At its southern end the Chalk rises up sharply to the south from beneath the Tertiary beds; but, as usual, the dip soon decreases towards the north. At the brick-yard on the eastern side of the outlier, the sections in different parts of the pit seem to show that the Tertiary beds here rest unevenly on the Chalk; for although the junction is not seen, the waved lines of bedding in the sands, &c., look as if caused by the beds having given way here and there, and filled pipes and hollows in the underlying Chalk. The section does not show an unbroken series of the Tertiary beds from top to bottom; but the upper beds are clear. Plastic clay, of the Reading Beds, chiefly green, has been found above the Chalk; but

Diagram-section from the Isle of Sheppey to a few miles west of Marlborough Forest, showing the Westerly Thinning of the Lower Eocene Beds in the London Basin. (Length nearly 120 miles.)



Vertical scale of 1600 feet to an inch. Feet. 0, 100, 200, 300, 400, 800

a. Bagshot Beds (Middle Eocene).
b^1. London Clay. }
b^2. Woolwich and Reading Beds. } Lower Eocene.
b^3. Thanet Sands. }
c. Chalk.

Horizontal scale, 20 miles to an inch.

Miles. 0 1 2 3 4 5 10

The section shows the thickness of the Lower Eocene beds in the London Basin, from the Isle of Sheppey to Marlborough Forest, after the deposition of the Bagshot (Middle Eocene) Beds upon them, but before any denudation had taken place through the latter, and does not, therefore, show the present surface of the country. As some of the beds are thin, and the horizontal scale is small (owing to the length of the section), it was needful to use a comparatively large vertical scale, which has been made just 66 times as great as the horizontal.

Any unconformity that there may be between the Chalk and the Tertiary beds is not taken into account, there being but few data to guide one in showing it, and it having nothing to do with the subject of this paper. The distance of the junction of the Chalk and the Tertiaries above or below the sea-level has been drawn as it now is.

The basement-bed of the London Clay runs right on to the western part of the district (though I am not sure that it is always present towards the east); but I have no means of settling the question whether that formation thins off to the west by the loss, step by step, of its higher beds in that direction, or whether the same bed is at the top throughout its greater extent, the thinning being caused by the absence of the lower or middle beds.

whether the "bottom-bed" occurs here or not, I do not know. Higher up, the sands and clays of the Reading Beds are overlain by a continuous bed, a few inches thick, of black flint-pebbles of various sizes, many large; and above this pebble-bed there are white and light-coloured sands, with thin seams of pipe-clay, about 12 or 15 feet thick. Now in the sections of the Reading Beds in the western part of the London Basin pebbles are very rarely seen, except in the green sand ("bottom-bed") lying directly on the Chalk; in that bed they are not always found, and when they do occur it is not in great numbers nor of large size: I have never seen, in that district, any regular pebble-bed in the Reading Series *. The basement-bed of the London Clay, however, usually contains pebbles, and generally many of large size, as was found to be the case at Stoke Farm, in the mass of London Clay nearest to the section now under notice; and very often there is a layer of them at the lowest part of this bed. I have therefore no doubt whatever that *the pebble-bed of this section belongs to the basement-bed of the London Clay; and therefore that the overlying sands are part of the Bagshot Beds, and that the London Clay proper has here thinned out.* The section would then stand thus:—

1. Lower Bagshot Beds.—Light-coloured sands, with seams of pipe-clay .... about 12 or 15 feet.
2. Basement-bed of the London Clay.—A pebble-bed . . a few inches.
3. Reading Beds.—Sands and plastic clays .... about 15 feet.

I will now try to show that the above conclusion is borne out by other facts. We have seen that at Stoke Farm the Reading Beds and the London Clay are neither more than 15 feet thick. That the latter thins westward from London has been shown by Mr. Prestwich †, although he seems to have underrated the extent of the thinning; and as from Reading to Great Bedwin, a distance of about 28 miles, it has dwindled from 350 feet to 15 (or at the rate of about 12 feet in a mile), one can have no difficulty in inferring that two miles further westward it has thinned out altogether (with the exception of part of its basement-bed). Moreover the upper sands of the section in question, with their seams of pipe-clay, are lithologically more like Lower Bagshot Beds than anything else.

At the brickyard on the western side of the outlier (close to the yard just noticed) the section was not very clear when I saw it (in May 1859). Chiefly sands were shown; and at one part there was, at the top, a small irregular patch of green sand: could this be a part

* The statement of Mr. Prestwich (in Quart. Journ. Geol. Soc. vol. x. p. 79) with regard to Marlborough Forest, that "the greater part of these fine woods are planted on a thin and irregular capping of the clays and pebble-beds [of the Reading Beds] on the Chalk," is likely to mislead, although, in a foot-note, Mr. Prestwich includes also "a clay and gravel drift." Only a small part of the Forest, not more than a square mile indeed, is on Lower Tertiary beds; but a very large part is on the drift-clay, brick-earth, and clayey pebble-gravel so abundant in this neighbourhood.

† Quart. Journ. Geol. Soc. vol. x. p. 401.

of the Bracklesham (or Middle Bagshot) Beds?—if so, the Lower Bagshot Sand must be thin here.

A little to the north-west of the northern end of the above outlier there is a patch of sand, thickly overgrown with wood.

At Leigh Hill is another sand-outlier, the boundary of which is not quite clear. There are some very large and fine Scotch-firs on and near this the most western mass of Lower Tertiary beds in the London Basin.

Surface-deposits on the Chalk of this District.—These are of two sorts—the more widely spread being a stiff clay of a brown or red colour with angular flints, which I term "Clay-with-flints *;" the other and more valuable one being a loam or sandy clay of various colours, mostly fit for making bricks of, and known therefore as "Brick-earth."

The Clay-with-flints lies very irregularly on the Chalk, for the most part filling pipes in that rock. The Brick-earth is generally underlain by the clay.

As there is no Survey-memoir illustrating Sheet 14, it will be well to note here the range of these surface-beds, which were at first mapped and published as Eocene in that sheet. The Clay-with-flints rarely occurs on the top of the great Chalk-escarpment overlooking the Vale of Pewsey; but it covers the Chalk over nearly the whole of the higher grounds from the eastern part of the district westward to near East Kennet—not, however, in one continuous sheet, but forming many separate patches. The Tertiary beds are free from it; indeed the Clay-with-flints does not seem to occur elsewhere than on the Upper Chalk, as I have before noticed (in the Geological Survey Memoir on Sheet 13, p. 55).

Over this widespread bed of clay there is here and there a mass of the more sandy Brick-earth. Near Tevals Farm, about two miles S.S.W. of Marlborough, there is a brickyard; there is another by the turnpike-road about a mile S.E. of the same town; and a third on the west of Hens Wood, some three miles to the E.N.E. Without doubt there are many other masses of Brick-earth, which perhaps may be too thin or too full of pebbles to be worked. The bricks made from this bed in the neighbourhood of Marlborough are remarkable for their beautiful rich crimson colour, as may be seen in many of the buildings in that town. These surface-beds are not marked by features as the outliers of true Tertiary beds are for the most part. Thus whilst the latter rise from above the surrounding Chalk, the former merely fill hollows in that rock, and have only been saved from denudation by their sheltered position. As to their age and origin I do not feel able to give an opinion with any certainty.

Part II.—This part does not refer to structure, but simply to thickness; in it I shall make use largely of the sections given by Mr. Prestwich in his papers "On the Thanet Sands †," "On the

* See Memoir illustrating Sheet 13 of the Map of the Geological Survey, p. 54.

† Quart. Journ. Geol. Soc. vol. viii. p. 235.

Woolwich and Reading Series *," and "On the Thickness of the London Clay †." It will be better to begin with the lowest formation, and to work upwards.

The Thanet Sand.—Mr. Prestwich has fully noted the westerly thinning out of this bed of fine soft light-coloured sand; and I cannot do better therefore than quote his words on the matter, from the first of the above-mentioned papers (p. 241). "In some parts of the neighbourhood of Canterbury they cannot be much less than 80 to 90 feet thick. They then apparently maintain a tolerably uniform thickness of from 60 to 70 feet, as far as Chatham, Upnor, and Gravesend. At Bexley Heath they have been ascertained to vary in thickness from 45 to 55 feet, and at Woolwich I find that they are 60 feet thick. Beneath London their thickness averages from 30 to 40 feet. They then become more rapidly thinner as they trend underground further westward, being only 20 feet thick at Wandsworth, 17 feet at Isleworth, 7 feet at Twickenham, and 3 feet at Chobham, beyond which they thin out, although I believe that originally they probably had a range westward coextensive in some measure with the green-coated flints overlying the Chalk ‡."

Along its line of outcrop in Surrey, the Thanet Sand thins westward from Croydon and Beddington (where it is full 30 feet thick), until at Ashstead it is but a few feet in thickness. Further to the west I know of no section in it.

Its thickness beneath London and the country to the west is known by means of well-sections: thus near Westbourne Grove it was found to be 18 feet thick §. Mr. Prestwich says, "At Willesden there are several deep wells, but I have not been able to obtain an exact section of any of them. From a good supply of water, however, being obtained before reaching the Chalk, it is probable that the Thanet Sands have here commenced ||." At the Hyde, 2½ miles north of the village, the following beds were found:—

1. London Clay, and its "basement-bed" .... 66 feet.
2. Woolwich and Reading Beds.—Sands, clays, and pebbles 34 ft. 8 in.
3. Chalk.

* Quart. Journ. Geol. Soc. vol. x. p. 75. † Ibid. p. 401.

‡ I hardly think that such is the case; for the bed of green-coated flints above the Chalk in Berkshire, &c., is a part of the "bottom-bed" of the Reading Beds, which lies on the top of the Thanet Sand when that formation is present, and is therefore not to be confounded with the bed of flints at its base. It is possible, however, that (as Mr. Prestwich believes) the two beds may join together to the west of London where the Thanet Sand has thinned out, and thus that the roughly laminated grey clay and the clayey green sand, with oyster-shells and green-coated flints, that overlie the Chalk at Reading and Newbury (see Memoir illustrating Sheet 13 of the Map of the Geological Survey, p. 23, and also the Memoir on Sheet 12, p. 27) may represent the bottom-bed not only of the Woolwich and Reading Beds, but also of the Thanet Sand. Speaking generally, where the Thanet Sand is present the bottom-bed of the Woolwich and Reading Beds does not contain the green-coated *angular* flints so common in Berkshire, &c., but the flints are in the state of pebbles: this need cause no surprise, however, as where the latter formation was not deposited directly on the Chalk, it is not likely that it should contain *unworn* flints that must be derived directly from that rock.

§ Quart. Journ. Geol. Soc. vol. x. p. 96. || Ibid. p. 95.

So that the Thanet Sand is absent, as is also the case further northward.

At Castlebear Hill, near Ealing, and at the Hanwell Lunatic Asylum, the Woolwich and Reading Beds were found directly above the Chalk *; and the Thanet Sand does not occur anywhere further to the west.

The Woolwich and Reading Beds seem to have their greatest thickness near London, but do not vary much in this respect eastward of Hungerford (not taking into account any northerly thinning).

With regard to the beds S.E. and E. of London, I do not agree with Mr. Prestwich in classing the thick pebble-bed of Blackheath &c., with the basement-bed of the London Clay: I take it rather to be the top part of the Woolwich and Reading Beds. In the neighbourhood in question the former really consists of a clayey pebble-bed, from a few inches to rather more than three feet in thickness. It may be seen at Loam-pit Hill (Lewisham), in the cutting on the London and Brighton Railway south of the New Cross Station, in that (on the Croydon and Epsom Railway) S.W. of West Croydon Station, in that (on the Mid-Kent Railway) east of Beckenham, and in a brickyard about half-way between the Bromley and Bickley Stations. At the eastern end of the long cutting at Bickley, I saw it (in November 1860) overlain by London Clay, and overlying a *sandy* pebble-bed, like that of Blackheath, which is here the top bed of the Woolwich and Reading Series. In the clayey "basement-bed" the pebbles were, as usual, without any orderly arrangement; whilst those of the underlying bed were arranged in lines of false bedding (with a westerly dip of 10° to 20°) through the whole length of the section (about 400 yards). The sides of this cutting have since been covered up.

I am also inclined to think that in a more eastern part of Kent Mr. Prestwich has again been too generous to the basement-bed of the London Clay. In the neighbourhood of Herne Bay he includes in it a bed of sand underlying the true London Clay, but which, for my part, I would rather class with the Woolwich and Reading Beds. At the southern end of the large cutting on the Sheerness Branch Railway, about a mile and a quarter north of Sittingbourne, I saw, in December 1860, the following section (quite clear, and of some length):—

London Clay, partly of a greenish colour; no pebbles at the base, and nothing like the usual basement-bed to be seen.

Light-coloured sand; at the base a bed of shells, in a bad state of preservation .... about 6 feet.

Brown clayey sand, with obscure casts of shells (*Cyrena cuneiformis*? and *C. cordata*?) and a few flint-pebbles .... about 1 foot.

White and light-coloured sand, with beds of shells, very perfect, but very easily broken (*Cyrena cuneiformis, C. cordata, Ostrea, Melania inquinata, Cerithium*), of which there was to be seen about 8 feet.

* Quart. Journ. Geol. Soc. vol. x. p. 94.

That this lower sand belongs to the Woolwich and Reading Beds there can be but little doubt, as it abounds in some of the characteristic fossils of that formation. The upper sand groups itself naturally with the lower, the only difference being that the former contains but few fossils. If such be the case, it follows that the basement-bed of the London Clay is here altogether absent. It is possible, however, that the upper sand and the loamy bed beneath may belong to it, although the former is utterly unlike the undoubted basement-bed wherever I have seen it, that is, from Marlborough Forest to near Hemel Hempstead on the northern side of the London Basin, and from Peckham and Croydon to Chiselhurst on the southern.

It is but right to state that Mr. Prestwich is very doubtful in separating the Blackheath pebble-bed from the Woolwich and Reading Beds, and that he has also some doubt as to the place which should be given to the sands that underlie the London Clay near Herne Bay. Thus he says, "The difficulty is, whether we are to consider any of the peculiar, fossiliferous, sandy, or conglomerate beds of Woolwich, Bromley, and adjacent districts as a fuller development of the basement-stratum of the London Clay, or whether they all belong to a distinct and underlying series. *I am rather inclined, on structural evidence, to the latter opinion*; nevertheless on palæontological grounds it might be presumed that a passage here exists between the two series*:" and again, "I feel slightly doubtful whether some of the thick pebble-beds under and around Shooter's Hill may not belong to the upper part of the Woolwich series, rather than to the basement of the London Clay; the beds which at Upnor and Herne Bay I have included in the 'Basement-bed' may also possibly belong to the upper section of the Woolwich series. I mention these doubts, which, however, do not affect the superposition and grouping of the three divisions here proposed" (Basement-bed of London Clay, Woolwich and Reading Beds, and Thanet Sand), "although it would modify the exact lines of separation, in order to direct attention to any new facts which may arise to throw light upon those questions where I consider the evidence not quite conclusive †."

If the upper sands of Upnor, &c., be classed with the Woolwich and Reading Beds, we need feel no surprise at so many fossils of that formation being found in them.

If the above-noticed beds be classed with the Woolwich and Reading Beds, that formation will have a thickness of about 50 feet near Herne Bay, instead of only 30; and at Croydon of 45 feet, instead of 36. At New Cross they are 54 feet thick; under parts of London from 40 to 70 feet; at Ealing 60 feet; at Hanwell 75 feet, and at Isleworth and Chiswick as much as 87 and 90 feet respectively ‡.

From London westward, by Windsor, Reading, Newbury, and Hungerford, the Reading Beds have a general thickness of from 40 to 60 feet (being subject to slight local changes), until near Great Bedwin, to the west of which place I have shown, in the first part

* Quart. Journ. Geol. Soc. vol. vi. p. 262. † Ibid. vol. x. p. 130, *foot-note*.
‡ Ibid. pp. 94, 96, 105, and 142 to 151.

of this paper, that they are not more than 15 feet thick. They do not increase further westward in Marlborough Forest, the last point where they occur in the London Basin.

There is one other fact that seems to point to a thinning of the Reading Beds, though in what direction is not clear. In the western part of the London Basin, the basement-bed of the London Clay is remarkable for the common occurrence of large rounded flintsin it (generally in a line at its lowest part), often 6 or 8 inches in their longest diameter, and sometimes as much as 14 inches*, besides the ordinary flint-pebbles. Now, where any pebbles are found in the Reading Beds in the same district, they are not of large size. The most westerly place† where I have seen rounded flints of any great size in that formation is at Chorley Wood Kiln, about two miles W.N.W. of Rickmansworth (in an outlier); and these were in the "bottom-bed," which there consists of 10 or 12 feet of green sand full of pebbles. It would seem likely, therefore, that *the large rounded flints of the "basement-bed" of the London Clay were derived at once from the Chalk, or that, if they came from the Reading Beds, it was from the lower part of that formation*; or, in other words, that *the London Clay sea stretched over the Chalk where the latter was either wholly uncovered, or but slightly covered, by any older Tertiary formation.* In confirmation of this, I may quote Mr. Prestwich's words: "It is probable that the denuding action (which accompanied the formation of the basement-bed of the London Clay) acted not only on the mottled clays and the pebble-beds forming the upper part of the underlying series, but that it in places extended to the Chalk itself ‡." Mr. Prestwich, however, thinks that the rounded flints were all derived from older Tertiary beds, and not directly from the Chalk.

The Basement-bed of the London Clay.—This bed§ seems to reach its greatest thickness near Reading, where the light-brown loam, with green sand, shells, flint-pebbles, and masses of limestone and of iron-stone, of which it there consists, is 5 to 12 feet thick, whilst at Northcot (to the west) and at Nettlebed (to the north) it is 9 feet||.

In well-sections in and near London it has been found to be from 2 to 5 feet thick. Near New Cross it is only about a foot (in one of the sections at Loam-pit Hill, near Lewisham, it is, however, only three inches), and near Bromley from a foot to 3 feet. Further

* This great size is noted by Mr. Prestwich in Quart. Journ. Geol. Soc. vol. vi p. 259 (explanation of fig. 4).

† I speak of the northern outcrop of the Reading Beds. According to the sections given by Mr. Prestwich (in Quart. Journ. Geol. Soc. vol. x.) and by Mr. Bristow (in the Geological Survey Memoir on Sheet 12), clay chiefly prevails along the southern outcrop at the western part of the London Basin, and the sands do not contain pebbles.

‡ Quart. Journ. Geol. Soc. vol. vi. p. 277.

§ Not including therein the pebble-bed of Blackheath, &c., nor the sands just beneath the London Clay near Herne Bay. (See above, p. 267.)

|| See Memoir illustrating Sheet 13 of the Maps of the Geological Survey, pp. 49, 40, 52. Mr. Prestwich is mistaken in saying that "westward of London in no case does the basement-bed of the London Clay present a thickness of more than 5 feet" (Quart. Journ. Geol. Soc. vol. vi. p. 280).

eastward it seems to be thin; and if we class the upper sands near Herne Bay, &c., with the underlying Woolwich and Reading Beds, "the basement-bed itself might be considered in this area to merge into the thin seam of sandy clay just at the base of the great mass of the London Clay*." Westward of Reading it is from 2 to 5 feet thick, and in Marlborough Forest it has been shown to consist merely of a line of pebbles (see p. 262).

London Clay.—Of the London Clay itself Mr. Prestwich has observed the westerly thinning, as before stated. To quote his words, "It would appear that the London Clay gradually expands as it ranges from west to east, at first rather rapidly until it attains a thickness of from 300 to 400 feet, and then very gradually until, in the neighbourhood of London, it averages from 400 to 440 feet thick. In the Isle of Sheppey, and on the opposite Essex coast, however, it reaches its greatest development, being there apparently as much as 470 to 480 feet thick†." The thinning is, however, much sharper on the west of Reading than Mr. Prestwich has supposed. He shows that a few miles to the south-east of that town the London Clay cannot be less than 370 feet thick; and says, "there exist no definite measurements in the neighbourhood of Hungerford or Newbury; taking, however, into consideration the dip of the beds and the height of the hills, I do not think that the entire thickness of the London Clay there exceeds 200 to 250 feet‡." During the progress of the Geological Survey the data wanted for the measurement of the thickness of the London Clay were found, and my friend and colleague Mr. Bristow tells me that its thickness on the south of Newbury is not more than 50 or 60 feet, and that westward towards Hungerford it is, if anything, less. I have shown that at Oare, on the north of Newbury, it is less than 20 feet, the Bagshot Sand being there within that vertical distance of the Reading Beds§. On the west of Great Bedwin it has been proved to be not more than 15 feet thick; and in Marlborough Forest the London Clay proper seems to have wholly thinned out‖, all that there remains of the formation being a pebble-bed forming part of its "basement-bed."

Of the Bagshot Beds, which belong to the Middle, and not to the Lower Eocene Series, I do not now treat. Enough to say that Mr. Bristow tells me that south of Newbury the Lower Bagshot Sands are at least 100 feet thick; but that, as they are not capped by any of the Middle Bagshot Beds within some miles distance, their full thickness cannot be given.

Effect of the Westerly Thinning of the Lower Eocenes.—The result of the westward thinning of the Lower Eocene strata is, that in that direction the Bagshot Beds gradually get nearer to the Chalk. In Marlborough Forest we have seen (p. 262) that there is but 15 feet

* Quart. Journ. Geol. Soc. vol. x. p. 130, *foot-note.*
† Ibid. vol. x. p. 407. ‡ Ibid. vol. x. p. 402.
§ Memoir illustrating Sheet 13 of the Map of the Geological Survey, p. 54.
‖ This thinning-out does not necessarily indicate the original edge of the basin, but may be for the most part due to denudation before the deposition of the Bagshot Beds.

between those formations. Now, if the thinning should continue (as there is good reason to suppose, from its constancy in the districts where enough of the beds to show their order and thickness has escaped denudation), still further west *the Bagshot Beds would rest directly on the Chalk, all the Lower Eocene strata having thinned out.* This will, perhaps, be made clearer by the diagram-section, p. 263, which shows the thickness of the various Lower Eocene beds from Woolwich to Marlborough Forest.

Part III. *Age of the Greywethers.*—Mr. Prestwich has inferred * that the blocks of Greywether-sandstone scattered over the surface of the Chalk and other formations have once formed part of the Woolwich and Reading Beds. His reasons are, that their distribution is "in accordance with the range of the Lower London Tertiaries" [the basement-bed of the London Clay, the Woolwich and Reading Beds, and the Thanet Sand] "rather than with that of the Bagshot Sands;" and that, as there is no reason for supposing them to have come from either the basement-bed or the Thanet Sand, they must be referred to the intermediate Reading Beds;—that this conclusion is borne out by the facts that the occurrence of the greywethers "is exactly coincident with the development and preponderance of the sand-beds of the mottled clay" (that is, the Woolwich and Reading) "series," and that "the lithological structure of each variety is respectively in accordance with the mineral components forming the strata in the immediate vicinity . . . . . . *i.e.* that the concretionary stone in each case represents the component parts of some portion of the adjacent Woolwich and Reading series;" thus, "in the neighbourhood of Hatfield, Hertford, and Ware, the sands of the Reading Series . . . . . . are often . . . . . . glutted with flint-pebbles; it is over this area more particularly that the Hertfordshire puddingstones are so abundant."

Speaking of the gravel-drift around Newbury, which contains many blocks of greywether-sandstone, Mr. Prestwich says, "The course of this drift is towards, and not from, the area of the Bagshot Sands; and as we have no proof of the extension of this formation over the chalk-downs, whereas we know that detached outliers of the Lower Tertiary sands extend far over those hills, we should expect to find in the drift the *débris* derived from the latter and from the Chalk, and not from the Bagshot Sands."

I think, however, that what has been said in the former parts of this paper must lessen the force of Mr. Prestwich's argument, founded as it is on evidence "circumstantial rather than direct." I have not only proved the extension of the Bagshot Sand over the chalk-downs, but have shown that in Marlborough Forest, owing to the dying-out of the London Clay and the thinning of the Reading Beds, that formation is but 15 feet or so from the top of the Chalk. If the Reading Beds became still thinner further westward, as is most likely to have been the case (unfortunately there are no outliers of any Tertiary bed on the Chalk in that direction), *the Bagshot Sand would gradually*

* Quart. Journ. Geol. Soc. vol. x. pp. 123–130.

get nearer to the Chalk, and at last would lie on that rock. Now it is just at the part where one would expect this to happen that the greywethers occur in by far the greatest number, which naturally leads to the inference that they have some connexion with that formation, and indeed have most likely been derived from it.

On the surface of the chalk-country westward of Marlborough (Sheets 14 and 34 of the Geological Survey Map) there are literally tens of thousands of greywethers. Speaking of their occurrence in this district, Prof. Ramsay says,—"A few of the places where they are most numerous are marked 'large stones' on the Ordnance Map; but these yield no idea of their surprising number, or of the extent of ground they cover, no indication being given of their occurrence over many large areas where they strew the ground so thickly that across miles of country a person might leap from stone to stone without touching the ground on which they lie. Many of these flat masses of grit are four or five yards across, and they are often four feet in thickness *." I saw one block, in a valley on the northern side of the Kennet, that measured $13 \times 10 \times 7$ feet, that is to say, contained, allowing for irregularity of surface, about 850 cubic feet. In the distance it looked like a small hut.

Greywethers are not only found on the surface of the Chalk and older formations, but also on the London Clay (though not in such large numbers), and that too at a distance of some miles from the outcrop of the underlying Woolwich and Reading Beds, as is the case to the north-west of London; which fact favours the notion that they have come from the overlying Bagshot Beds rather than from a formation below the London Clay.

As it is known that here and there sandstone occurs in various parts of the Bagshot Series, there is nothing unlikely in the view that greywethers may have been thence derived. Indeed Mr. Prestwich has noticed that most of the stones have "a lithological structure very similar to that of the blocks found irregularly dispersed sometimes in the lower, but more especially in the upper division of the Bagshot Sands between Esher and Strathfieldsaye."

I do not think, however, that all greywethers came from the Bagshot Sands. Many, I have no doubt, have been derived from the Woolwich and Reading Beds; indeed I have seen a large mass of sandstone in place in an outlier of that formation at Langley Park, near Beedon, to the north of Newbury †. Again, on the south-east of London there is a thick pebble-bed in that formation, which in the neighbourhood of Bromley is often hardened into a pudding-stone, large blocks of which may be seen in the railway-cutting at Beckenham. The blocks of pudding-stone so common on the surface of the chalk-district of Hertfordshire, &c., I think (with Mr. Prestwich) also belong to this Series. Other greywethers possibly, but not large ones, came from the Basement-bed of the London Clay, which in some places contains a bed of sandstone. But I hold that the occurrence, in vast numbers, of these sandstone-blocks westward of Marl-

* Memoir illustrating Sheet 34 of the Geological Survey Map, p. 41.

† See Memoir illustrating Sheet 13 of the Geological Survey Map, p. 35.

borough, just where we should expect, on quite independent grounds, that the Bagshot Sand at one time rested at once on the Chalk, proves, as far as indirect evidence can, that there they have come from that formation; and it seems to me that their sudden abundance in that neighbourhood, where they almost form a giant pavement along some of the valleys, cannot be in any other way so well accounted for as by that westerly thinning of the Lower Eocene beds treated of in the second part of this paper, and the result of which has been to bring the Bagshot Series without doubt very near to, and most likely actually on, the Chalk in that neighbourhood.

According to this view, it is in that district where the greywethers have suffered least vertical displacement (through the denudation of the softer beds of the formation to which they belonged), in their subsidence from their original position to the one they now occupy, that they occur in the greatest abundance.

On the Sands of Netley and Headley Heaths.—It may be as well to mention here that Mr. Godwin-Austen is disposed to class with the Lower Bagshot Beds some outliers of sand that occur on the Chalk of Surrey, to the east of Guildford. For my own part, however, I do not think that the sands of Netley Heath and Headley Heath are of so great an age. I take them to belong to the same set of beds as the sands of Chipsted (south of Croydon) and Paddlesworth (near Folkestone), which have been referred by Mr. Prestwich to the age of the Crag *. I think that their method of occurrence, or their "lie," is too irregular to allow us to class them with the Lower Bagshot Beds. At Headley they seem to abut against an outlier of the Lower Eocene Beds, with which series most surely they have no kinship; and they here and there spread some way down the slopes of the valleys.

From what has gone before it is clear that, just to the north of the district where these sands are found (in Surrey), the London Clay is not less than 400 feet thick: I cannot think it likely that that formation should thin off so suddenly southwards, without any sign, and that the Lower Bagshots should also cut through the Woolwich and Reading Beds and the Thanet Sand to the Chalk. This would show a great unconformity between the Middle and Lower Eocene Series, which we have no other reason to look for; the resting of the Bagshot Beds on the Chalk, that I have shown to be most likely to take place at the western end of the London Basin (see p. 262), being caused chiefly by "overlap."

Nevertheless, as all that one can say of the Headley Sands is that they are newer than the London Clay, there is just a possibility that they may belong to the Bagshot Series; but, from what I have seen of them (in many places), I take this opportunity of stating my belief that they are much more likely to belong to the Crag, or even to a later formation, though I can as yet see no evidence as to their exact place in the geological series.

However, should they turn out to belong to the Bagshot Beds,

* Quart. Journ. Geol. Soc. vol. xiv. p. 322.

they will give further evidence in favour of the theory that the greater part of the Greywethers have come from that formation; for patches of them occur in many places along the Chalk-range of Kent, in which, and on the surface of the older cretaceous beds rising from its base, there are many greywether-blocks, that in this case would here, as near Marlborough, have some connexion with the range of the Bagshot Beds, being more plentiful where that Series is least separated from the Chalk.

I have noticed the sands of Netley and Headley Heaths but shortly. A more detailed account of them will be given in a memoir (now preparing) to illustrate Sheet 8 of the Map of the Geological Survey of Great Britain. All that is needful here is to note the bearing that they *may* have on the Greywether-question.

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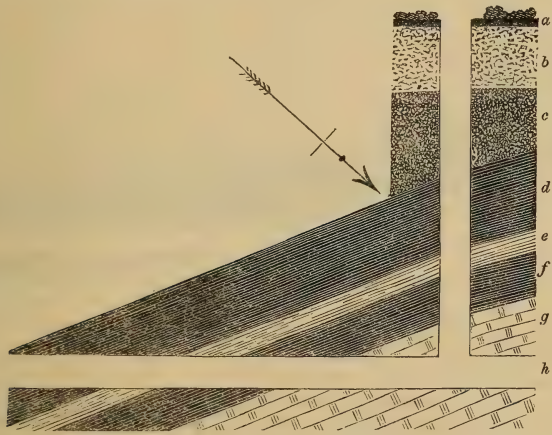
3. *On a Deposit with* Insects, Leaves, *&c., near* Ulverston. By John Bolton, Esq.

[Communicated by the President.]

The deposit described in this communication has been sunk through during the progress of works undertaken by the Lindale Cote Iron-ore Company, for drainage-purposes. The mines are situated in the well-known hæmatite district of Low Furness, about three miles S.W. of Ulverston, in a valley between two ranges of low hills belonging to the Mountain-limestone series. The physical geology is varied in character,—a fine sequence of the following beds in descending order from the Upper Silurian occurring in the hills lying north of this valley, viz., Lower Ludlow Rocks, Upper Ireleth Slates, Lower Ireleth Slates, Coniston Grit, Coniston Flags, Coniston Limestone (equivalent to the Bala Slates), and Green Slates with Porphyry, which last rocks extend northward for many miles beyond the boundary of Furness. South of the valley in which these mines are situate, the Mountain-limestone is developed on a large scale, being upwards of six miles in breadth. The exact position of Lindale Cote Mine, upon the promontory of Furness, is about halfway between Morecombe Bay and the estuary of the Duddon.

In sinking shafts to a water-way driven from the Lindale Cote to Urswick Tarn, in 1855, down the course of a valley lying about 100 feet below the table-land, and receiving the drainage of about 600 acres, a deposit of greenish-drab clay, six feet in thickness, was met with at a depth of forty feet from the surface, in the shaft nearest but one to the mines, and at the highest "level." This clay-bed contained pieces of unfossilized wood, associated with numerous leaves, seed-vessels, and other vegetable remains. Among the few which can be determined are, leaves of Beech, with the epicarp of the fruit-receptacle, and a well-preserved branch of Sphagnum. A few well-preserved Insects also occurred in the deposit. Of these some have been determined by Mr. Stainton, F.G.S., as fragments belonging apparently to a land Hemipterous insect, and one as a portion of an Orthopterous wing. Three nearly perfect specimens of Apterous Hemiptera he referred to *Cimex*, or an allied genus. Microscopical examination of this clay shows us the conditions under which it was deposited*. It is seen to be chiefly composed of lacustrine *Diatomaceæ*, the facies of which point directly to a mountain-tarn as the origin and support of their existences. The list of forms obtained from it is nearly paralleled by those which Dr. Balfour and other gatherers of *Diatomaceæ* have obtained from subfossil clay- and peat-deposits in the Mull of Cantire and elsewhere. The genera represented are *Gomphonema*, *Tribunella*, *Epithemia*, *Surirella*, *Cocconeis*, *Cyclotella*, *Pleurosigma*, *Campylodiscus*, *Navicula*, *Tetracyclus*, *Odontidium*, *Cymatopleura*, *Cymbella*, *Stauroneis*, *Pinnularia*, *Synedra*, and *Eunotia*. These have been kindly determined for me by Dr. Wallich, F.G.S. Siliceous spicules of freshwater Sponges also occur in this deposit.

Fig. 1.—*Section of a Shaft at the Lindale Cote Mines, near Ulverston.*



a. Soil; 3 feet.
b. "Pinel" (Rubble); 10 feet.
c. Gravel; 12 feet.
d. Black muck; 16 feet.
e. Clay bed with vegetable matter and Insect-remains; 6 feet.
f. Black muck; 14 feet.
g. Limestone; 12 feet.
h. Water-way.

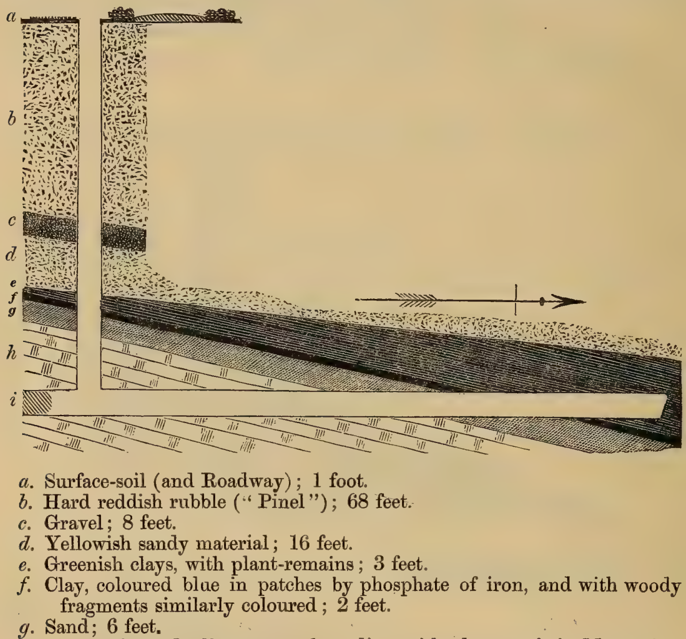
The length of the water-way driven from the mines to the tarn is a mile and a quarter; and in the portion tunnelled twelve vertical shafts were sunk at convenient distances—nine in the bare Mountain-limestone at the lower end of the adit, and the remaining three through the overlying Drift, which at No. 10 shaft was thirty feet

* To Miss E. Hodgson, of Ulverston, is due the credit of examining this deposit for *Diatomaceæ*, and mounting the specimens that are here referred to.

in thickness, at No. 11 sixty feet, and at No. 12 thirty feet. It is therefore evident that a basin in the limestone was crossed by the line of the work.

Probably these clays have a considerable extension to the N.E. and S.W.; for thin beds of the same deposits were met with in a trial-shaft sunk by the Lindale Cote Company at the highest part of the table-land, one-third of a mile S.W. of No. 11 shaft, and at the same level. Here, as in the first-proved locality, the clays yielded vegetable remains and *Diatomaceæ*. The accompanying section is that of the shaft in question:—

Fig. 2.—*Section of a Shaft at the Lindale Cote Mines, near Ulverston.*



a. Surface-soil (and Roadway); 1 foot.
b. Hard reddish rubble ("Pinel"); 68 feet.
c. Gravel; 8 feet.
d. Yellowish sandy material; 16 feet.
e. Greenish clays, with plant-remains; 3 feet.
f. Clay, coloured blue in patches by phosphate of iron, and with woody fragments similarly coloured; 2 feet.
g. Sand; 6 feet.
h. Very soft sandy limestone, abounding with characteristic Mountain-limestone fossils; 22 feet.
i. The North Drift, with the Iron-ore in the Limestone.

The eight feet of gravel alluded to in this section is of the ordinary alluvial character, made up of water-rolled pebbles of Upper and Lower Silurian rocks, bedded in quartz-sand. There is elsewhere evidence of this drift-deposit having resulted from north-westerly currents.

From the lowest part of the soft limestone thus pierced, a horizontal drift was driven northward in search of iron-ore; and in progress of the work, it was found that the limestone and the lowest superimposed beds had a steep downward inclination; also, that the plant-bearing deposit, when cut through by the gallery, had thickened to fifteen feet. The wood imbedded in the lower seams of the clay was partly converted into a soft, blue pigment, having phosphate of iron for its colouring-matter.

Thus it appears evident that the areas anciently covered by the lake-water were those of the long valleys which course sinuously between the low hills of Furness.

A second adit, driven southward from the bottom of the shaft, cut into a good bed of iron-ore at twenty feet from the commencement.

Glancing backwards for a moment at this scant record of a local and comparatively insignificant deposit, I diffidently claim a value for it in any scheme cast for the determination of Pleistocene time. In the absence of great and sudden cataclysmal irruptions of water which could fill valleys with drifted material, and of which I conceive we have no settled evidence, it appears to me that the time required for the deposition of this great thickness of nearly 100 feet of transported material upon the comparatively flat surface of this lacustrine clay by the ordinary degradation of the low hills around it must be one far extended beyond our ordinary notions. The material of which the whole thickness of the superimposed deposit is composed is of strictly local origin, and, in the absence of violent sweeps of north-lying water, and sudden fillings-up, by such means, of the shallow valleys by the locally derived detritus, I am at a loss to see how the distribution could have been effected, except by ordinary aqueous and pluvial agencies extended through a long period of time.

P.S.—Since the above paper was communicated, the miners have exhausted the iron-ore in the pit, section fig. 2; and then they sank to a further depth of about 30 feet, but without getting through the soft limestone. They have now left it altogether, and have sunk another shaft about 220 yards to the north of it; and at about the same relative depth they have found the same deposit, containing vegetable remains, &c., but not in abundance. The miners say also that they found the same material in a shaft about 200 yards north from this new shaft, that is, about 420 yards north of No. 2 section. If this be correct (and I have no reason to doubt it), it demonstrates that the deposit covers a triangular area, the three sides of which are respectively 420, 450, and 600 yards in length.—May 24, 1862, J. B.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 7, 1862.

The Rev. R. Stopford Brooke, Fern Lodge, Campden Hill, Kensington; Henry Francis Blanford, Esq., Bouverie Street; Edward Fitton, Esq., 6 Gloucester Crescent, Westbourne Terrace; Frederick Hill, Esq., Penhellis, Helston, Cornwall; John Langley King, Esq., 56 Wells Street, London; and Charles Rogers, Esq., 16 Beaufoy Square, Maida Vale, were elected Fellows.

The following communications were read:—

1. *On new* Labyrinthodonts *from the* Edinburgh Coal-field. By Professor Huxley, F.R.S., Sec. G. S., &c.

[Plate XI.]

1. *Note respecting the Discovery of a new and large Labyrinthodont* (Loxomma Allmanni, *Huxley*) *in the Gilmerton Ironstone.*

During my visit to Edinburgh in January last, my friend Professor Allman, becoming aware that I was engaged in collecting materials for the study of the genus *Rhizodus* (Owen), very liberally granted me free access to the large collection of vertebrate fossils from Burdie House and Gilmerton, in the Museum of the University.

I thus became acquainted, for the first time, with the upper and under aspects of the head, and with the indubitable scales of this remarkable fish; and, putting the information thus obtained with that derived from the study of specimens in many other collections, I am now in a position to prove that *Rhizodus* is one of the cycliferous Glyptodipterini.

But, while looking through the large series of remains from the Gilmerton ironstone in the Edinburgh Museum, most of which are referable to *Rhizodus*, I came upon two or three specimens of a very different character. The most important and significant of these is the fragment of the hinder part of the upper wall of a large cranium (Pl. XI. fig. 1) presenting its smooth inner, or under, surface to the eye. Where the substance of the bone has been broken away, however, the impressed surface of the matrix shows that the outer, or upper, surface was ornamented with strong inosculating ridges separated by intermediate grooves. The serrated sutures of the bones composing this fragment of a skull are, for the most part, distinctly traceable, and prove it to be composed of two quadrate, supraoccipital elements, with two elongated parietal bones, the apposed edges of which are deeply notched at the junction of their middle with their posterior third, so as to give rise to a rounded parietal foramen, $\frac{3}{10}$ths of an inch wide. The parietals unite, in front, with a pair of frontals, which are narrow behind, but expand anteriorly, and then become broken and disfigured. An arcuated postfrontal is connected with the posterior moiety of the outer edge of each frontal, and with the antero-external edge of the parietal. Externally, its smooth, almost vertically bevelled, margin bounds the inner and posterior part of the orbit. The latter cavity has an irregularly oval shape, the long axis of the oval being directed, from without and in front, obliquely inwards and backwards, at an angle of about 45° with the long axis of the skull. The anterior and outer part of the wall of the orbit is broken away; but, internally, it is bounded by a stout prefrontal, on the under face of which is the indication of a ridge, now broken away, but which once projected towards the palate. The prefrontal joins the postfrontal and, just in front of the junction, expands, somewhat suddenly, outwards, so as to form a sort of promontory which disturbs the even contour of the orbit on its inner side.

The postero-lateral boundary of the orbit is formed, in its hinder half, by a postorbital bone, and, in its anterior half, by what appears to be the jugal bone. All that remains of the outer boundary is a trihedral bar of bone 0·5 inch wide, which I take to be the hinder part of the maxilla, though it may be the continuation, forwards, of the jugal. This bony bar is concave on its outer or upper surface, which is coarsely sculptured, while its inner and outer surfaces slope towards one another, so as to form an edge below, which is sharp in front and gradually dies away behind. The outer face is flat, and exhibits a delicate rugose sculpture: the inner is slightly excavated.

Behind the orbit the lateral part of the roof of the cranium widens, and is produced, at its external and posterior angle, into a broad, expanded, and irregularly shaped plate, whose extreme outer point is broken away. In consequence of the projection of this plate beyond the general contour of the skull, the lateral margin of the latter curves suddenly outwards, midway between the orbit and the postero-lateral extremity, and then passes into the straight outer edge of the plate in question. This plate appears to be mainly formed by the quadrate and squamosal bones. Internally it presents a curved contour, convex inwards, which sweeps round when it reaches the posterior margin of the skull, and then passes backwards into the lateral boundary of the epiotic bone. The posterior contour of the skull, consequently, presents a deep notch between the epiotic bone and the plate in question. The epiotic bone, small and pointed posteriorly, is wedged in between the supraoccipital element, the parietal, and the squamosal.

The description here given refers chiefly to the right (proper) half of the skull. The left half is broken away, so as to leave only the left supraoccipital, the left parietal, and part of the left frontal and postfrontal. The complete preservation of the latter bone fortunately enables one to form an accurate judgment of the minimum width of the interorbital space.

The structure of the cranial fragment which has been described proves it, without doubt, to belong to a Labyrinthodont Amphibian, and affords sufficient evidence of the character of the whole skull. The straightness of what remains of the external edge renders it probable that the skull was elongated, like that of *Archegosaurus*; and on completing the left side of the posterior part of the skull by the aid of the right side, and restoring the general contour on the basis of *Archegosaurus*, we get a diagram of the whole skull which is probably not very far removed from the truth.

Posteriorly the skull had a width of $10\frac{1}{4}$ inches; and if the snout were even less acute than that of *Archegosaurus*, its total length would be about 14 inches. The largest *Archegosaurus* skull known does not exceed 12 inches in length.

From the skull of *Archegosaurus*, and from that of all other Labyrinthodonts at present known, the present specimen is distinguished by the proportional size, backward position, form, and very oblique disposition of the long axes of the orbits. And as the orbits of species of known genera of Labyrinthodonts do not differ from one another in any essential respect, I conceive this character to be of generic importance; and I propose the name of *Loxomma* for the new genus thus characterized. The species may be termed *Loxomma Allmanni*, after the eminent Professor of Natural History in the University of Edinburgh, who aided me so essentially in discovering it.

The skull, however, was not the first relic of this interesting Amphibian which came to light. What, in fact, originally led me to divine the existence of a large new Labyrinthodont in the Scotch coal-field, was the discovery of a rhomboidal plate of bone so extremely similar to the middle sternal plate of a Labyrinthodont as at once to awaken suspicion. Subsequently I found another specimen, exhibiting this median plate with the triangular lateral plates, which are connected with its antero-lateral edges in Labyrinthodonts, *in situ*. This specimen is represented in fig. 2.

The median plate is $5\frac{3}{4}$ inches long, by at least $2\frac{1}{4}$ inches broad at its widest part. Its anterior extremity is broken away, but, I think, not for any great extent. Its posterior end (almost entire) is abruptly truncated, and $\frac{3}{4}$ of an inch wide. It continues of about the same width for nearly an inch, and then its edges, becoming thinner, sweep outwards with a slight curve until the plate attains the maximum width I have mentioned, at a distance of $2\frac{1}{2}$ inches from its hinder end. Here it becomes so completely overlapped by the lateral plates, that no more can be said about its lateral contour. A fragment of a somewhat larger plate of the same kind leads me to believe, however, that the bone does not attain any much greater width anteriorly. The middle of the plate is thicker than its edges; and shallow, slightly reticulated grooves diverge from the concealed centre of the bone, towards its thin edges, before reaching which they are lost. The form of what remains of the lateral plates is given in the figure; they are thicker internally, and exhibit the same radiating grooved sculpture as the median plate. The grooves diverge from the middle of the inner margin of each plate.

2. *Description of a new Labyrinthodont* (Pholidogaster pisciformis, *Huxley*).

Loxomma is not the only Labyrinthodont in the Edinburgh coal-field. Some years ago a remarkable fossil was obtained from the same district by Sir Philip Egerton and the Earl of Enniskillen, but as, on mature consideration, it appeared to them not to be a fish, it was handed over to the British Museum. My attention was long ago drawn to this specimen by Mr. Davis, of that Institution, who, at the same time, very justly remarked upon the resemblance in the arrangement of the scales between this animal and *Archegosaurus*.

A recent careful study of the fossil has fully borne out Mr. Davis's suspicion, and has convinced me that the fossil is an Amphibian allied to *Archegosaurus*, though it differs from the latter in the form of the head, the extent to which the ossification of the vertebral column has proceeded, and in the characters of its dermal armour. It shares with *Archegosaurus*, however, the peculiarity of having its overlapping scales arranged in double oblique series between the pectoral and pelvic arches only, whence, and on account of its fish-like form, I propose the name of *Pholidogaster pisciformis* for the genus and species.

The specimen (Pl. XI. fig. 3) is in a very indifferent state of preservation, and is so disposed in the matrix as to show the under or ventral surface of the head and body. Its total length is about 43 or 44 inches, of which the head occupies less than $\frac{1}{6}$th, the ramus of the lower jaw being 7 inches long. At its hindmost or widest part, the head measures about 5 inches in transverse diameter. In shape it resembles an oval bisected along its short diameter, the snout being completely rounded off. In front of the symphysis of the mandible, the under surface of the premaxilla is visible, bearing the stumps of two teeth. These teeth are situated at some distance (about 0·7 of an inch) from the middle line, and pass outside the ramus of the mandible. They are conical, and round in transverse section. Neither is entire; but the fragment on the right side is the longer (0·2 inch), and is slightly curved, its convexity being directed forwards. The bases of the teeth are marked by strong longitudinal grooves.

The right ramus of the mandible is better shown than the left, though both rami are more or less distorted and crushed. The angular piece is large, and has the form and sculpture common among Labyrinthodonts.

Between the hinder parts of the rami of the mandible, but nearer the left than the right, are two bony plates, having the form of right-angled triangles, with their bases backwards, and their perpendiculars directed inwards, close to and parallel with one another. More of the right plate is visible than of the left, and its outer angle is seen to be produced into a process which is bent at a right angle towards the dorsal side of the body. A coarse sculpture, consisting of ridges which radiate fanwise from the outer angle of each plate towards its inner edge, and anastomose, so as to leave elongated pits, marks the surface of these plates.

I conceive that these correspond with the lateral thoracic plates of the Labyrinthodonts, thrown out of their proper places and approximated, so as to hide the anterior half of the lozenge-shaped median plate, distinct traces of the posterior half of which plate appear to me to be still visible.

The ventral armour commences behind these thoracic plates, and forms an oblong sheet of scales, about 4 inches broad and 17 inches long, while each scale may measure half an inch long by ·15 broad. When the scales are well preserved and separately distinguishable, they are seen to be somewhat oat-shaped, the outer end being much more obtuse in some scales than in others. The scale is thick, and rises to a sort of ridge in the middle. The inner end of its outer face is commonly bevelled off, or grooved, so as to receive the outer end of the next scale in front of and internal to it. The scales are so arranged as to form oblique series, directed inwards and forwards, and meeting in the middle line.

Posteriorly (fig. 4) the scales seem to become longer, so as to assume a bar-like character; and at the extreme posterior end of the shield there are two irregular, broad, flat plates, apparently bony, and each rather more than half an inch wide. The structure of the fossil is here, however, very obscure.

Vertebral centra become distinctly visible on the left side of the posterior third of the dermal shield. None of them are completely exposed; but, from what appears, they measure rather less than half an inch antero-posteriorly, and a little more in a direction at right angles to this. They are well ossified, slightly constricted in the middle, and have either flat or biconcave articular ends—probably the latter. The under surface, which is exposed, exhibits a median ridge and two lateral depressions.

The characters of the neural arches can nowhere be distinctly made out, though well-marked traces of them are discernible, particularly in the caudal region, where indications of subvertebral arches, or chevron-bones, are also to be found.

At a distance of about 19 inches from the hinder end of the ramus of the mandible, and about 17 inches from the end of the tail, a stout bone, 1·6 inch long, broad at each end and thinner in the middle, lies obliquely across the axis of the body. Its vertebral end is half an inch wide, and has a well-marked, though shallow, groove or longitudinal depression on its outer surface. An oval depression, filled with matrix, occupies the anterior face of the opposite end of this bone. There are fragments of one or two other long bones behind this; and the ventral armour, which ends about an inch in front of the bone described, is connected posteriorly, as I have stated above, with two much-broken, broad, thin, bony plates.

I take these parts to be the remains of the pelvic girdle and member, though their condition is such as to render it almost impossible to decipher their precise nature.

DESCRIPTION OF PLATE XI.

Fig. 1. Cranium of *Loxomma Allmanni*, one-third the natural size.
Fig. 2. Median and lateral sternal plates of the same Labyrinthodont.
Fig. 3. *Pholidogaster pisciformis*, one-fifth the natural size.
Fig. 4. Scales of *Pholidogaster*, of the natural size.

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2. *On the* Flora *of the* Devonian Period *in* North-eastern America. By J. W. Dawson, LL.D., F.G.S., Principal of M'Gill College, Montreal.

[Plates XII.–XVII.]

Contents.

The existence of several species of land-plants in the Devonian rocks of New York and Pennsylvania was ascertained many years ago by the Geological Surveys of those States, and several of those plants have been described and figured in their Reports*. In Canada Sir W. E. Logan had ascertained, as early as 1843, the presence of an abundant, though apparently monotonous and simple, flora in the

* Hall and Vanuxem, Reports on the Geology of New York; Rogers, Report on Pennsylvania.

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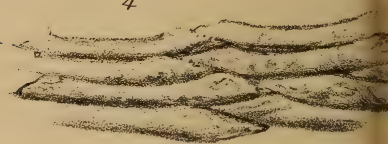

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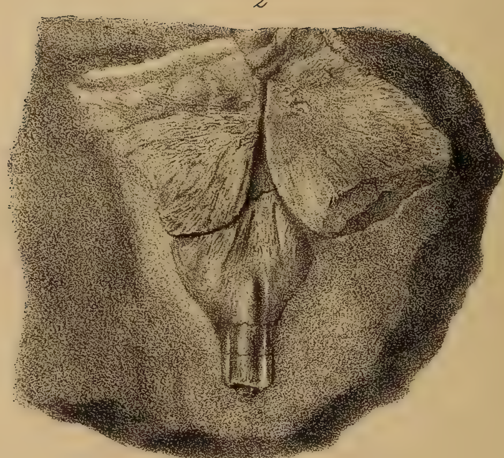

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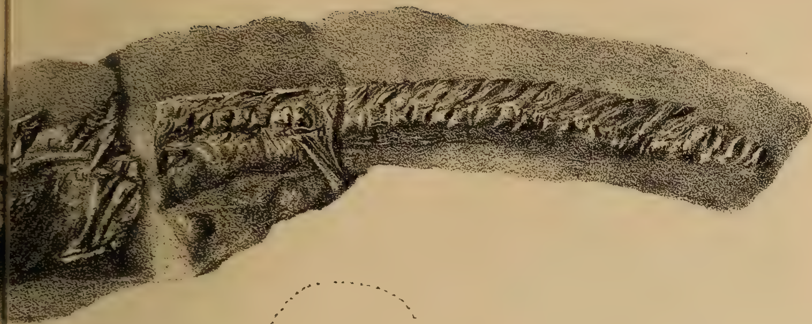

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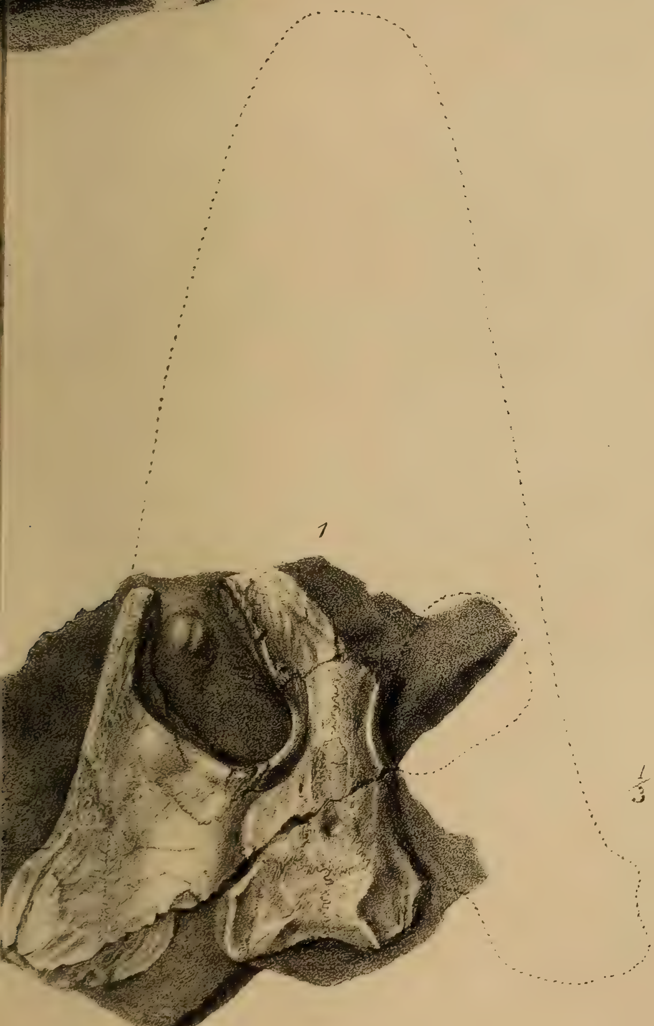

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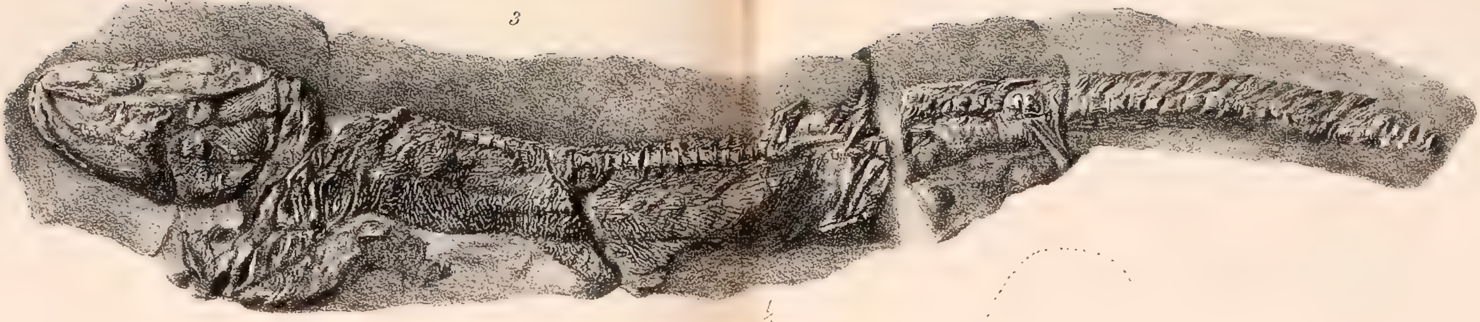

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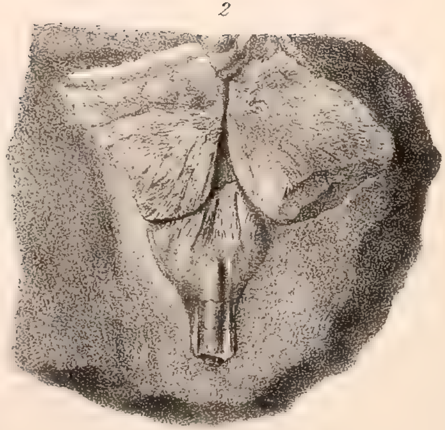

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J. S. Dinkel lith. ad nat.

W. West imp.

CARBONIFEROUS LABYRINTHODONTS.

Devonian strata of Gaspé; but it was not until 1859 that these plants were described by the author in the 'Proceedings' of this Society*. More recently Messrs. Matthew and Hartt, two young geologists of St. John, New Brunswick, have found a rich and interesting flora in the semi-metamorphic beds in the vicinity of that city, in which a few fossil plants had previously been observed by Dr. Gesner, Dr. Robb, and Mr. Bennett of St. John; but they had not been figured or described. These plants, however, I described in the 'Canadian Naturalist'†, together with some additional species, of the same age, found at Perry, in the State of Maine, and preserved in the collection of the Natural History Society of Portland. The whole of the plants thus described I summed up in the paper last mentioned as consisting of 21 species, belonging to 16 genera, exclusive of genera like *Sternbergia* and *Lepidostrobus*, which represent parts of plants only.

In the past summer I visited St. John; and, in company with Messrs. Matthew and Hartt, explored the localities of the plants previously discovered, and examined the large collections which had been formed by those gentlemen since the publication of my previous paper. The material thus obtained proving unexpectedly copious and interesting, I was desirous of having opportunities of fuller comparison with the Devonian Flora of New York State; and, on application to Prof. Hall, that gentleman, with consent of the Regents of the University of New York, kindly placed in my hands the whole of his collections, embracing many new and remarkable forms. Prof. C. H. Hitchcock, State-geologist of Maine, had in the meantime further explored the deposits at Perry, and has communicated to me three new species discovered by him. The whole of these collections, amounting in all to more than sixty species, constitute an addition to the Devonian Flora equal in importance to all the plants previously obtained from rocks of this age, and establish for some of the species a very extensive distribution both geologically and geographically; they allow, also, more satisfactory comparisons than were heretofore practicable to be instituted between the Devonian Flora and that of the Carboniferous Period.

I shall first shortly notice the geological character of the localities, with lists of the fossils found in each, and shall then proceed to describe the new species.

I. Notices of the Localities of the Devonian Plants.

1. *State of New York.*—The geology of this State has been so fully illustrated by Prof. Hall and his colleagues, and the parallelism of its formations with those of Europe has been so extensively made known by Murchison and others, that it is only necessary for me to state that the fossils entrusted to me by Prof. Hall range from the Marcellus Shale to the Catskill group inclusive, and thus belong to the Middle and Upper Devonian of British geologists. The plants are distributed in the subdivisions of these groups as follows:—

* Quart. Journ. Geol. Soc. vol. xv. p. 477.

† Vol. vii. May 1861.

Upper Devonian.

Catskill Group.

Aporoxylon.
Sigillaria Simplicitas, *Vanuxem.*
Lepidodendron Gaspianum, *Dawson.*
Psilophyton princeps, *Dawson.*
Cyclopteris Jacksoni, *Dawson.*
Rhachiopteris punctata, sp. nov.
—— cyclopteroides, sp. nov.

Chemung Group.

Sigillaria Vanuxemii, *Gœppert.*
Syringodendron gracile, sp. nov.
Stigmaria exigua, sp. nov.
Lepidodendron Chemungense, *Hall.*
—— corrugatum, *Dawson.*
Lycopodites Vanuxemii, sp. nov.
Cyclopteris Halliana, *Gœppert.*
Psilophyton princeps, *Dawson.*
Acanthophyton spinosum, sp. nov.
Rhachiopteris striata, sp. nov.

Middle Devonian.

Hamilton Group.

Syringoxylon mirabile, sp. nov.
Dadoxylon Hallii, sp. nov.
Aporoxylon.
Sigillaria.
Didymophyllum reniforme, sp. nov.
Calamites Transitionis (?), *Gœppert.*
—— inornatus, sp. nov.
Lepidodendron Gaspianum, *Dawson.*
—— corrugatum, *Dawson.*
Psilophyton princeps, *Dawson.*
Cordaites Robbii (?), *Dawson.*
——, sp. nov.
—— angustifolia, *Dawson.*
Cyclopteris incerta, sp. nov.
Rhachiopteris striata, sp. nov.
—— tenuistriata, sp. nov.
—— pinnata, sp. nov.

2. *Maine.*—The only locality in this State that has hitherto afforded fossil plants is Perry, near Eastport, in the eastern part of the State. The plant-bearing rocks are grey sandstones, resembling those of Gaspé, and associated with red conglomerate and trappean or tufaceous rocks, which, according to the recent observations of Prof. C. H. Hitchcock*, rest unconformably on shales or slates holding Upper Silurian fossils†. I have little doubt that these beds at Perry are a continuation of part of the series observed at St. John, New Brunswick; and it is probable that they are Upper Devonian. The following species occur at this place:—

Lepidodendron Gaspianum, *Dawson.*
Lepidostrobus Richardsonii, *Dawson.*
—— globosus, *Dawson.*
Psilophyton princeps, *Dawson.*
Leptophlœum rhombicum, sp. nov.
Megaphyton?
Aporoxylon?
Cyclopteris Jacksoni, *Dawson.*
—— Brownii, sp. nov.
Sphenopteris Hitchcockiana, sp. nov.

3. *Canada.*—Devonian beds holding fossil plants occur in Eastern Canada, in Gaspé, and in Western Canada, at Kettle Point, Lake Huron. At the former place there is an extensive series of sandstones and shales, regarded by Sir W. E. Logan as representing the whole of the Devonian series, and containing plants throughout, but

* Report on the Geological Survey of Maine, now in the press.
† See also notices by Dr. Jackson and Prof. Rogers in the 'Proceedings of the Boston Society of Natural History.'

more abundantly in its central portion*. At the latter a few plants have been found in shales of Upper Devonian age. The plants found at Gaspé were described in my former paper, and are—

Prototaxites Logani, *Dawson.*	Psilophyton robustius, *Dawson.*
Lepidodendron Gaspianum, *Dawson.*	Selaginites formosus, *Dawson.*
Psilophyton princeps, *Dawson.*	Cordaites angustifolia, *Dawson.*

The plants from Kettle Point, noticed with doubt in my former paper, I may now refer to the following species:—

Sagenaria Veltheimiana, *Gœppert.*	Calamites inornatus, sp. nov.

4. *New Brunswick.*—The rocks in the vicinity of the city of St. John, constituting a part of the coast metamorphic series of New Brunswick, have been described in the official reports of Dr. Gesner and Dr. Robb†; and additional facts respecting their stratigraphical relations, ascertained by Mr. Matthew, were stated in my paper in the 'Canadian Naturalist,' already referred to. The new interest attached to these beds, in consequence of the discovery of their copious fossil flora, induced me to re-examine all the sections, in company with Mr. Matthew, during my late visit; and that gentleman has recently extended the limits of our observations eastward in the direction of Mispec. The results of these observations I shall state in some detail, as the precise age of the St. John series has not until now been determined.

The oldest rocks seen in the vicinity of St. John are the so-called syenites and altered slates in the ridges between the city and the Kennebeckasis River. These rocks are in great part gneissose, and are no doubt altered sediments. They are usually of greenish colours; and in places they contain bands of dark slate and reddish felsite, as well as of grey quartzite. In their upper part they alternate with white and graphitic crystalline limestone, which overlies them in thick beds at M'Clakeney's and Drury's Cones on the Kennebeckasis, and again on the St. John side of an anticlinal formed by the syenitic or gneissose rocks, at the suburb of Portland. These limestones are also well seen in a railway-cutting five miles to the eastward of St. John‡, and at Lily Lake. Near the Kennebeckasis they are unconformably overlain by the Lower Carboniferous conglomerate, which is coarse and of a red colour, and contains numerous fragments of the limestone.

At Portland the crystalline limestone appears in a very thick bed, and constitutes the ridge on which stands Fort House. Its colours are white and grey, with dark graphitic laminæ; and it contains occasional bands of olive-coloured shale. It dips at a very high

* Reports of the Geological Survey of Canada; paper on the Devonian Plants of Gaspé, Quart. Journ. Geol. Soc. vol. xv.

† Gesner's Second and Third Reports on the Geological Survey of New Brunswick; Robb, in Johnston's Report on the Agriculture of New Brunswick.

‡ At this place the limestone is penetrated by a thick vein of graphic granite, holding black tourmaline; and at Drury's Cove, not far distant, it contains dykes of dark-coloured trap.

Fig. 1.—*Section taken along the Eastern Side of Courtney Bay, New Brunswick.*

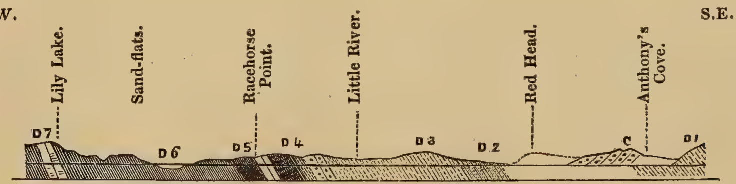
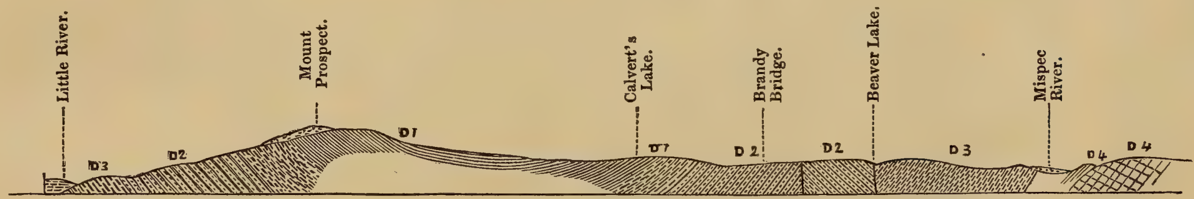


Fig. 2.—*Section from the Valley of Little River to Mispec River, New Brunswick.*



C. Lower Carboniferous Conglomerate.
D 1. Upper red sandstone and conglomerate of the Devonian Series.
D 2. Second conglomerate, and red and green sandstone and shales of the Devonian Series.
D 3. Conifer-sandstone and plant-beds of the Devonian Series.
D 4. Trappean rock, sandstone, and conglomerate.
D 5. Black papyraceous shale.
D 6. St. John Shales, and Lingula-beds.
D 7. St. John Limestone.

angle to the south-east. Three beds of impure graphite appear in its upper portion. The highest is about a foot in thickness, and rests on a sort of underclay. The middle bed is thinner and less perfectly exposed. The lower bed, in which a shaft has been sunk, seems to be three or four feet in thickness. It is very earthy and pyritous. The great bed of limestone is seen to rest on flinty slate and syenitic gneiss, beneath which, however, there appears a minor bed of limestone. Above the great limestone are beds of a hard grey metamorphic rock, apparently an indurated volcanic ash, associated with some sandstone; and this is succeeded by the great series of grey, olive, and black shales and flags which underlie the city of St. John. These rocks are well exposed on both sides of Courtney Bay, in the city of St. John, and in Carlton. Though somewhat contorted, they have a general dip to the south-east at angles of 50° to 70°. In some of the beds there are great numbers of *Lingulæ*, which have not as yet been identified with any described species. There are also trails of Worms, and scratches which may have been produced by the feet of Crustaceans or the fins of Fishes.

The comparatively coarse shales above described are succeeded by a thick band of black papyraceous shale, much contorted, and with a few thin seams of calcareous matter arranged in the concretionary form known as cone-in-cone. No fossils were found in them, but two thin seams of anthracitic coaly matter are stated to have been seen on their line of strike eastward of Courtney Bay*.

Overlying these beds is a group of very different character. It consists of purplish-red and green grit and shale, with beds of red conglomerate and red sandstone. Interstratified with these are massive beds of a greenish rock, consisting of trappean and felspathic fragments, imbedded in a shining reddish paste, or sometimes presenting the appearance of a compact trap or amygdaloid. This rock usually presents an appearance of greater alteration than the neighbouring beds, and contains veins of epidote, quartz, and calc-spar. Its hard and massive character causes it to resist denudation, and to project above the surface in irregular masses. It has usually been regarded as a trap; I am disposed, however, to consider it as more probably a tufaceous or volcanic ash rock, except in a few places, where it is either an amygdaloidal trap or a mass of fragments of such material too intimately connected to be separated from each other. It is evidently a stratified member of the series, though its beds are very unequal in hardness and texture, and probably also in thickness. This portion of the series is well exposed on the east side of Courtney Bay, in the southern part of the city of St. John, and in the direction of Carlton, where its tufaceous or trappean members constitute prominent elevations. It seems also to be this member of the series which, turning to the south, constitutes Cape Meogenes.

Reposing on the rocks last described is the most interesting member of the series, consisting of hard buff and grey sandstones, with black and dark-grey shales. The sandstones contain numerous Coniferous trunks; and the shales, which are sometimes highly

* Gesner's Second Report.

graphitic, abound in delicate vegetable remains, often in a very perfect state of preservation. These rocks appear on the east side of Courtney Bay, near Little River, at the extremity of the point of land on which the city of St. John stands, and in the ledges and cliffs on the shore westward of Carlton. In all these places they are quite conformable with the underlying rocks, though the dip gradually diminishes in ascending.

No rocks newer than the above are seen at Carlton or in the city of St. John; but near Little River a few beds of red shale and coarse sandstone seem to indicate the commencement of a new member of the series, the coast-section failing at this point. Mr. Matthew has, however, succeeded in finding a continuation of the section further inland, exhibiting first, in ascending order, grey sandstone and grit, with dark shale holding fossil plants, among which is *Calamites Transitionis*. This may perhaps be regarded as the top of the group last mentioned. Above it, and passing into it at their base, are reddish sandstones, grits, and conglomerate, alternating with green, greenish-grey, and red shale. Resting on these is a thick-bedded, coarse, angular conglomerate, succeeded by evenly bedded shales, shaly sandstones, and grits, of dark-red and purplish colours. These are the highest beds seen, as beyond this place they are bent in a synclinal, and reappear with reversed dips.

Another most important observation of Mr. Matthew is that near Red Head the member of the St. John series last described is overlain unconformably by a conglomerate similar to that of the Kennebeckasis, and probably the Lower Carboniferous conglomerate. It dips to the north-west, or in the opposite direction from that of the underlying beds, at an angle of 30°; but Mr. Matthew regards the dip as due in part to false bedding.

The whole of the deposits above described may be summed up as follows, the thicknesses stated being from measurements and estimates made by Mr. Matthew, and to be regarded as merely approximate* (see figs. 1 & 2).

Carboniferous System.

	Feet.
Coarse red conglomerate, with pebbles of the underlying rocks, and constituting in this vicinity the base of the Carboniferous System.	

Devonian System (or perhaps, in part, Upper Silurian).

1. Dark-red and greenish shales; flaggy sandstones and grits; coarse angular conglomerate	1850

* In my paper in the 'Canadian Naturalist,' I gave a sectional view of the general arrangement, as observed on a line of section from the Kennebeckasis River to the extremity of the peninsula on which St. John stands. The sections referred to in the text represent the same series, as seen on the east side of Courtney Bay, immediately to the east of St. John, with the continuation ascertained by Mr. Matthew towards the Mispec River.

		Feet.
2.	Reddish conglomerate, with quartz pebbles; reddish, purple, and grey sandstones and grits; deep-red, grey, and pale-green shales. A few fossil plants	2350
3.	Blackish and grey hard shale and arenaceous shale; buff and grey sandstone and flags. Many fossil Plants; Crustaceans and *Spirorbis*	2000
4.	Reddish conglomerate, with slaty paste and rounded pebbles; trappean or tufaceous rock; red, purplish, and green sandstones and shales. Thickness variable	1000
5.	Black papyraceous shale, with layers of cone-in-cone concretions	400
6.	Hard, generally coarse and micaceous, grey shales and flags, of various shades of colour, and with some reddish shale and tufaceous or trappean matter at the bottom. *Linguæ*, Burrows, and Trails of animals	3000 feet or more.
7.	White and grey crystalline limestone, with bands of shale and beds of graphite	600 feet or more.
8.	Gneissose and other metamorphic beds, with bands of quartz-rock and slate. Thickness unknown.	

The Devonian age of the upper members of this great series of beds I regard as established by their fossils*, taken in connexion with the unconformable superposition of the Lower Carboniferous conglomerate. The age of the lower members is less certain. They may either represent the Middle and Lower Devonian, or may be in part of Silurian age. Their only determinable fossil, the *Lingula* of the St. John shales, affords no decisive solution of this question, and the evidence of mineral character is not to be relied on in the case of beds so remote from those regions in which the Devonian rocks of America have been most minutely studied.

In mineral character, Nos. 1 & 2 of the above sectional list might very well represent the Old Red Sandstone, or Catskill group of the New York geologists. Nos. 3 & 4 might be regarded as the analogues of the Chemung and Portage groups. No. 5 would represent the Genesee Slate; No. 6 the remainder of the Hamilton group; No. 7 the Corniferous Limestone; and No. 8 might be regarded as a metamorphosed equivalent of the Oriskany and Schoharie Sandstones. The entire want of the rich marine fauna of these formations is, however, a serious objection to this parallelism. If, on the other hand, we employ as our scale of comparison the development of the Devonian system in Gaspé, Nos. 1 & 2 will correspond very well with the upper member of the Gaspé series, and No. 3 with the rich plant-bearing beds of the middle of that series; but no mineral

* The scanty animal remains of the plant-beds No. 3 accord very well with the evidence of the fossil Plants. They are a small Trilobite, apparently a *Phillipsia*, three other Crustaceans, one of which is probably a *Stylonurus*, another a *Eurypterus*, and the third a Decapod not apparently referable to any described genus. These Crustaceans are now in the hands of Mr. Salter. (See his paper on these fossils, read before the Society, May 21, 1862.) There is also a shell, apparently a *Loxonema*, and a *Spirorbis*.

equivalent of the St. John shales and limestones occurs at Gaspé, unless we seek for it in the Upper Silurian.

The rocks of the St. John group extend along the coast as far as the frontier of Maine, and there can scarcely be any doubt that the plant-bearing beds at Perry represent some portion of the St. John series, most probably Nos. 2 & 3 of our sectional list. At Perry the plant-beds rest on a trappean bed, which may be the equivalent of our No. 4, a member of the series much more constant in its occurrence than would be anticipated from its composition. According to Prof. Hitchcock, this last bed at Perry rests unconformably on shales containing a *Lingula* which may be identical with that of St. John, and also other fossils of distinct Upper Silurian forms. The analogy of Perry, therefore, as well as of Gaspé, would point to an Upper Silurian age for the lower members of the St. John series, though at St. John they appear to be conformable with the overlying beds. On the other hand, the unconformability at Perry renders it possible that the lower members of the St. John series may be wanting there; and to assign a Silurian date to the lower beds at St. John would imply the entire absence of the copious and characteristic Lower Devonian marine fauna observed at Gaspé and in Nova Scotia, as well as in Maine, though not in immediate connexion with the Perry beds; while, if the whole series of St. John be Devonian, the absence of this fauna would be accounted for by the metamorphism of the lower beds.

In the present state of the evidence, it would be premature to decide this question, which may be settled either by the discovery of portions of the lower beds in a less altered state, or by tracing the St. John series into connexion with the similar deposits in Maine. In the meantime, therefore, we may be content to regard the upper members of the series as belonging to the later part of the Devonian Period, leaving the lower members to be regarded as Lower Devonian or possibly Upper Silurian.

The fossiliferous portion of the St. John series presents the richest local flora of the Devonian Period ever discovered. It far excels, in number of genera and species, the Lower Carboniferous flora as it exists in British America, and is comparable with that of the Middle Coal-measures, from which, however, it differs very remarkably in the relative development of different genera, as well as in the species representing those genera.

It is only just to observe, that the completeness of the following list is due to the industrious labours of an association of young gentlemen of St. John, who, under the guidance of Messrs. Matthew and Hartt, have diligently explored every accessible spot within some distance of the city, and have liberally placed their collections at my disposal for the purposes of this paper.

Dadoxylon Ouangondianum, *Dawson.*
Sigillaria palpebra, sp. nov.
Stigmaria ficoides (var.), *Brongn.*
Calamites transitionis, *Gœppert.*
—— cannæformis, *Brongn.*
Asterophyllites acicularis, sp. nov.
—— latifolia, sp. nov.
—— scutigera, sp. nov.
—— longifolia, *Brongn.*
—— parvula, *Dawson.*

Annularia acuminata, sp. nov.
Sphenophyllum antiquum, *Dawson.*
Pinnularia dispalans, sp. nov.
Lepidodendron Gaspianum, *Dawson.*
Lycopodites Matthewi, *Dawson.*
Psilophyton elegans, sp. nov.
—— glabrum, sp. nov.
Cordaites Robbii, *Dawson.*
—— angustifolia, *Dawson.*
Cyclopteris Jacksoni, *Dawson.*
—— obtusa, *Gœppert.*
—— varia, sp. nov.
—— valida, sp. nov.
Neuropteris serrulata, sp. nov.
—— polymorpha, sp. nov.
Sphenopteris Hoeninghausi, *Brongn.*
—— marginata, sp. nov.
—— Harttii, sp. nov.
—— Hitchcockiana, sp. nov.
Hymenophyllites Gersdorffii, *Gœppert.*
—— obtusilobus, *Gœppert.*
—— curtilobus, sp. nov.
Pecopteris (Alethopteris) decurrens, sp. nov.
—— (——) ingens, sp. nov.
—— (——) obscura (?), *Lesquereux.*
Trichomanites, sp. nov.
Cardiocarpum cornutum, sp. nov.
—— obliquum, sp. nov.
Trigonocarpum racemosum, sp. nov.

II. Descriptions of the Species.

(*Angiospermous Dicotyledon.*)

1. Syringoxylon mirabile, gen. et sp. nov. Pl. XII. figs. 1 to 5.

Woody tissue close, thick-walled. Ducts many times the diameter of the wood-cells, thin-walled, with transverse pores in several series. Medullary rays of two or more series of muriform cells. Growth-rings distinct.

This genus and species are founded on a small fragment of wood, mineralized by carbonate of lime, silica, and iron-pyrites. It is evidently the wood of an angiospermous exogen, and does not differ materially from that of some modern trees. It is, in so far as I am aware, the first instance of such wood in Palæozoic rocks, and would imply the existence in the Devonian Period of trees of a higher grade than any that are known in the Carboniferous System. This fact is not, however, in itself more remarkable than the occurrence of a single Land-snail in the Coal-formation, more especially when we consider the perishable character of the wood of angiosperms as compared with that of gymnosperms and cryptogams, and the small amount of attention usually bestowed by geologists on fragments of mineralized wood. It is also to be remarked that, as I have elsewhere had occasion to note, the Devonian flora has in other points a more modern aspect than that of the Coal—a circumstance which may perhaps relate to a different distribution of land and water, and to the comparative absence of the wide inundated flats of the Coal-period. It may, however, merely result from the unequal and fortuitous preservation of some descriptions of plants rather than others in the beds of one or both of these periods.

The specimen is labelled as from Eighteen-mile Creek on Lake Erie, and was collected several years ago by Prof. Hall from a limestone in the upper part of the Hamilton group. It has unfortunately no matrix attached to it; but Prof. Hall assures me that he has no reason to doubt its genuineness.

(*Exogenous Gymnosperms.*)

(*Coniferæ.*)

2. Dadoxylon (Araucarites) Ouangondianum, Dawson.

'Canad. Naturalist,' vol. vi. pp. 165, 166, figs. 1 to 4.

"*Branching trunks, with distinct zones of growth, and a pith of the* Sternbergia *type. Wood-cells very large, with three to five rows of contiguous, alternate, hexagonal areoles with oval pores. Medullary rays with one to three series of cells, and as many as* 14 *rows of cells superimposed on each other**."

In sandstone at St. John, where many large trunks occur, calcified and silicified, and in part converted into anthracite and graphite†. My specimens are from the collection of Mr. Matthew, and are described at length and figured in the paper referred to in the footnote. I have no doubt that this is the Coniferous tree referred to by Dr. Gesner, 'Second Report,' p. 12.

3. Dadoxylon Hallii, sp. nov. Pl. XIII. fig. 11.

Wood-cells very large, with five rows of contiguous, alternate, hexagonal areoles. Medullary rays very frequent, and with as many as thirty rows of cells superimposed.

This species occurs in a pyritized state at Hemlock Creek, Ontario County, New York, in beds of the Hamilton group. It resembles *D. Ouangondianum* in the great size of the wood-cells and the numerous rows of areoles, but differs so markedly in the development of the medullary rays that I regard it as certainly belonging to a distinct species. The specimen, being completely pyritized, can be examined only as an opaque object, so that some of the details of its structure cannot be made out; but the forms of the wood-cells and their areoles, and of the medullary rays, are so beautifully modelled in pyrites that no uncertainty exists as to the points of structure above specified. I have dedicated this species to Prof. Hall, its discoverer.

4. Aporoxylon.

Among Prof. Hall's specimens is one, from Seneca Lake, which may possibly be allied to the plant on which Unger has founded the genus above named. It is a flattened pyritized stem or branch, one inch and a quarter in breadth at the larger end, and slightly tapering, and ten inches in length. It is marked with spirally arranged distant scars, as if of excurrent branches; and it seems to have been woody, with a thin bark and a large pith. The wood is imperfectly

* In the case of this and other species described in my paper on the Precarboniferous Flora of New Brunswick, I shall copy in this paper the specific characters merely, referring for fuller descriptions to my paper in the 'Canadian Naturalist,' vol. vi. pp. 161 *et seq.*

† This and other fossil plants found at St. John afford remarkable examples of the conversion of vegetable matter into graphite, without loss of its form or even of its internal structure.

preserved, but shows slender cylindrical fibres destitute of markings, and with mere traces of medullary rays. The general arrangement of parts resembles that in *Prototaxites*, but the markings on the cell-walls are absent. I regard it as quite possible that this may merely be wood of *Dadoxylon* or *Prototaxites*, in which casts of the interior cavities of the cells may have been taken in pyrites, while the cell-walls and medullary rays have been destroyed, and the spaces occupied by them partially obliterated by pressure. Whatever its precise character, it must have been an excurrent stem with many small branches proceeding from it, in the manner of ordinary coniferous trees*.

In the collections made by Mr. Richardson (of the Canâdian Geological Survey) at Perry are fragments of stems or branches having a structure somewhat similar to that above described, but still more imperfectly preserved.

(*Sigillariæ.*)

5. Sigillaria palpebra, sp. nov. Pl. XIII. fig. 12.

Ribs narrow, about a quarter of an inch in width. Leaf-scars transversely acuminate, small.

My only specimen is a small fragment, showing three or four ribs, and with only a few of the scars preserved. The most perfect leaf-scars are shaped much like a half-closed eye; but the specimen is only a cast, and very imperfect. Locality, St. John.

6. Sigillaria Vanuxemii, Gœppert. Pl. XII. fig. 7.

Hall's 'Report Geol. New York,' p. 184, fig. 51; Gœppert's 'Flora Silurisch.' p. 546.

Areoles hexagonal, rather longer than broad. Vascular scars indistinct, apparently two in each areole. Bark thick. Ligneous surface obscurely ribbed, with small elongated scars in the furrows. Woody axis sulcated longitudinally; its diameter equal to one-fourth that of the stem. There are about twelve rows of areoles on a stem half an inch in diameter.

This beautiful little *Sigillaria* is figured, but not named nor described, in Vanuxem's 'Report on the Geology of New York,' fig. 51, p. 184. It is named and described by Gœppert from Vanuxem's figure†. An examination of the original specimen—a sandstone-cast six inches in length, imbedded among brachiopodous shells—enables me to give the above more complete description. The bark is in a coaly state, and the woody axis, though flattened, is quite manifest, and still retains some carbonaceous matter, though destitute of structure. The plant must have been of slender growth, unless it were a branching species. It approaches *S. minima* of Brongniart, but is smaller and not ribbed; in which last respect it resembles *S. ele-*

* Similar stems, more nearly resembling those described by Unger in external form, occur in the Catskill group.

† 'Flora der Silurischen,' &c. p. 546.

gans, of which it may be regarded as a diminutive Devonian prototype.

Its locality is Allen's quarry, near Oswego, and the formation is the Chemung group.

7. SIGILLARIA SIMPLICITAS, Vanuxem.

Vanuxem's 'Report Geol. New York,' p. 190, fig. 54.

Ligneous surface with narrow, slightly rugose elevated ribs, about a quarter of an inch wide, in a stem five inches in diameter. Leaf-scars indistinct.

Under the above name Vanuxem has figured a *Sigillaria*, the only specimen of which is a portion of a decorticated stem, with only scarcely distinguishable traces of the leaf-scars. It is from the Catskill group, between Mount Upton and N. Bainbridge.

In Prof. Hall's collection there is a specimen in a similar condition, with wider ribs, and which may have belonged to another species, though it is possibly a part of an older stem of the above. It is from the Hamilton group, shore of Lake Erie, near Buffalo*.

8. SYRINGODENDRON GRACILE, sp. nov. Pl. XIII. fig. 14.

Ribs about a line in breadth, with elevated elongated areoles, each with three punctiform vascular scars in a vertical line. Areoles three-eighths of an inch distant vertically. Bark marked with delicate striæ converging toward the areoles. On the inner surface of the bark are fine longitudinal and transverse striæ, and the scars appear as elongate depressions.

This species is described from a small fragment of the bark in a slab from the Hamilton group of Akron, Ohio, in the collection of Prof. Hall. It resembles in some respects *S. pachyderma*, but is smaller and has thinner bark and more elongated areoles. On the same slab are *Cyperites*, which may have been the leaves of this plant, fragments of stipes of Ferns, and branchlets of *Psilophyton*.

9. STIGMARIA EXIGUA, sp. nov. Pl. XIII. fig. 13.

Scars small, in depressed spaces, six in an inch vertically. Stem cylindrical, an inch in diameter.

This diminutive *Stigmaria* was probably the root of one of the slender Sigillaroid trees above described. It is evidently quite distinct from *Stigmaria minuta*, Lesquereux, which is, however, a similar species of nearly as great age. Like many others of the Devonian plants from New York, it occurs in a marine bed; and the

* Some obscurely marked fragments in my collection, from Gaspé and St. John, appear to indicate the existence of a species with wider ribs than the above. Neither Vanuxem's specimens nor these are sufficiently perfect to admit of description; and the somewhat singular name which I have quoted from him may therefore be taken as representing one or more species of *Sigillaria* imperfectly known.

cylindrical cavity within the bark has been filled with sand and the stems of a small branching Coral, which may perhaps have grown within the hollow bark, which in this case, as in that of the *Stigmariæ* of the Coal-measures, seems to have been almost indestructible. The specimen is from the Chemung group, at Elmira, New York.

10. STIGMARIA FICOIDES (variety), Brongniart.

Large roots of *Stigmaria*, in some instances with rootlets attached, occur, though rarely, in the sandstone or arenaceous shale near St. John—only two or three specimens having been found. They are not distinguishable from some varieties of the *Stigmaria ficoides* of the Coal-measures.

11. DIDYMOPHYLLUM RENIFORME, sp. nov. Pl. XIII. fig. 15.

Areoles prominent, spirally arranged, reniform; each resembling a pair of small Stigmaroid areoles attached to each other. Areoles $\frac{1}{20}$*th of an inch in transverse diameter, and about* $\frac{1}{4}$*th of an inch distant transversely, and* $\frac{3}{8}$*ths vertically, in a stem* $\frac{3}{4}$*ths of an inch in diameter.*

The genus *Didymophyllum* was established by Gœppert for a plant of the Lower Carboniferous series of Silesia, resembling *Stigmaria*, but with double rootlets. The present plant, though specifically distinct, comes fairly within the characters of the genus. I believe it to have been a slender Stigmaroid root or rhizome, sending out its rootlets in pairs instead of singly. It occurs as a cast with the thin coaly bark in part preserved, and is from the Hamilton group, near Skaneatales Lake, New York. A flattened specimen, apparently of the same species, occurs on a slab from the Marcellus Shale. Both are in Prof. Hall's collection.

(*Calamiteæ**.)

12. CALAMITES TRANSITIONIS, Gœppert.

'Canad. Nat.' vol. vi. p. 168, fig. 5.

This species, so characteristic, according to Gœppert, of the Upper Devonian and Lower Carboniferous series in Europe, is abundant at St. John, both in the sandstone containing Coniferous trees, and the shales which afford Ferns, *Cordaites*, &c. Some of the beds of the latter are filled with flattened stems. This was one of the first fossils recognized in the St. John rocks, specimens having been shown to me in 1857 by the late Prof. Robb†.

A small specimen in Prof. Hall's collection, from the Hamilton group, may possibly belong to this species, though proportionally some-

* In placing the *Calamites* here, I do not mean to affirm that all the plants usually included in that genus are gymnospermous; but I believe that many of them are.

† Dr. Gesner mentions ('Second Report', 1840, p. 12) a Calamite (probably this species) as occurring near Little River.

what wider in its ribs. Being only a part of a single internode, it cannot be certainly determined, though it appears at least to indicate the presence of a species of *Calamites* in that group.

13. Calamites cannæformis, Brongniart.

This species, presenting the characters which it exhibits in the Coal-measures, occurs in the ledges west of Carlton, associated with the last species, but in much less abundance. It is a widely distributed species, but has not, I believe, been found previously in rocks older than the Lower Carboniferous.

14. Calamites inornatus, sp. nov. Pl. XVII. fig. 56.

Ribs continuous, as in C. Transitionis, *but flat and broad, the breadth of each being a quarter of an inch in a stem four inches in diameter. Nodes distinct, prominent in the flattened stem, owing to their greater density as compared with the internodes.*

This species is allied to *C. Transitionis,* but has much wider ribs. It was a woody plant, as, when flattened, a stem four inches in diameter affords a film of compact coal about a line in thickness, which is quite as much as a *Sigillaria* or even a Conifer of the same size would yield under similar circumstances. It much resembles Gœppert's figure of *C. variolatus,* but wants the stigmata said to be characteristic of that species,—instead of which, it has, in the coaly matter representing the stem, numerous irregularly disposed round spots surrounded by concentric circles; but these are evidently concretionary, and of the same nature with the beautiful concentric concretions which appear in some specimens of cherry-coal and of albertite.

The specimen above described is in Prof. Hall's collection from the Genesee slate, from the shore of Cayuga Lake. A comparison of this specimen with the obscure Calamite-like fossils from Kettle Point, Lake Huron, in the collection of the Canadian Survey, referred to in my former paper, satisfies me that they probably belong to the same species.

(*Asterophylliteæ.*)

15. Asterophyllites acicularis, sp. nov. Pl. XIII. fig. 16.

Stems slender, striated, thickened at the nodes, leafy. Leaves one-nerved, linear, slightly arcuate, ten to fifteen in a whorl, longer than the internodes. Length of leaves one-half to three-fourths of an inch.

This plant is abundant in some layers of shale near St. John. It resembles *A. foliosa,* L. & H., but the leaves are longer, less curved, and more numerous in a whorl. Some of the specimens show that the stem was leafy, as well as the branches; and I have a specimen, apparently the termination of a main stem, showing the whorls of leaves diminishing in size toward the apex. My specimen of this and the following species of *Asterophyllites* are from the collections of Messrs. Matthew and Hartt, and were obtained from the ledges and cliffs west of Carlton.

16. Asterophyllites latifolia, sp. nov. Pl. XIII. fig. 17.

Stem somewhat slender, with enlarged nodes. Leaves oblong-lanceolate, about thirteen in a whorl, one-nerved, longer than the internodes. Length of leaves varying from one-fourth of an inch, near the ends of branches, to an inch or more.

This species abounds in the same locality with the preceding, and is often very perfectly preserved. It has some resemblance to *A. galioides*, L. & H., and to *A. fertilis*, Sternberg; but it differs from the former in the number and form of the leaves, and from the latter in the acuteness of their points.

17. Asterophyllites? scutigera, sp. nov. Pl. XIII. figs. 18, 19, 20.

Stems simple, elongated, attaining a diameter of half an inch, obscurely striated; bearing on the nodes whorls of round or oval scales, or flattened nutlets, which at the ends of the stems are crowded into a sort of spike, while on other parts of the stems the nodes are sometimes an inch apart.

This is a plant of uncertain nature, which I place only conjecturally in this genus. The stems, which are very long, may have been horizontal or immersed, and the apparent scales may either have constituted a sort of sheath, as in *A. coronata*, Unger, or may have been seeds or nutlets flattened like the rest of the plant. Near some of the specimens are fragments of linear leaves, which may have belonged to this plant, though I have not found them attached. When flattened obliquely, the stems appear as rows of circular marks, which represent the harder tissue of the nodes, and have a very singular appearance. This plant, though found with the preceding, does not occur in the layers which contain the other plants; and this may possibly mark a difference of habitat.

18. Asterophyllites longifolia, Brongniart.

In the shales containing the preceding species are some fragments of an *Asterophyllites* with slender stems, internodes about an inch in length, and linear leaves two or three inches in length, and about 6 to 8 in a whorl. It may belong to the species here named; but the remains are not sufficiently distinct to render this certain.

19. Asterophyllites parvula, Dawson.

'Canad. Nat.' vol. vi. p. 168, figs. 6 *a, b, c.*

"*Branchlets slender. Leaves 5 or 6 in a whorl, subulate, curving upward, half a line to a line long. Internodes equal to the length of the leaves or less. Stems ribbed, with scars of verticillate branchlets at the nodes.*"

This diminutive species was originally found by Mr. Matthew in the graphitic shale, associated with the conifer-sandstone, at the southern part of the city of St. John. Small fragments of it have subsequently been obtained from the shales of Carlton.

20. ANNULARIA ACUMINATA, sp. nov. Pl. XIII. fig. 21.

Leaves oblong, acuminate, one-nerved, 6 *to* 9 *in a whorl, erect or slightly spreading. Whorls usually found disconnected.*

Detached whorls of this species occur, though rarely, on the surfaces of the shales of Carlton. It seems to be a plant of the same type with *A. sphenophylloides*, Unger, which, according to Lesquereux, occurs in the Coal-formation of Pennsylvania.

21. SPHENOPHYLLUM ANTIQUUM, Dawson.

'Canad. Nat.' vol. vi. p. 170, fig. 7.

"*Leaflets cuneate, one-eighth of an inch wide at the apex, and less than one-fourth of an inch long. Nerves three, bifurcating equally near the base, the divisions terminating at the apices of six obtuse, acuminate teeth.*" *About* 8 *leaves in a whorl.*

This plant was described from a few detached leaflets from the graphitic shale of St. John, which preserved their form and venation in the most wonderful perfection, though they were completely changed into films of shining graphite. I have since obtained from Mr. Hartt a specimen found at Carlton, which, though the individual leaflets are more indistinct, shows their general arrangement in whorls of 8 or 9 on a slender stem. It is a beautifully symmetrical little plant, quite distinct from any of the species in the Coal-measures.

22. PINNULARIA DISPALANS, sp. nov. Pl. XIII. fig. 22.

Smooth slender stems, producing nearly at right angles long branchlets, some of which produce secondary branchlets in a pinnate manner. Stem and branches having a slender vascular axis.

This plant was not very dissimilar from some common forms of Carboniferous *Pinnulariæ*. Its main stem must once have been cylindrical, and had a delicate central axis, now marked by a darker line of graphite in the flattened specimens. The branches were not given off in one plane, and also show traces of an axis. There are indications that the stems grew in bundles or groups. It was probably, as has usually been supposed in the case of the species in the Coal-formation, an aquatic root or submerged stem of an *Asterophyllites* or some similar plant.

(*Acrogenous Cryptogams.*)

(*Lycopodiaceæ.*)

23. LEPIDODENDRON GASPIANUM, Dawson. Pl. XIV. figs. 26, 27, 28; and Pl. XVII. fig. 58.

Dawson, Quart. Journ. Geol. Soc. vol. xv. p. 483, figs. 3 *a*–3 *d*.

This species, originally discovered in Gaspé, and described in my paper* on the plants of that locality, was afterwards recognized among the fossils from Perry, and more recently at St. John; and numerous and beautiful specimens are contained in Prof. Hall's

* Quart. Journ. Geol. Soc. vol. xv. p. 483.

collections from New York State, where the species occurs in the base of the Catskill group and in the upper part of the Hamilton group. The varied aspects of the species presented in the numerous specimens thus submitted to me would, with a less perfect suite of examples, afford grounds for specific or even generic distinctions. Flattened specimens, covered with bark, present contiguous, elliptical, slightly elevated areoles, with an indistinct vertical line and a small central vascular scar (fig. 58). Decorticated specimens, slightly compressed, show elliptical depressed areoles, not contiguous, and with only traces of the vascular scars (fig. 26). In more slender branches the areoles are often elevated at one end in the manner of a *Knorria* (fig. 28); and in some specimens the areoles are indistinct, and the vascular scars appear as circular spots, giving the appearance presented by the plants named *Cyclostigma* by Haughton (fig. 27). All these forms are, however, merely different states of preservation of the same species.

This plant is closely allied to *L. nothum*, Unger, but differs in its habit of growth and in the size of the areoles relatively to that of the branches. The branches were long and slender, bifurcating rarely, and, unless they were very woody, must have been pendent or decumbent. No large trunks have been seen. It was a widely distributed and abundant species in the Upper and Middle Devonian Periods. The plant figured by Prof. Rogers in the 'Report on Pennsylvania,' p. 829, fig. 677, can scarcely belong to any other than this species; and it is also figured in Vanuxem's 'Report on New York,' p. 191, fig. 55, and p. 157, fig. 38.

24. Lepidodendron Chemungense, Hall.

Hall's 'Report Geol. New York,' p. 275, fig. 127.

Decorticated stem covered with oval, acuminate, scale-like areoles, more acute and smaller in proportion to the size of the stem than in L. Gaspianum.

The only specimen I have seen is a curved branch, very well figured in Prof. Hall's 'Report on the Geology of New York,' p. 275, fig. 127. It is a *Knorria* state of a *Lepidodendron* or *Sagenaria*, of more robust growth than *L. Gaspianum*, but with smaller areoles. It much resembles a decorticated branch of *L. elegans* of the Lower Coal. Gœppert includes it in his protean species *Sagenaria Veltheimiana*, but it does not correspond precisely with any of the forms figured by him. I think it best, therefore, to retain Prof. Hall's specific name, until better specimens shall enable a satisfactory comparison to be made. Its locality is Elmira, New York, and its geological position is the Chemung group.

25. Lepidodendron corrugatum, Dawson. Pl. XII. fig. 10.

Dawson, Quart. Journ. Geol. Soc. vol. xv. p. 68, fig. 2.

Areoles elliptical, distant, and separated by a flat surface of corrugated bark. Vascular scar central, oval, or linear.

In Prof. Hall's collection are specimens from the Chemung and

Hamilton groups, from Akron, Ohio, which I cannot distinguish from the above species, first recognized by me in the Lower Coal-measures of Nova Scotia, and noticed in my paper on the "Lower Carboniferous Coal-measures of British America," Quart. Journ. Geol. Soc. 1858, vol. xv. p. 68. *L. corrugatum*, like other *Lepidodendra*, presents many varieties of growth and preservation; but Prof. Hall's specimens are quite undistinguishable from some of those in my cabinet from the Lower Coal-measures of Horton, Nova Scotia.

26. LEPIDOSTROBUS RICHARDSONI, Dawson.

'Canad. Nat.' vol. vi. p. 174, fig. 10.

"*Axis not distinctly preserved; form cylindrical* (?)*; scales oblong, with an obscure midrib.*" From Perry, Maine.

27. LEPIDOSTROBUS GLOBOSUS, Dawson.

Round or roundish oval, covered with obscure pointed scales.

This and the preceding are very distinct but puzzling objects, collected by Mr. Richardson at Perry, and are probably the fructification of *Lepidodendra* or allied plants.

28. LYCOPODITES MATTHEWI, Dawson.

'Canad. Nat.' vol. vi. p. 171, fig. 8.

"*Leaflets one-veined, narrowly ovate-acuminate, one-tenth to one-fourth of an inch in length, somewhat loosely placed on a very slender stem, apparently in a pentastichous manner.*"

This species was described from specimens found by Mr. Matthew in the graphitic shale in the city of St. John. Somewhat larger specimens have since been obtained from the same bed; but I have not seen the plant elsewhere.

29. LYCOPODITES VANUXEMII, sp. nov. Pl. XVII. fig. 57.

Hall's 'Report on the Geology of New York,' p. 273, fig. 125; Vanuxem's 'Report, Geol. New York,' p. 175, fig. 46.

Stem slender. Leaves pinnate, contiguous, linear, about half an inch in length.

This plant appears as graceful, feathered stems, apparently growing in groups. It seems to be very closely allied to *L. pinnæformis*, Gœppert, differing chiefly in its more slender stem and shorter pinnules. Still it is very doubtful if it were really a Lycopodiaceous plant. Its leaves were certainly in one plane, and some of the specimens show that they were flattened horizontally, like the filaments of a feather. It may have been related to Ferns rather than to *Lycopodiaceæ*. It occurs in the Chemung group, at Ithaca, New York. It is well figured in Hall's 'Report,' p. 273, fig. 125, and in Vanuxem's 'Report,' p. 175, fig. 46.

30. Psilophyton princeps, Dawson.

Quart. Journ. Geol. Soc. vol. xv. p. 479, figs. 1 *a* to 1 *i*.

This remarkable plant, so characteristic of the whole Devonian system at Gaspé, filling many beds with its rhizomes, in the manner of the *Stigmaria* of the Coal-measures, and preserved in such abundance and perfection that it is much better known to us in its form, structure, and habit of growth than any other plant of the period, proves, as might have been anticipated, to have had a wide distribution in space as well as in time. Fragments of its stems are distinguishable in the sandstones of Perry, and numerous fine specimens occur among the plants from New York State committed to me by Prof. Hall. It occurs in the Hamilton group at Schoharie, New York, and at Akron, Ohio, in the Chemung group at Cascade Falls, and in the Catskill group at Jefferson. Most of the specimens are stems, which show the habit of growth very perfectly. They confirm my inference from the structure of the Gaspé specimens that the plant was woody and rigid, as they often do not lie in one plane, but extend upward and downward in the manner of firm branches buried in sand. Most of the New York specimens seem to have been drifted; but groups of rhizomes, possibly *in situ*, occur in argillaceous sandstone from Fullenham, Schoharie, and in similar beds at Cazenovia and Cascade Falls. These are the only instances presented by Prof. Hall's collections of root-beds resembling those of Gaspé. In New York only the Upper and Middle Devonian have as yet afforded land-plants ; but in Gaspé *Psilophyton princeps* occurs in the Lower Devonian, and fragments which may have belonged to it occur in the Upper Silurian.

31. Psilophyton elegans, sp. nov. Pl. XIV. figs. 29, 30; and Pl. XV. fig. 42.

Stems slender, produced in tufts from thin rhizomes, bifurcating and curving at their summits. Surface smooth, with very delicate wrinkles. Fructification in groups of small, broadly oval scales, borne on the main stem below the points of bifurcation.

I distinguish this species from *Psilophyton princeps* by its smaller size, its smoother surface, its growth in tufts, and the different form of its organs of reproduction. Still it must be admitted that imperfect specimens could not readily be distinguished from branchlets of *P. princeps*. It was found by Mr. Matthew in the shales near Carlton.

32. Psilophyton? glabrum, sp. nov.

Smooth, flattened, bifurcating stems, two lines in width, with a slender woody axis.

These are objects of doubtful nature. They must have been stems or roots, bifurcating in the manner of *Psilophyton*, but having a very slender woody axis. They may have been either roots of some plant, or stems of a smooth and comparatively succulent species of *Psilophyton.*

33. Selaginites formosus, Dawson.

'Canad. Nat.' vol. vi. p. 176, figs. 11, 12; *Knorria* (?), Quart. Journ. Geol. Soc. vol. xv. p. 486, fig. 5.

"*Stems covered with flat, broad, angular, imbricating scales of unequal size, and ornamented with minute scaly points.*"

This is the plant noticed in my paper on the plants of Gaspé* as probably a *Knorria*. Better specimens have subsequently enabled me to describe it as above, and to refer it to *Selaginites*, without, however, maintaining that it is certainly a Lycopodiaceous plant. It occurs in the shales associated with the Devonian coal-seam at Gaspé.

34. Leptophlœum rhombicum, nov. gen. et sp. Pl. XII. fig. 8; and Pl. XVII. fig. 53.

Stem covered with contiguous rhombic areoles, each with a single small scar a little above its centre, and above this a very slight furrow. Decorticated stems with spiral punctiform scars in slight depressions. Bark thin. Pith-cylinder very large, with transverse markings of the character of Sternbergia.

This plant seems to have presented a straight cylindrical stem, supporting leaves with thick bases, and of which only traces remain. Its bark was thin; and it seems to have had a thin woody cylinder, within which was a very large *Sternbergia*-pith. One specimen shows a growth of young wood at the extremity of the stem, on which the rhombic scars are only imperfectly developed; and at the extremity of this younger portion, the transverse structure of the pith exhibits itself through the thin bark in such a manner that this portion, if separated from the remainder of the stem, might be described as a *Sternbergia*. This is another peculiar phase of these remarkable, transversely wrinkled piths that seem to have belonged to so many of the Carboniferous and Devonian plants. The markings on the surface of the stems of this plant somewhat resemble those of *Lepidodendron tetragonum*, *Ulodendron minus*, and *Lomatofloyos crassicaule*, but the vascular scars and the general structure of the stem are quite different. Still I believe this plant to be more nearly allied to *Ulodendreæ* and *Lepidodendreæ* than to any other plants.

35. Cordaites Robbii, Dawson. Pl. XIV. fig. 31 *a*, *b*, *c*.

Leaves elongated, lanceolate, sometimes three inches wide and a foot in length. Veins equal and parallel. Base broad, clasping the stem, point acuminate.

When this species was described in my paper in the 'Canadian Naturalist†,' only very imperfect specimens were in my possession; but numerous and fine specimens recently found now enable me more perfectly to characterize the species. The leaves vary much in form; and in their young state, as represented in fig. 31 *a*, were

* Quart. Journ. Geol. Soc. vol. xv. p. 486.

† May 1861, p. 168.

often of a regularly oblong form. They have numerous equal parallel nervures, which were probably fibro-vascular, like those of Ferns, as they present precisely the same appearance as the nervures of the plants of this family preserved with them, and which, in these beautiful graphitized specimens, are traced in deeper lines of graphite than the film of the same material which represents the intervening parenchyma. In the best-preserved specimens, the leaf is quite smooth; but in some the space between the nervures rises into little ridges, so as to give a striated appearance. These different aspects, however, often occur on different portions of the same leaf. The present species so closely resembles *C. borassifolia* of the Coal-formation that it might readily be mistaken for it; but it differs somewhat in the form of the leaf, and still more in the venation, the nervures in the present species being perfectly *equal* *.

In the paper already referred to, I have stated at length my reasons for preferring, in the case of this plant and *C. borassifolia*, the generic name *Cordaites*, to *Poacites*, *Flabellaria*, and *Nœggerathia*, all of which have been applied to such plants, together with others having no affinity to them. To the name *Pychnophyllum*, proposed by Brongniart, this objection does not apply; but *Cordaites*, I believe, has priority, and is due to the describer of the typical species.

I associate the genus *Cordaites* with Lycopodiaceous plants without hesitation, notwithstanding the peculiar character of its foliage, because Corda has shown that its stem is strictly acrogenous in structure, and of the same type with those of *Lomatofloyos* and *Ulodendron*—a fact which excludes it alike from association with Monocotyledonous plants and with Ferns.

It is worthy of notice that, while the leaves of *Cordaites*, unlike those of *Sigillaria* and *Lepidodendron*, were not attached by narrow bases, but clasping, they were still, like those of nearly all other Devonian and Carboniferous plants, deciduous and capable of disarticulation, as is proved by the immense abundance of fallen leaves, while the stems, probably remaining attached to the soil, are rare. It is further to be observed that these leaves were rigid, and long resisted decomposition; on which account, no doubt, they formed a favourite base of attachment for the little *Spirorbes* which swarmed both in the Devonian and Carboniferous Periods. At St. John many of these leaves are covered with these little shells.

The leaves of the present species are very abundant in the shales of the vicinity of St. John, and indeed are eminently characteristic of them; and on this account I regard the dedication of it to my late lamented friend, Dr. Robb, as specially appropriate. I have not recognized this plant in the specimens from Gaspé or Perry; and the only indication of it in the New York collection is a fragment of a leaf from the Hamilton group of Cazenovia, New York, not sufficiently perfect to render its identification certain.

* The nervures in *C. borassifolia* are alternately thick and thin; but there is an undescribed species in the *Upper* Coal-measures of Nova Scotia which has equal nervures.

36. Cordaites angustifolia, Dawson.

Leaves linear, much elongated, one-tenth to one-fourth of an inch broad, with delicate, equal, parallel nervures.

This species, originally described from specimens collected at Gaspé, where it abounds in the roof of the little Devonian coal-seam, occurs also at St. John, and in the Marcellus Shale of New York; and it has also been found by Sir W. E. Logan in the *Upper Silurian* of Cape Gaspé, together with fragments which may have belonged to *Psilophyton.* It usually occurs as long riband-like detached leaves, not always easily distinguishable from the flattened stems and roots of other plants found in the same beds. I have not seen the apex nor the base of the leaf, but among Prof. Hall's specimens from the Marcellus Shale is one which appears to consist of the remains of several leaves, attached to a short stem, of which the structure and markings have perished.

Plants closely resembling this are described by Unger and Gœppert, from the Devonian of Europe; but the characters given do not enable me to identify any of them with the present species. Such plants are placed by those writers in the genus *Nœggerathia,* which I reject for the reasons above stated.

37. Cordaites (?). Pl. XVI. fig. 59.

One of Prof. Hall's specimens from the Hamilton group is a cast of a stem which appears to have produced closely adpressed clasping leaves, obscurely striated, and widening upward. I refer it to this genus, but cannot determine whether it belonged to either of the species above described or to a third, though perhaps the latter is the more probable supposition.

38. Megaphyton (?).

An obscurely marked stem in Mr. Richardson's collection, from Perry, appears to indicate a plant of this genus, but does not afford sufficient characters for description.

(*Filices.*)

39. Cyclopteris Halliana, Gœppert. Pl. XVII. figs. 54, 55.

Gœppert, 'Flora Silurisch.' p. 498; *Sphenopteris laxa,* Hall, 'Report Geol. New York,' p. 275, fig. 127.

The original specimen of this beautiful plant has been submitted to me by Prof. Hall, and corresponds very closely with the figure above referred to, and with Gœppert's description, based on that figure. The nervures, which Gœppert notes as simple or dichotomous, are apparently the latter, and the pinnules seem to have been slightly lobed at the margins as in *Adiantum.* Its densely leafy rachis, with its rich terminal pinnules and delicate drooping lateral pinnæ, give it an appearance at once unique and graceful; while the form, arrangement, and venation of the pinnules are peculiar features of that antique group of Cyclopteroid Ferns so highly characteristic of the Devonian and Lower Carboniferous beds.

This group of Ferns, including the present species, with *C. Jacksoni*, *C. obliqua*, *C. Hibernica*, and others, is no doubt generically distinct, as Lesquereux very properly maintains, from the *Cyclopterides* of the Coal-measures; but this industrious observer has unfortunately applied to it the generic name *Nœggerathia*, which is used by Unger, Gœppert, and others for leaves with parallel striation and supposed to be monocotyledonous. On this account, rather than increase the confusion of the nomenclature, I in the meantime retain, with the above explanation, the name *Cyclopteris*. The present species occurs in the Chemung group of New York.

40. Cyclopteris Jacksoni, Dawson.

'Canad. Nat.' vol. vi. p. 173, fig. 9.

"*Frond bipinnate; rachis stout and longitudinally furrowed; pinnœ alternate; pinnules obliquely obovate, imbricate, narrowed at the base, and apparently decurrent on the petiole; nerves nearly parallel, dichotomous; terminal leaflet large, broadly obovate or lobed.*"

This species, first described, in my paper in the 'Canadian Naturalist,' from a specimen found at Perry, occurs also in small fragments at St. John, and large specimens occur in the collection of Prof. Hall from the Old Red Sandstone of Montrose, New York. It is closely allied to *C. Hibernica*, and is its American representative.

41. Cyclopteris obtusa, Lesquereux. Pl. XV. fig. 33.

To this species, described by Lesquereux, from the Old Red Sandstone of Pennsylvania, I refer a beautiful Fern not unfrequent in the shales near St. John. Lesquereux places it, for the reasons above mentioned, in the genus *Nœggerathia*.

42. Cyclopteris valida, sp. nov. Pl. XVII. fig. 52.

Tripinnate; primary divisions of the rachis stout and wrinkled. Pinnœ regularly alternate. Lower pinnules nearly as broad as long, deeply and obtusely lobed, narrowed and decurrent at the base; regularly diminishing in size and breadth toward the point, and the last pinnules narrowly obovate and confluent with the terminal pinnule. Nerves delicate, several times dichotomous.

This is the most perfect and beautiful of the St. John Ferns. It resembles at first sight *Sphenopteris macilenta*, L. & H.; but on examination it differs materially in details. It is an elaborate and ornate example of the peculiar type of *Cyclopteris* already referred to as characteristic of the Upper Devonian Period.

43. Cyclopteris varia, sp. nov. Pl. XV. fig. 34.

Pinnate (or bipinnate). Pinnœ with a thick petiole. Pinnules decreasing in size to the terminal one, which is ovate and lobed. Pinnules oblique, decurrent on one side. Nerves frequently dichotomous.

This Fern has been found only in fragments. It seems to have been a thick fleshy frond, but the specimens are insufficient to show its habit of growth. Its nearest allies seem to be *C. Villiersi*, Sternberg (*Neuropteris Villiersi*, Brongn.), and *Cyclopteris heterophylla*, Gœppert; but it differs from both.

44. Cyclopteris Brownii, sp. nov. Pl. XII. fig. 9.

Pinnules large, cuneate, with distant, once-forked nerves, and waved margins.

This is a mere fragment, but indicates a very distinct plant from any known to me elsewhere. It was collected at Perry by Prof. C. H. Hitchcock, and is named in honour of Mr. Brown, of Perry, one of the earliest explorers of the beds at that place.

45. Cyclopteris incerta, sp. nov. Pl. XVI. fig. 44.

Stipes half an inch in diameter, giving off branches at acute angles, on which are borne, below, branching and recurved remains of fertile pinnules and, above, traces of terminal obovate pinnules.

I describe this plant rather as an indication of a species than as one actually known. The parts remaining are similar in arrangement to those of *Cyclopteris Acadica* of the Lower Coal-measures of Nova Scotia, and prove the existence of a somewhat similar species during the era of the Hamilton group in New York, from which this specimen is derived.

46. Neuropteris serrulata, sp. nov. Pl. XV. fig. 35 *a*, *b*.

Bipinnate. Rachis thin and slender. Pinnæ alternate, sparsely placed, and of few pinnules. Pinnules obovate, narrowed at base, sessile, delicately but sharply serrate, especially at the apex. Terminal leaflet rounded and lobed, scarcely serrulate. Midrib visible nearly to the apex. Pinnules about two lines in length.

From the St. John shales, where it seems to be rare. It is a delicate little species, quite distinct, in so far as I am aware, from any heretofore described.

47. Neuropteris polymorpha, sp. nov. Pl. XV. fig. 36 *a*, *b*, *c*.

Pinnate or bipinnate. Rachis or secondary rachis irregularly striate. Pinnules varying from round to oblong, unequally cordate at base, varying from obtuse to acute. Terminal leaflet ovate, acute, angulated or lobed. Midrib delicate, evanescent. Nervures slightly arcuate, at acute angles with the midrib.

This Fern is very abundant in the shales near Carlton, at St. John. At first sight it appears to constitute several species, but careful comparison of numerous specimens shows that all the various forms figured may occur on the same frond. In its variety of forms it resembles *N. heterophylla*, Brongn., or *N. hirsuta*, Lesquereux; but it differs from the former in its delicate midrib and acutely angled nervures, and from the latter in its smooth surface.

48. Sphenopteris Hœninghausi, Brongniart.

One of the Ferns from the shales near St. John appears to be identical with the above species, which belongs to the Lower Carboniferous of Europe.

49. Sphenopteris marginata, sp. nov. Pl. XV. fig. 38 *a, b.*

This resembles the last species in general form, but is larger, with the pinnules round or round-ovate, divided into three or five rounded lobes, and united by a broad base to the broadly winged petiole.

Found with the preceding. One specimen, given to me by Mr. Hartt, shows a frond 6 inches in length.

50. Sphenopteris Harttii, sp. nov. Pl. XVI. fig. 48 *a, b.*

Bipinnate or tripinnate. Divisions of the rachis margined. Pinnules oblique, and confluent with the margins of the petiole; bluntly and unequally lobed. Nerves small, oblique, twice-forked.

This beautiful Fern very closely resembles *S. alata* from the coal-field of Port Jackson, but differs in several of its details. I name it in honour of Mr. Hartt, the discoverer of several of the St. John Ferns. Found with the preceding.

51. Sphenopteris Hitchcockiana, sp. nov. Pl. XVI. fig. 51 *a, b, c.*

Stipes stout, straight, rugose, giving off slender secondary petioles, which ramify dichotomously and terminate in minute obovate leaflets.

This beautiful plant, from Perry, which I name in honour of its discoverer, who worthily bears a name long noted in American Geology, has the aspect rather of a stem with excurrent branchlets than of a frond. Its venation cannot be distinguished. It belongs to a peculiar group or subgenus (*Davallioides* of Gœppert) characteristic of the Devonian and Lower Carboniferous, and represented in Europe by such plants as *S. petiolata*, Unger, *S. refracta*, Gœppert, and *S. Devonica*, Unger. Some of these plants (and this applies to the one now noticed) convey the impression that they may be subaquatic portions of Ferns bearing pinnules of different form in the air. Immense numbers of leaflets, apparently of this species, are scattered over certain surfaces of the St. John shales, but have not yet been seen in connexion with their rachis; and one of Prof. Hall's specimens from New York exhibits a stipe quite like that of the present species, but with mere traces of the pinnæ.

52. Hymenophyllites curtilobus, sp. nov. Pl. XV. fig. 39.

Bipinnate. Rachis slender, dichotomous, with divisions margined. Leaflets deeply cut into subequal obtuse lobes, each one-nerved, and about one-twentieth of an inch wide in ordinary specimens.

According to Lesquereux, the genus *Hymenophyllites* is characteristic in America of the Upper Devonian. In Europe it is represented also in the Lower Coal. I have not seen any species in the Carboniferous rocks of Nova Scotia or New Brunswick. The present is the only new species occurring at St. John. It resembles a gigantic variety of *H. obtusilobus*, Gœppert (*Sphenopteris trichomanoides*, Brongn.).

53. Hymenophyllites obtusilobus, Gœppert.

Found with the preceding.

54. Hymenophyllites Gersdorffii, Gœppert. Pl. XV. fig. 37.

Found with the preceding.

55. Pecopteris (Alethopteris) decurrens, sp. nov. Pl. XV. fig. 40 *a, b, c.*

Bipinnate. Pinnules rather loosely placed on the secondary rachis, but connected by their decurrent lower sides, which form a sort of margin to the rachis. Midrib of each pinnule springing from its upper margin and proceeding obliquely to the middle. Nerves very fine and once-forked. Terminal leaflet broad.

This Fern so closely resembles *Pecopteris Serlii* and *P. lonchitica* that I should have been disposed to refer it to one or other of these species but for the characters above stated, which appear to be constant. *P. Serlii* is abundant in the Lower Carboniferous of Northern New Brunswick, and *P. lonchitica* is the most common Fern throughout the whole thickness of the Joggins Coal-measures; but in neither locality does the form found at St. John occur. On this account I think it probable that the latter is really distinct. In Murchison's 'Siluria,' 2nd edit., p. 321, a Fern from Colebrook Dale is figured as *P. lonchitica*, which, so far as I can judge from the engraving, may be identical with the present species. Locality, St. John.

56. Pecopteris (Alethopteris) ingens, sp. nov. Pl. XV. fig. 41 *a, b.*

Pinnules more than an inch wide, and three inches or more in length, with nervures at right angles to the midrib and forking twice.

Only a few fragments of pinnules of this species have been found in the shales near St. John. They are usually doubled along the midrib, as if it had been their habit to be folded in a conduplicate manner. Their general aspect suggests a resemblance to the Mesozoic Tænio-pterids rather than to the Pecopterids of the Coal-formation.

57. Pecopteris (Alethopteris). Pl. XVI. fig. 49.

Mr. Hartt has recently sent to me, from St. John, a pinna of a *Pecopteris* having oblong, obtuse pinnules attached by the whole base, with a slender midrib, and slightly repand edges. The nervures are not preserved. It closely resembles *A. obscura*, Lesquereux, from the Coal of Pennsylvania.

58. Trichomanites (?). Pl. XVI. fig. 50 *a, b.*

A minute frond, collected at St. John by Mr. Hartt, may possibly represent a plant of this genus; but it may be merely the nervures of a leaf whose parenchyma has been removed by decay.

59. Rhachiopteris pinnata. Gen. et sp. nov. Pl. XVI. fig. 60.

Stipes half an inch wide or less, unevenly striate, giving off opposite branches, which are abruptly broken off at short distances from the stipe.

Unger has established as a provisional family, under the name of *Rhachiopterides,* a number of species, referred to several genera, of stipes of ferns showing structure; and I now propose under the above name to include such Devonian stipes as indicate the existence of distinct species of Ferns, of which the fronds have perished. This has the advantage of provisionally recognizing the existence of such species, and of preventing their stipes from being referred, in their flattened state, to other families of plants. It also serves to remind us of the fact that, while in some localities we have a number of species of Ferns in a good state of preservation, in others an equal number of species are represented only by fragments of stipes. The latter state of things is especially noteworthy in the Middle Devonian of New York, from the lower member of which, the Marcellus Shale, the present species is derived.

60. Rhachiopteris cyclopteroides, sp. nov.

Very thick stipes, not observed to branch, and marked with uneven longitudinal striæ.

Base of the Catskill group, New York.

61. Rhachiopteris punctata, sp. nov. Pl. XVI. fig. 61.

Stipes marked with obscure longitudinal ridges, between which are transverse furrows or punctures; greatest diameter an inch.

These stipes are marked in the manner of those of *Cyclopteris Rimeriana,* Gœppert, of the Upper Devonian; and Unger figures a similar stem from the Devonian of Thuringia. The present specimens are from the Catskill group of New York. Fragments with similar markings occur both at St. John and Gaspé.

62. Rhachiopteris striata, sp. nov.

Stipes regularly and distinctly striated longitudinally.

Many short fragments of these stipes occur on the surfaces of beds of the Chemung group at Richfield, Ohio, and the Hamilton group at Akron, Ohio. They are not distinguishable from similar fragments of the stipes of *Cyclopteris Acadica,* and, like these, might, when flattened, be mistaken for leaves with parallel veins.

63. Rhachiopteris tenuistriata, sp. nov. Pl. XIV. fig. 32 *a, b*; and Pl. XVI. figs. 45, 46.

Stipes smooth, finely striated, and in some specimens with little linear ridges scattered over the surfaces, and perhaps marking the position of minute hairs. Largest stems an inch in diameter, branching pinnately and dichotomously, and terminating in recurved divisions or in long flattened petioles.

More than one species may possibly be included under this name;

but all the specimens are apparently stipes of species of *Cyclopteris* or *Sphenopteris*. They occur in the Genessee Shale and Marcellus Shale. Many somewhat similar stipes occur at Perry and at Gaspé.

Note.—Since writing the above paper, I have received from Mr. Hartt two additional Ferns, collected by Mr. Lann and Mr. Payne, of St. John. One of them is a pinnule of a *Neuropteris*, in some points resembling *N. gigantea*. It is about an inch in length, broadly oval in form, and with a thick and persistent midrib and crowded nervures, forking twice. The other is a *Sphenopteris*, with elongated pinnatifid pinnæ, much in the style of *S. intermedia*, Lesquereux. Neither of these plants seems identical with any described species; but more perfect specimens are required for their description.

(*Incertæ sedis.*)

64. Cardiocarpum cornutum, sp. nov. Pl. XIII. figs. 23, 24.

Broadly ovate, emarginate at base, dividing into two inflexed processes at top. A mesial line proceeds from the sinus between the cusps, downward. Nucleus more obtuse than the envelope, and acuminate at the top. Surface of the flattened envelope striate, that of the nucleus more or less rugose. Length about seven lines.

Numerous in shale near St. John. The specimens are all perfectly flattened, and many of them are also distorted, being elongated or shortened according to the direction in which they lie in the shale. The nucleus constitutes a strongly shaded spot of graphite. The flattened envelope appears as a less distinct wing or border.

65. Cardiocarpum obliquum, sp. nov. Pl. XIII. fig. 25.

Unequally cordate, acuminate, smooth, with a strong rib passing down the middle; length about three lines.

Found with the preceding. It somewhat resembles some of the forms of *C. acutum*, L. & H.

66. Trigonocarpum racemosum, sp. nov. Pl. XVI. fig. 47 *a, b, c.*

Ovate, obtusely acuminate, in some specimens triangular at apex. In flattened specimens the envelope appears as a wing. Attached in an alternate manner to a thick, flexuous, furrowed rachis.

This is evidently a fruit or seed, borne in a racemose manner on a stout rachis. In some specimens the seeds are close to each other, in others more remote. Attached to some are apparently traces of calyx-leaves or bracts. Shales of St. John.

67. Acanthophyton spinosum, gen. et sp. nov. Pl. XII. fig. 6 *a, b.*

Cylindrical branches, ramifying in an alternate manner, striated, and with scattered tubercles, on which are borne short spines or prickles.

These specimens, from the Hamilton group of New York, resemble fragments of branches of some spiny or prickly exogenous plant. The stipes of some Ferns, as *Neuropteris lineata*, have a spinous appearance when deprived of their pinnules; but the present specimens are obviously of different character. In Prof. Hall's collections from the Chemung group there are similar stems, with tubercles, but with a minutely punctured surface. These may possibly indicate a distinct species.

(*Algæ.*)

Among Prof. Hall's specimens are several which probably belong to *Algæ*; but I regard them as too obscure in their affinities to merit detailed description, with the exception of the following.

68. Uphantænia Chemungensis, Vanuxem. Pl. XVII. fig. 62.

Vanuxem's 'Report, Geol. New York,' p. 153, fig. 50.

Flabellate, invested, conical or hollow, cylindrical fronds, marked externally with cross striæ, dividing the surface into rectangular spaces; and in the cylindrical forms with rows of tubercles.

Vanuxem has figured and described, under the above name, a flabellate frond which he represents as apparently consisting of tape-like bodies interwoven like basket-work. The specimens submitted to me have, however, rather the character of a continuous surface marked out into spaces by radiating and concentric striæ. With these fan-like forms are associated others that are bluntly conical, and others still that are elongately conical or cylindrical; and some of the latter are covered with large tubercles arranged in vertical and transverse rows, so as to give an appearance like that of stems of the genus *Halonia*. One of these curious stem-like objects is illustrated by fig. 62 (from a photograph). Some of the specimens are much more finely marked than others, but there are gradations in this; and there are indications that some of the more finely marked stems had flabellate or conical fronds upon them. These objects are very perplexing, and are found in marine beds, but mixed with remains of land-plants. On the whole I regard them as *Algæ* with funnel-shaped fronds sometimes prolonged into cylinders, and, when adult, bearing fructification in tubercles on the sides of the cylinders. In general form these plants may be compared with *Algæ* of the family *Dictyoteæ*; but there is no indication that they resembled these in details of structure. Some of the specimens have a slight carbonaceous coating. The cylindrical forms seem to have been regarded by Conrad as shells, and were named *Hydroceras*. The specimens in my possession are from the Chemung group in New York and Ohio. They may represent several species, but, on the other hand, it is quite possible that they may be different states and portions of the same plant.

Geological and Geographical Distribution of the Devonian Plants of Eastern America.

Names of Species.	Upper Silurian.	Lower Devonian.	Middle Devonian.		Upper Devonian.					
	Gaspé.	Gaspé.	Gaspé.	New York.	Gaspé.	New York.	Maine.	New Brunswick.	Pennsylvania.	Carboniferous.
1. Syringoxylon mirabile				*						
2. Dadoxylon Ouangondianum								*		
3. —— Halli				*						
4. Aporoxylon				*			*			
5. Prototaxites Logani †			*							
6. Sigillaria Palpebra								*		
7. —— Vanuxemii						*				
8. —— Simplicitas				*						
9. Syringodendron gracile				*						
10. Stigmaria exigua						*				
11. —— ficoides								*		*
12. Didymophyllum reniforme				*						
13. Calamites Transitionis								*		*
14. —— cannæformis								*		*
15. —— inornatus				*	*					
16. Asterophyllites acicularis								*		
17. —— latifolia								*		
18. —— scutigera								*		
19. —— longifolia								*		*
20. —— parvula								*		
21. Annularia acuminata								*		
22. Sphenophyllum antiquum								*		
23. Pinnularia dispalans								*		
24. Lepidodendron Gaspianum			*	*	*	*	*	*	*	
25. —— Chemungense						*				
26. —— corrugatum						*				*
27. Sagenaria Veltheimiana ‡					*				*	*
28. Lepidostrobus Richardsoni							*			
29. —— globosus							*			
30. Lycopodites Matthewi								*		
31. —— Vanuxemii						*				
32. Psilophyton princeps	*	*	*	*	*	*	*			
33. —— elegans								*		
34. —— glabrum								*		
35. Selaginites formosus			*		*					
36. Leptophlœum rhombicum							*			
37. Cordaites Robbii								*		*?
38. —— angustifolia	*	*	*	*				*		
39. Cordaites ?				*						
40. Megaphyton ?							*			
41. Cyclopteris Halliana						*				

† This species was not noticed in the descriptions, as no new facts relating to it had been obtained.

‡ I have marked this species as occurring in Pennsylvania, being of opinion that it is the same with *Lepidodendron primævum* of Rogers.

Geological and Geographical Distribution of the Devonian Plants of Eastern America (continued).

Names of Species.	Upper Silurian.	Lower Devonian.	Middle Devonian.		Upper Devonian.					
	Gaspé.	Gaspé.	Gaspé.	New York.	Gaspé.	New York.	Maine.	New Brunswick.	Pennsylvania.	Carboniferous.
42. Cyclopteris Jacksoni							*	*		
43. —— obtusa								*	*	
44. —— valida								*		
45. —— varia								*		
46. —— Brownii							*	*		
47. —— incerta				*						
48. Neuropteris serrulata								*		
49. —— polymorpha								*		
50. Sphenopteris Hœninghausi								*		*
51. —— marginata								*		
52. —— Hartii								*		
53. —— Hitchcockiana							*			
54. Hymenophyllites curtilobus								*		
55. —— obtusilobus								*		
56. —— Gersdorffii								*		*
57. Alethopteris decurrens								*		*
58. —— ingens								*		
59. —— obscura?								*		*?
60. Trichomanites								*		
61. Rhachiopteris pinnata				*						
62. —— cyclopteroides						*				
63. —— punctata						*				
64. —— striata				*		*				*?
65. —— tenuistriata				*						
66. Cardiocarpum cornutum								*		
67. —— obliquum								*		
68. Trigonocarpum racemosum								*		
69. Acanthophyton spinosum										

III. Conclusion.

In the course of the preceding pages, I have endeavoured to notice points of general geological and botanical interest as they occurred; and it will now be necessary only to mention a few leading results, as to the Devonian Flora, which may be deduced from the observations above recorded.

1. In its general character the Devonian Flora resembles that of the Carboniferous Period, in the prevalence of Gymnosperms and Cryptogams; and, with few exceptions, the generic types of the two periods are the same. Of thirty-two genera to which the species described in this paper belong, only six can be regarded as peculiar to the Devonian Period. Some genera are, however, relatively much

better represented in the Devonian than in the Carboniferous deposits, and several Carboniferous genera are wanting in the Devonian.

2. Some species which appear early in the Devonian Period continue to its close without entering the Carboniferous; and the great majority of the species, even of the Upper Devonian, do not reappear in the Carboniferous Period; but a few species extend from the Upper Devonian into the Lower Carboniferous, and thus establish a real passage from the earlier to the later flora. The connexion thus established between the Upper Devonian and the Lower Carboniferous is much less intimate than that which subsists between the latter and the true Coal-measures. Another way of stating this is, that there is a constant gain in number of genera and species from the Lower to the Upper Devonian, but that at the close of the Devonian many species and some genera disappear. In the Lower Carboniferous the flora is again poor, though retaining some of the Devonian species; and it goes on increasing up to the period of the Middle Coal-measures, and this by the addition of species quite distinct from those of the Devonian Period.

3. A large part of the difference between the Devonian and Carboniferous Floras is probably related to different geographical conditions. The wide swampy flats of the Coal Period do not seem to have existed in the Devonian era. The land was probably less extensive and more of an upland character. On the other hand, moreover, it is to be observed that, when in the Middle Devonian we find beds similar to the underclays of the Coal-measures, they are filled, not with *Stigmaria*, but with rhizomes of *Psilophyton*; and it is only in the Upper Devonian that we find such stations occupied, as in the Coal-measures, by *Sigillaria* and *Calamites*.

4. Though the area to which this paper relates is probably equal to any other in the world in the richness of its Devonian Flora, still it is apparent that the conditions were less favourable to the preservation of plants than those of the Coal Period. The facts that so large a proportion of the plants occur in marine beds, and that so many stipes of Ferns occur in deposits that have afforded no perfect fronds, show that our knowledge of the Devonian Flora is relatively far less complete than our knowledge of that of the Coal-formation.

5. The Devonian Flora was not of lower grade than that of the Coal Period. On the contrary, in the little that we know of it we find more points of resemblance to the Floras of the Mesozoic Period, and of modern tropical and austral islands, than in that of the true Coal-formation. We may infer from this, in connexion with the preceding general statement, that in the progress of discovery very large and interesting additions will be made to our knowledge of this flora, and that we may possibly also learn something of a land fauna contemporaneous with it.

6. The *facies* of the Devonian Flora in America is very similar to that of the same period in Europe, yet the number of identical species does not seem to be so great as in the coal-fields of the two continents. This may be connected with the different geographical

On the FLORA of the DEVONIAN PERIOD in NORTH-EASTERN AMERICA. By J. W. DAWSON, LL.D., F.G.S., Principal of M'Gill University, Montreal.

[Read December 17, 1862, and printed in this volume by permission of the Council.]

APPENDIX, September 1862.—In a recent visit to Perry, the author (with the aid of Mr. Brown, of that place) thoroughly examined the present exposure of the plant-bearing bed. Among the specimens obtained were the following. (1.) Wood of a conifer of the genus *Dadoxylon.* (2.) A new *Stigmaria* of the type of *S. exigua.* (3.) Specimens of *Lepidostrobus Richardsoni,* showing it to have been the fructification of a new and interesting species of *Lycopodites.* (4.) Another species of *Lycopodites* allied to *L. Erdmanni,* Germar. (5.) A new species probably of the genus *Anarthrocanna,* Gœppert. (6.) A new *Cordaites.* (7.) More perfect specimens of *Cyclopteris Browniana,* showing it to have been a large and beautiful flabellate leaf or frond, possibly identical with that from the Upper Devonian of Pennsylvania, figured by Prof. Rogers, 'Pennsylvania Report,' vol. ii. part 2. pl. 22. (8.) A Fern allied to *Cyclopteris Jacksoni,* but with a stem similar to that of *C. Roemeriana,* Gœppert. (9.) New species of *Sphenopteris, Trichomanites,* and *Carpolites.* (10.) Specimens of *Leptophlœum rhombicum,* showing its leaves and fructification. These, with some interesting specimens recently collected by Mr. R. Bell, of the Geological Survey, at Gaspé, Dr. Dawson hopes to describe in a future paper.

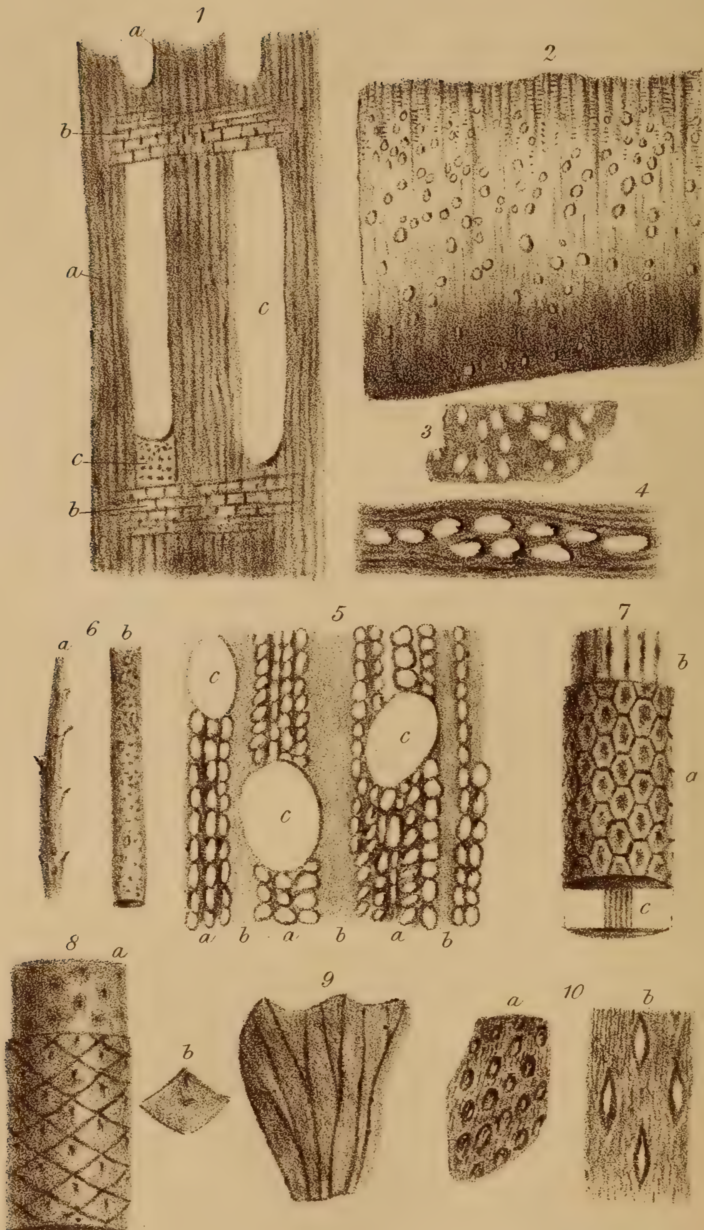
ADDITIONAL NOTE, October 23, 1862.—I am informed by Prof. Hall, in a letter* bearing date Oct. 13th, 1862, that recent observations made by Prof. Orton, Mr. Way, and himself, indicate that the beds which have afforded the plants noticed in this paper as from the Catskill group of New York really belong to a somewhat lower horizon, that of the Chemung group, while the Catskill group proper, as now restricted by Prof. Hall, has not afforded any of these fossils.

This restriction renders it desirable that the following *corrigenda* should be made in my paper :—

Page 298, line 2, *for* Catskill Group *read* Chemung and Portage Groups.
,, ,, line 7, *dele* Chemung Group.
,, 307, line 2 from bottom, foot-note, *for* Catskill *read* Chemung.
,, 313, line 2, *for* Catskill *read* Chemung.
,, 315, line 14, *for* Catskill Group *read* same group.
,, 323, line 22, *for* Base of the Catskill group *read* From the Middle Devonian of.
,, ,, line 29, *for* Catskill *read* Chemung.

J. W. D.

* See letter from Professor Hall to Dr. Dawson, on the corrected range of the Catskill and Chemung groups in New York, in the Canad. Nat. and Geol. vol. vii. No. 5, October 1862, p. 377.



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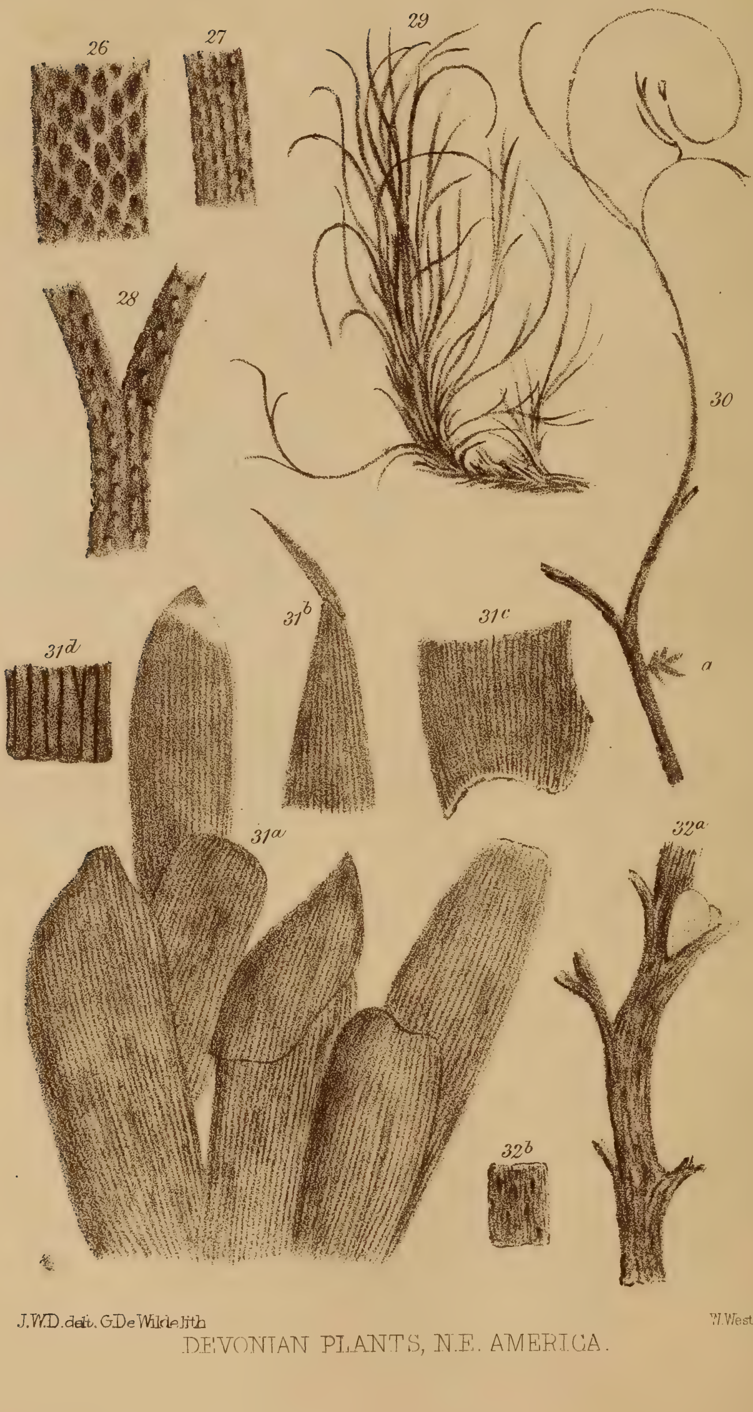

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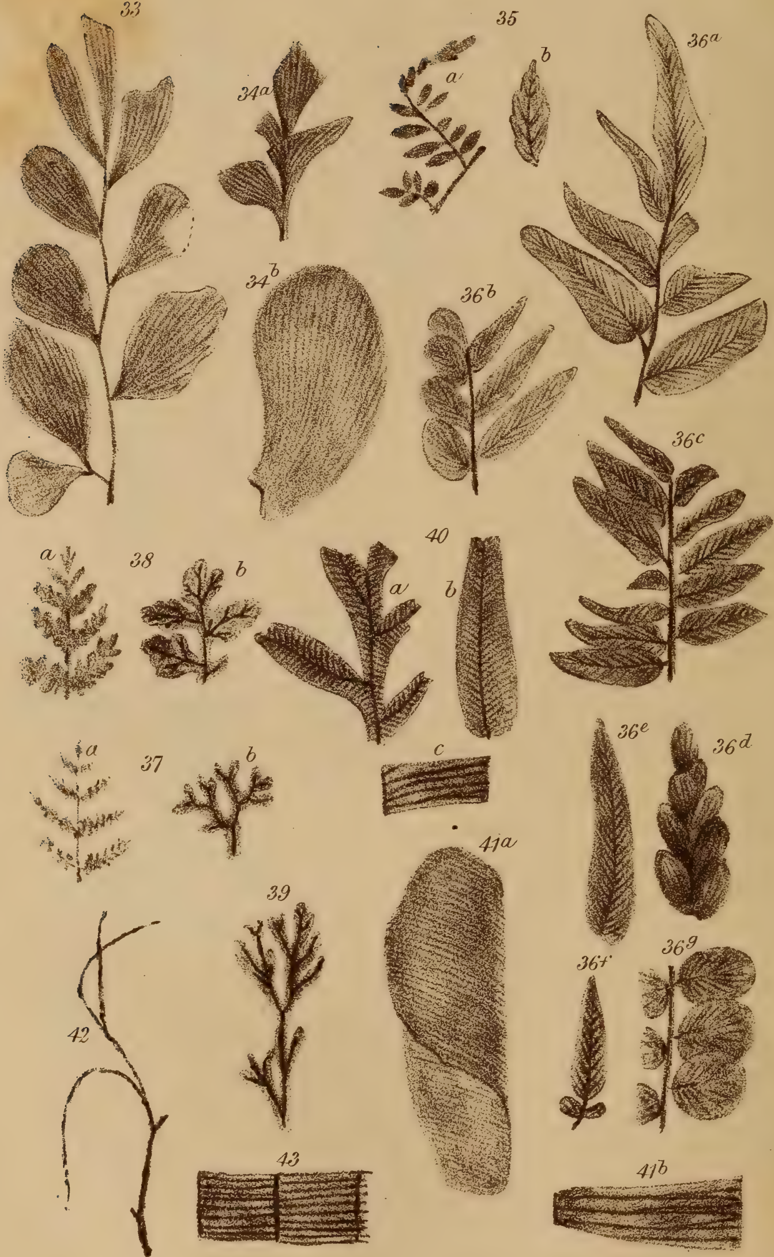

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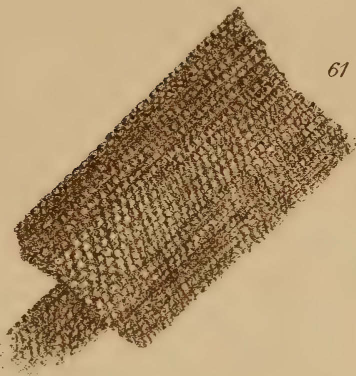

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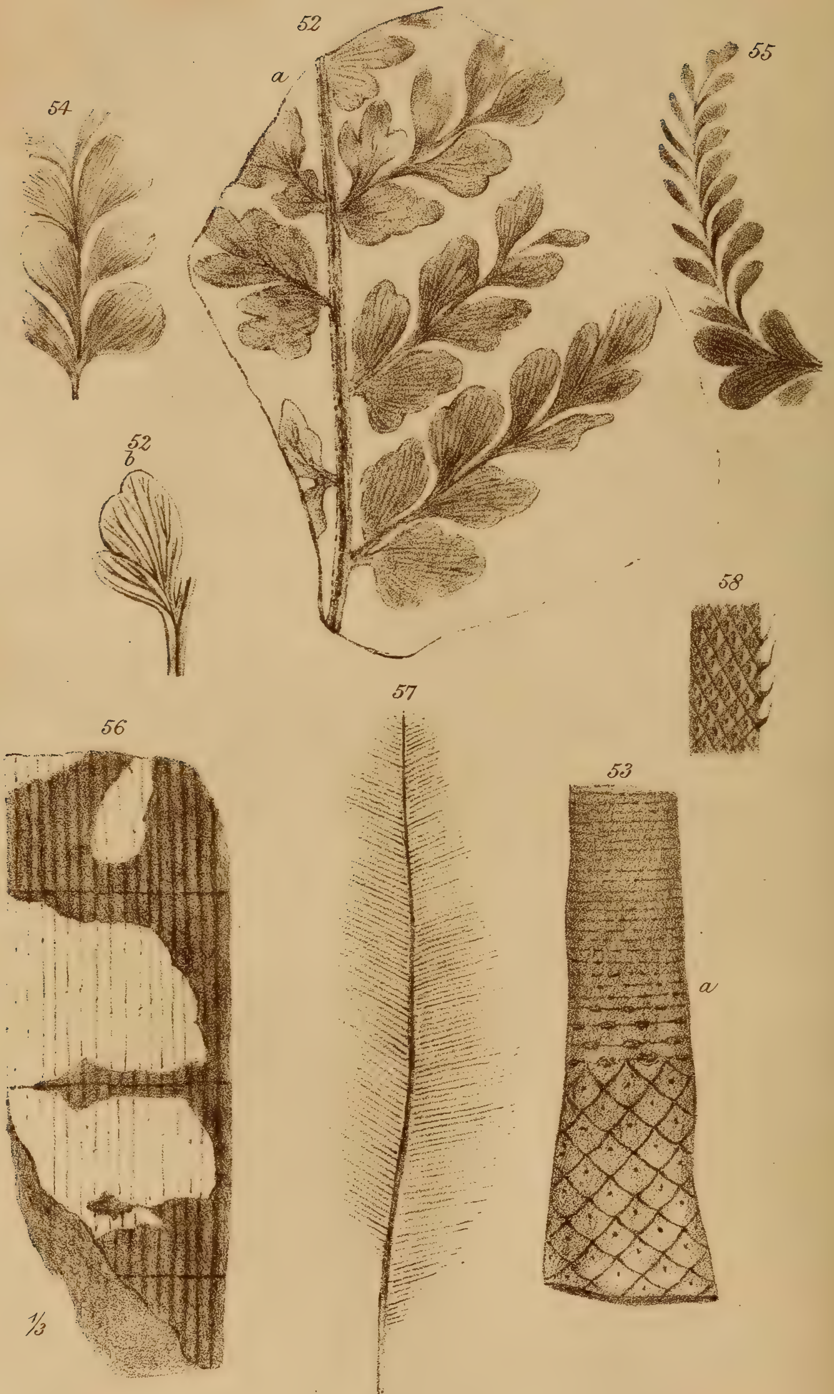

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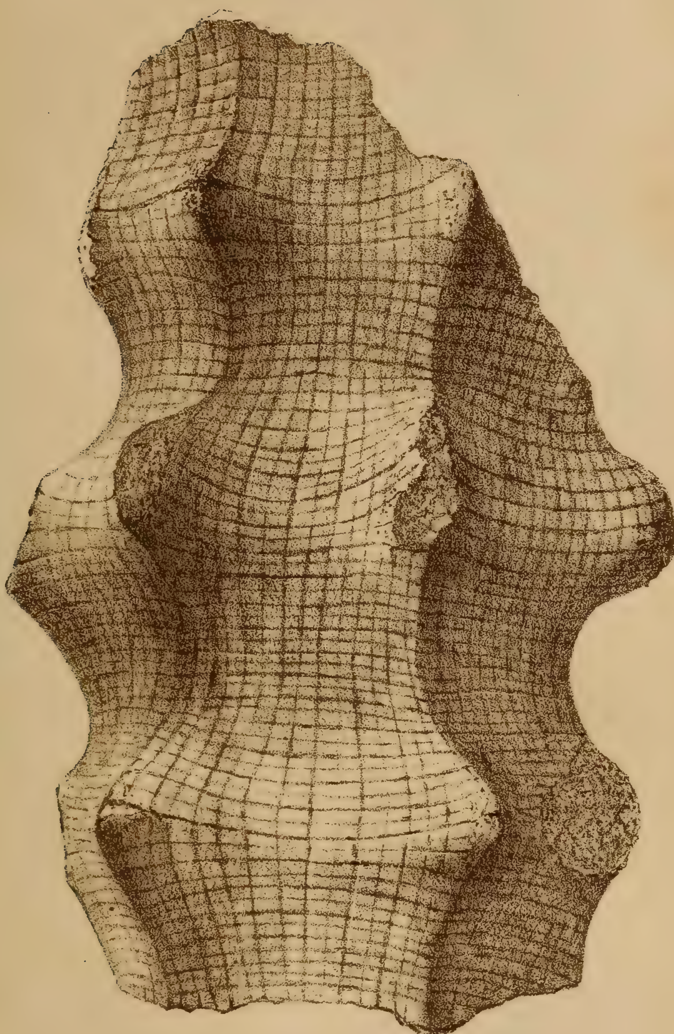

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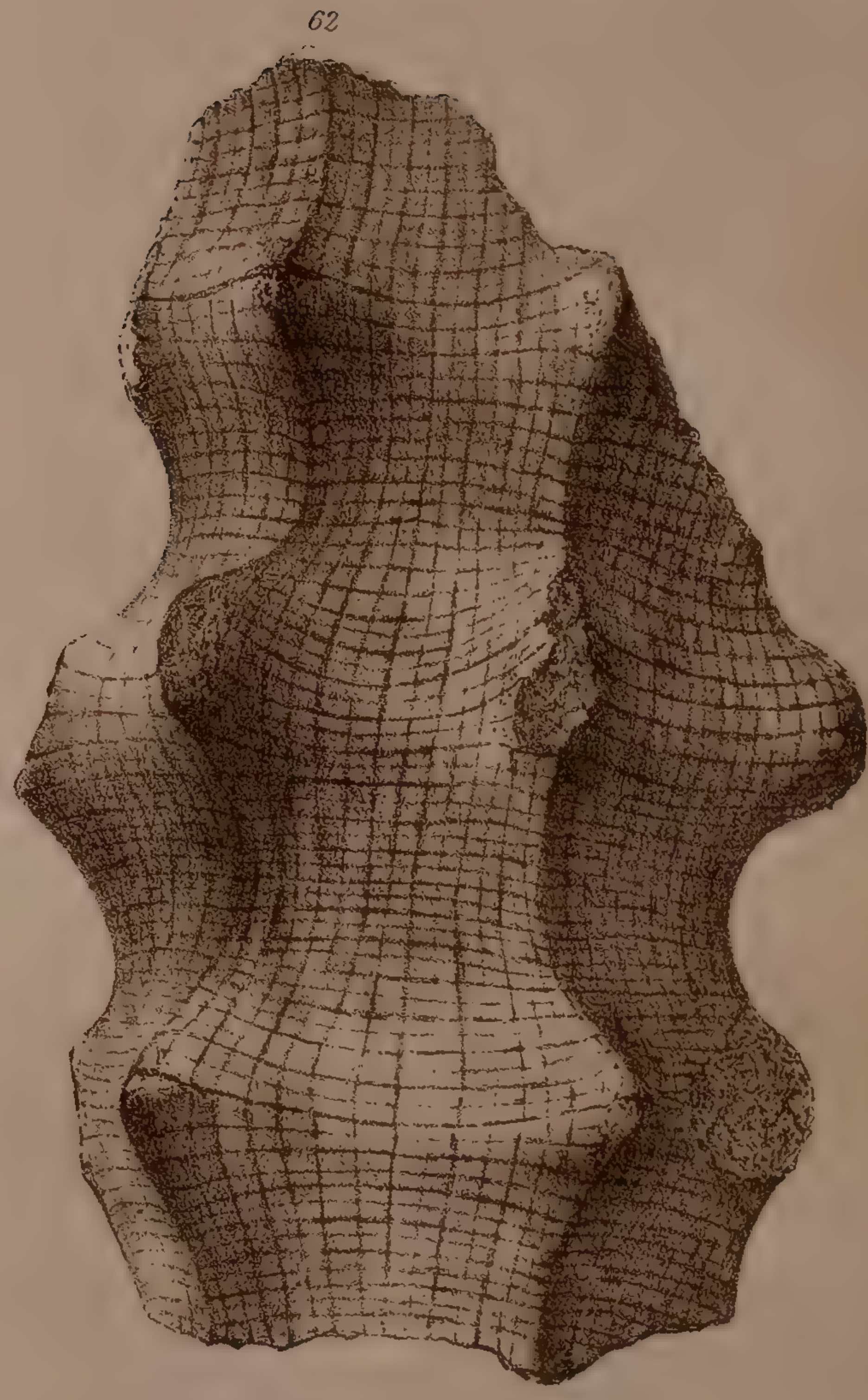

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DEVONIAN PLANTS OF NORTH-EASTERN AMERICA.

conditions in these two periods; but the facts are not yet sufficiently numerous to prove this.

7. The above general conclusions are not materially different from those arrived at by Gœppert, Unger, and Bronn, from a consideration of the Devonian Flora of Europe.

EXPLANATION OF PLATES XII.—XVII.

Illustrative of the Devonian Flora of North-eastern America.

Plate XII.

Fig. 1. *Syringoxylon mirabile*; longitudinal section, highly magnified. *a*, woody fibres; *b*, medullary rays; *c*, ducts.
2. ——; transverse section.
3. ——; portion of a duct, highly magnified, showing the pores.
4. ——; medullary ray, highly magnified.
5. ——; transverse section, highly magnified; letters of reference as in fig. 1.
6. *Acanthophyton spinosum*: *a*, smooth species or variety; *b*, punctated species or variety.
7. *Sigillaria Vanuxemii*: *a*, retaining the outside; *b*, decorticated; *c*, axis.
8. *Leptophlœum rhombicum*: *a*, natural size; *b*, an areole enlarged.
9. *Cyclopteris Brownii.*
10. *Lepidodendron corrugatum*: *a*, portion of a small stem; *b*, part of a larger stem.

Plate XIII.

Fig. 11. *Dadoxylon Halli*; longitudinal section, magnified.
12. *Sigillaria Palpebra*: *a*, natural size; *b*, an areole magnified.
13. *Stigmaria exigua.*
14. *Syringodendron gracile*: *a*, natural size; *b*, an areole magnified.
15. *Didymophyllum reniforme*: *a*, natural size; *b*, an areole magnified.
16. *Asterophyllites acicularis*: *a*, natural size; *b*, a leaf enlarged.
17. *A. latifolia*: *a* and *c*, natural size; *b*, leaf enlarged.
18. *A. scutigera*; ordinary aspect of the stem. 19. Apex of stem. 20. Stem compressed diagonally.
21. *Annularia acuminata.*
22. *Pinnularia dispalans.*
23 & 24. *Cardiocarpum cornutum.*
25. *C. acutum.*

Plate XIV.

Fig. 26, 27, 28. *Lepidodendron Gaspianum*, in various states.
29 & 30. *Psilophyton elegans*: *a*, fructification.
31. *Cordaites Robbii*: *a*, a group of young leaves; *b*, point of leaf; *c*, base of leaf; *d*, venation magnified.
32. *Rhachiopteris tenuistriata*: *a*, natural size; *b*, a portion magnified.

Plate XV.

Fig. 33. *Cyclopteris obtusa.*
34. *C. varia.*
35. *Neuropteris serrulata*: *a*, natural size; *b*, a pinnule enlarged.
36. *N. polymorpha*: *a* to *g*, various forms of pinnules.
37. *Hymenophyllites Gersdorffii*: *a*, natural size; *b*, magnified.
38. *Sphenopteris marginata*: *a*, natural size; *b*, magnified.
39. *Hymenophyllites obtusilobus*; natural size.
40. *Pecopteris decurrens*: *a*, a portion of a frond; *b*, terminal leaflet (*c*, magnified).
41. *P. ingens*: *a*, natural size: *b*, magnified.

Fig. 42. *Psilophyton elegans*, portion of stipe.
43. Fragment of stem of *Asterophyllites*.

PLATE XVI.

Fig. 44. *Cyclopteris incerta*: *a*, stipe; *b*, remains of fertile pinnules; *c*, remains of leaflets.
45 & 46. *Rhachiopteris tenuistriata*.
47. *Trigonocarpum racemosum*: *a* and *b*, natural size; *c*, fruit, magnified.
48. *Sphenopteris Harttii*: *a*, terminal pinna; *b*, portion of frond.
49. *Alethopteris obscura*?
50. *Trichomanites* (?): *a*, natural size; *b*, portion enlarged.
51. *Sphenopteris Hitchcockiana*: *a*, natural size; *b*, *c*, pinnules magnified.
59. *Cordaites* (?) (from a photograph).
60. *Rhachiopteris pinnata* (from a photograph).
61. *R. punctata* (from a photograph).

PLATE XVII.

Fig. 52. *Cyclopteris valida*: *a*, natural size; *b*, pinnule enlarged.
53. *Leptophlœum rhombicum*: *a*, immature portion of stem, showing Sternbergian structure.
54. Terminal pinna of *Cyclopteris Halliana*. 55. Lateral pinna.
56. *Calamites inornatus*; one-third of natural size.
57. *Lycopodites Vanuxemii*.
58. *Lepidodendron Gaspianum*; portion of stem, flattened, covered with bark, and retaining remains of the leaves.
62. *Uphantænia Chemungensis* (from a photograph).

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3. *On* UPPER EOCENE FOSSILS *from the* ISLE OF WIGHT. By Prof. F. SANDBERGER.

[From a Letter to W. J. Hamilton, Esq., F.R.S., For. Sec. G. S., &c.]

As you wish me to give you my opinion respecting these Tertiary beds of the Isle of Wight, I will do it as fully as I can at present *.

I consider the upper formations of Hempstead to be the exact equivalent of those at Weinheim, Jeurres, and Bergh (*Rupelien inférieur*, Dumont). I had already arrived at this opinion, on receiving from Saemann, in Paris, *Voluta Forbesi*, Edw., which Mr. Edwards himself considers as identical with *V. Rathieri*, together with some other fossils which have hitherto only been found in this horizon. The collection now sent adds *Cerithium plicatum*, with varieties, which Mr. Edwards calls *C. subcostellatum*, Forb., and *C. inornatum*, Morr.; also *C. elegans*, Desh. (*C. variabile*, in the collection, and *C. Austenii* belong to the same species), *C. Lamarckii*, Brongn. (= *C. Sedgwickii*, Morr.), also *Ostrea adlata*, S. Wood (= *O. cyathula*, Lam., *juv.*), *Lucina Thierensi*, Héb., *Corbula subpisum*, D'Orb., *Panopœa minor*, Forb. (= *P. Heberti*, Bosq., *juv.*), *Ostrea callifera*, Lam., *O. longirostris*, Lam., *Tellina Nystii*, Desh. (*Tellina*, sp. indeterm. in the collection), *Lithodomus delicatulus*, Desh. (*Modiola*, sp. indeterm. in the collection), hitherto only known from Merigny, Waldböckelheim,

* I had forwarded to Prof. Sandberger a collection of Upper Eocene fossils from the Isle of Wight, made for him by Mr. F. Edwards, F.G.S.—W. J. H.

and Alzey,—so that I now can no longer doubt that the upper beds of Hempstead accurately correspond with our "Marine Sand."

Much more difficult is it to make out the lower beds; I can at present only point out one horizon which corresponds with anything in Alsace or Germany—the freshwater limestone of Bembridge and Sconce=beds at Buxweiler (Alsace) and Abstadt (Baden). Here the following species are decidedly identical:—*Helix Vectiensis*, Edw., *H. D'Urbani*, Edw., *H. occlusa*, Edw., *Planorbis rotundatus*, Sow., *Pl. oligyratus*, Edw., *Pl. lens*, Brongn., and *Pl. elegans*, Edw. Unfortunately I have not the means of ascertaining whether the analogies can be carried further. I am also disposed to believe that the freshwater limestones of Castelnandary in France belong to the same horizon, from whence I have received about twenty species from Deshayes and Lartet. At the same time I cannot venture to consider this so certain as the comparisons with Abstadt, and particularly with Buxweiler (Dép. Bas-Rhin).

The fossils from Headen Hill and Colwell Bay have no resemblance with those of our "Marine Sand." They probably belong to the level of Dumont's *Tongrien Inférieur* (Lethen and Westeregeln) and *Tongrien Supérieur=Marne supérieur au gypse*. It will be necessary for me to compare the marine forms with those of Westeregeln and Bernburg, from whence I am expecting a collection. But the comparison will at all events be difficult, because the English beds are almost entirely brackish, and the German are all purely marine; it will therefore be some time before I can give any account of them. In the meantime it appears to me of great importance to be able to point out an exact equivalent of the beds at Alzey and Buxweiler and Abstadt, which, with the exception of the Bohnerz in South Germany, are the only representations of the Lower Oligocene.

May 21, 1862.

Edward William Cooke, Esq., The Ferns, Hyde Park Gate South; Edmund Jones, Esq., 10 Guildford Street, Russell Square; and William George Lemon, Esq,, Blackheath, were elected Fellows.

The following communications were read:—

1. *On the* Metamorphic Rocks *of the* Banffshire Coast, *the* Scarabins, *and a* Portion *of* East Sutherland. By R. Harkness, Esq., F.R.S., F.G.S., Professor of Geology and Mineralogy, Queen's College, Cork.

Introduction.—I am not aware of any memoir which has reference to the metamorphic rocks of Banffshire, save that of Mr. R. J. H. Cunningham, published in the 'Transactions of the Highland and Agricultural Society of Scotland' (vol. xiii.). In this memoir there is a great amount of information concerning the *lithology* of the rocks which compose the metamorphic strata of this portion of

Scotland, but comparatively little can be gleaned as to the mode in which the several rocks forming these metamorphic deposits are associated together.

Along the Banffshire coast the sections exposing rocks of a metamorphic nature are, on the whole, very satisfactory; and the mode in which these rocks are here arranged can, in most instances, be distinctly made out. In this part of the North of Scotland there is laid down on geological maps an area represented as occupied by strata analogous to those which make up the Lower Silurian of the South of Scotland; and in this area it has been stated that *Graptolites* occur. With reference to the latter, I have reason to believe that what have been assumed to be *Graptolites* are simply dendritic markings of oxide of manganese; and, as concerns the affinity in the mineral nature of the deposits of Banffshire and the South of Scotland, although there is a general resemblance between them, still the former have a decidedly more crystalline character. This crystalline character of the rocks of Banffshire is by no means equally uniform; and a section along the coast of this county shows that in the eastern extremity less of the result of metamorphic action is visible among the strata than in the western side.

On traversing the coast from the Old Red Sandstone of Gamrie, on the east, to the Old Red Sandstone of Buckie, on the west, there is seen, among the strata, especially between Gamrie and Banff, a gradual increase of the metamorphic appearance in the several rocks which occupy this interval; and, west from Banff, rocks having a gneissose aspect are abundantly developed along the coast.

§ 1. *Section from Gamrie to Buckie.* (Fig. 1.)

Commencing on the west side of Gamrie Bay, we have the Old Red deposits, which, in Mr. Cunningham's memoir, are represented as abutting against the highly inclined "Greywacke" rocks which form this side of the bay, the latter being intersected by greenstone. This juncture is, however, now obscured by débris. These older rocks, which here appear in the condition of drab shales, dip to the S.E.; and the same rocks can be seen on the opposite side of the bay, with the same S.E. inclination, at Crovie Head.

On passing westwards along the coast, there is seen coming out from beneath the drab shales a grey sandstone series, some of the beds of which are made up of layers of pebbles about the size of a pea; and, in some instances, these pebbly layers are very distinct. This greywacke-sandstone series has, in some of its layers, a cherty composition; and it passes downwards into quartz-rock, as seen at Melross Head. In this portion of the section, from the drab shales downwards to the quartz-rock, the whole of the strata have a uniform S.E. dip. At a short distance in the interior from Melross Head, a small area of syenite occurs, as laid down in Mr. Cunningham's map.

At Melross Head a roll occurs; and on the western side the newer strata succeed the quartz-rocks, and dip N.W. These continue for some distance, and again the higher drab shales occur at Melross, where they have been worked for roofing-purposes. Between this point and Macduff, many contortions and rolls are seen in the rocks exposed along the coast; and the strata gradually assume a more altered character as they approach the latter place.

The section, as shown in the cliffs between Gamrie and Macduff, exhibits the following arrangement. First, and highest, a mass of drab shale; second, a series made up of greywacke-sandstones, with cherty beds and pebbly layers; and third, and lowest, a small exposure of quartz-rocks. West from Macduff fine-grained gneiss and crystalline greywacke-sandstone overlie quartz-rocks, which form an axis at the entrance into Banff Harbour.

At Banff, opposite the Railway-station, are seen well-developed (and here dipping N.W.) quartz-rocks. To these, on the west, succeed grey gneiss, with intercalated quartz-rocks—the latter, at the boundaries of each stratum, often showing their original condition in the form of fine pebbly layers of rounded quartz. Strata of this nature prevail for a short distance to the west of Banff; but they soon become masked by the sandy shore, which prevails until the Black Pots Tile-works are reached. Here a synclinal occurs; and at Whitehills the prevailing dip is S.E., although the strata are much contorted.

The S.E. dips obtain to near a mass of fine-grained syenite, where N.W. dips again occur. West of the syenite, rolls are again abundant; but, after a short distance, S.E. dips again set in, and continue to the Burn of Boyne, wh ere limestone comes out from beneath the gneiss. This limestone, w hich has been extensively wrought at

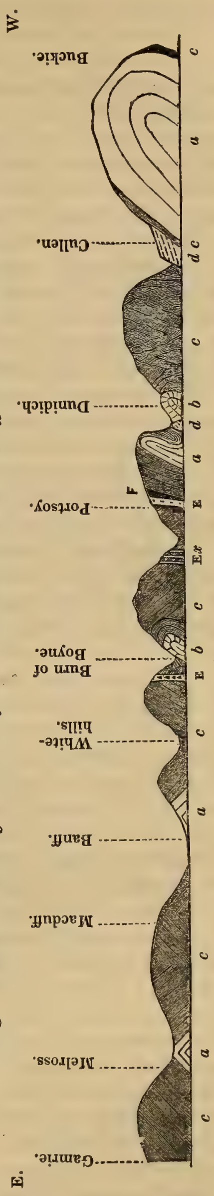


Fig. 1.—*Section along the Coast from Gamrie to Cullen, Banffshire.* Length 25 miles.

E. Syenite. Ex. Granite-veins near Portsoy. F. Serpentine.
b. Limestone. *d.* Old Red Sandstone.
a. Quartz-rock. *c.* Gneiss, greywacke-sandstone, and greywacke-shale.

the Burn of Boyne, is very indistinct in its stratification, and greatly jointed. It seems to have a very persistent character, and can be traced, on its strike, for a long way into the interior of Banffshire, and always exhibits the same aspect as regards the indistinct nature of its stratification. In the interior of the county, it is worked about three miles S.E. of Keith, at Black Hillock, where its imperfect stratification is well seen.

The limestone of the Burn of Boyne is the site of another anticlinal, which is *pushed over to the N.W.*; and consequently the overlying gneiss seems to come from beneath it. Very soon, however, N.W. dips occur; and these continue in the gneiss, which is much intersected by granite-veins to Portsoy, where, at the Downie, a mass of fine-grained syenite makes its appearance. This syenite, at the Downie of Portsoy, seems to manifest itself in a synclinal axis. Immediately west of the Downie, the celebrated Portsoy serpentine is seen. This possesses nothing like bedding in its aspect; but it reposes upon a mass of black schist, thin-bedded, and dipping S.E. at 70°—a dip the reverse of that of the strata which occur E. of Portsoy. This black schist, which forms the highest strata seen in the neighbourhood of Portsoy, is probably the equivalent of the drab shales before alluded to as forming the highest strata seen between Macduff and Gamrie. Westwards from the black schist of Portsoy, S.E. dips continue for about a mile, when an axis of quartz-rock presents itself. This is an extension northwards of the mass of quartz-rock which is so amply developed in the Hill of Durn.

A short distance west from this quartz-rock axis, N.W. dips occur; but almost immediately S.E. inclinations again obtain; and these continue to Red Harbour, where a singular isolated mass of Old Red Sandstone is seen. In this axis of quartz-rock another instance of a roll pushed over to the N.W. occurs.

At Sandend or Dunidich, on the west side of Red Harbour, limestone again makes its appearance. Although much contorted, it is very distinctly bedded, and has a prevailing S.E. dip. This limestone, on its strike, is well seen in the interior, and is also worked at several localities. At Fordyce it possesses the same character as to regularity of bedding, dipping here S.E., at 45°. S.S.W. from this it is exhibited at Keith in the cutting of the Dufftown Railway, and extends in a S.S.W. direction to Dufftown. At the railway cutting at Keith, and a little southward, this limestone *appears* to dip under quartz-rock, and to lie upon gneiss, the result of a complete reversal of the strata.

This limestone contrasts strongly in the perfection of its bedding all along its strike with that of the Burn of Boyne and the Black Hillock already referred to.

Although these two areas of limestone differ so much in their stratigraphical aspect, I have little doubt that they occupy the same horizon, and that their different appearance is the result of different degrees of mechanical forces, which have operated in modifying these beds of limestone at the period when the great flexures and contortions produced the anticlinals and synclinals of this portion of Scotland*.

Westwards from the limestone of Sandend a succession of gneissic strata occurs. These strata are perpendicular; but they soon become greatly contorted, and present both N.W. and S.E. dips. Among them strata of quartz-rock are seen, on one of which the old Castle of Findlater is situated. These contorted rocks obtain along this portion of the coast, from Sandend to Logie-head.

From Logie-head to the Maiden Pap of Port Long, gneiss, with N.W. dips, exhibits itself, having beneath it thin-bedded quartz-rocks, which repose upon hard grey beds. The thin-bedded associated quartz-rocks are well seen in the neighbourhood of Cullen.

On the shore, a little west of Cullen, isolated quartz-rock is seen; and also masses of Old Red Conglomerate, one of which is seen on the west side of the bay, reposing on the metamorphic strata, as represented in Mr. Cunningham's section. On this side of the bay, a thin series of gneiss is seen resting upon quartz-rock, and having a S.E. inclination. Along the cliffs westwards to Portnockie, the quartz-rocks, occasionally overlain by Old Red Sandstone, are seen with the same S.E. dips. Here the quartz-rocks become greatly developed; and they continue along the coast with the same dips to Findochtie, where the strata are flatter, but have still the S.E. inclinations. At Port Essie, the same rocks, having the same inclination, but at greater angles, present themselves; and these make up the cliffs along the coast to Buckie, where, on the shore, some grey beds occur among the quartz-rocks. West of Buckie, Old Red Conglomerates appear on the shore; and at the Gallochie Burn, between Buckie and Port Gordon, the same Old Red Conglomerates, with red sandstones, are seen dipping N.N.W. at a low angle; and these form a portion of the eastern margin of the Old Red Sandstone area, which is so extensively developed in the county of Elgin, along the shores of the Moray Firth.

The quartz-rocks which are so extensively developed on the coast between Cullen and Buckie are extensions northwardly of the mass which is so well seen in the Bin of Cullen. Like the strata previously described, they appear to form an axis in this area, the centre of which is probably at Findochtie, where the beds are more nearly horizontal than elsewhere along this coast. Here again we have another instance of an axis being pushed over towards the north-west.

The arrangement of the metamorphic rocks, as exhibited along the Banffshire coast, leads to the conclusion that here the deposits have, in their sequence, a great affinity to the series of strata which compose the altered sedimentary rocks of other portions of the Highlands. At the base considerable thicknesses of quartz-rocks sometimes present themselves; and these, where they do occur, are seen in the condition of axes. Upon these quartz-rocks, in some instances, limestones are found; but the persistence of the lime-

* I am indebted to the Rev. Mr. Grigor, of Macduff, for pointing out to me the limestone localities near Keith.

stones is by no means constant, and the higher portions of the metamorphic rocks of Banffshire present themselves in the condition of gneiss, with associated quartzose layers, or, when only in a partially altered condition, as greywacke-sandstone, with pebble-beds, succeeded by greywacke-shales.

There is one feature with reference to the metamorphic rocks of this county which, although not confined to this district, but prevalent to a great extent in the whole of the metamorphic rocks of Scotland, is of considerable interest. This is the great predominance of S.E. dips. On referring to the map attached to Mr. Cunningham's memoir, it will be seen that the strike of these metamorphic rocks is extremely uniform, and that S.E. dips almost exclusively obtain among the metamorphic series.

An occurrence of this kind could only result from the planes of the several axes being depressed towards the N.W., and by this circumstance producing, over a considerable area to the north-west of these axes, an inversion of the strata, and so packing these together that in many cases the superior deposits seem to occupy a position below the *lowest* member of the series, the quartz-rocks.

There is also another circumstance of interest in connexion with the rocks of Banffshire, and which, like that just referred to, is common likewise to other areas in the North of Scotland. This is the slight influence which the plutonic rocks exercise in producing the direction of the axes, or in modifying the inclination of the strata.

The districts in this country which exhibit granitic or syenitic masses have, on the flanks of these plutonic areas, the strata striking right into them, and there is nothing like an indication of a periclinal arrangement of altered sedimentary rocks around plutonic masses. The small effect resulting from the influence of rocks of this nature has been expatiated upon by Mr. Cunningham; and he gives many instances of the comparatively small part which they have played in effecting the changes of position in, and in altering the character of, the sedimentary rocks.

§ 2. *Section from the Sea at Berridale over the Scarabins to Strath Naver.* (Fig. 2.)

There occurs, near the southern extremity of Caithness and on the eastern side of Sutherland, a very extensively developed series of quartz-rocks, and these form the hills which are known under the name of the Scarabins. Their mineral nature is alluded to by Sir Roderick Murchison and Professor Sedgwick, in their memoir "On the deposits contained between the Primary Rocks and the Oolitic Series in the North of Scotland"*, and they are also referred to by the former in one of his memoirs on the Northern Highlands†.

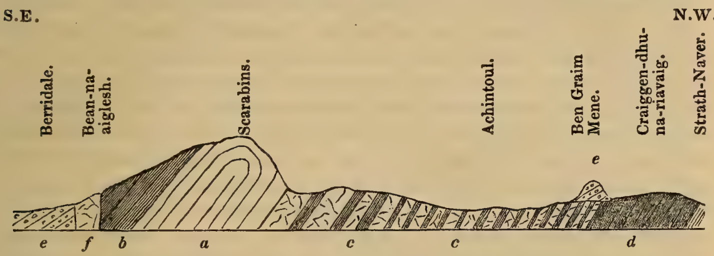
Last summer, after examining the metamorphic rocks of Banffshire, I had an opportunity of traversing the Scarabins, and the portion of Sutherland which lies between them and Strath Naver.

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 125 *et seq.*

† Quart. Journ. Geol. Soc., vol. xv. p. 384 *et seq.*

On this occasion I endeavoured to make out the relation of these quartz-rocks to the deposits which are so fully exhibited in Sutherland, and which form the upper or flaggy gneiss of Murchison*.

Fig. 2.—*Section from Berridale to Strath Naver.* Length 30 miles.



f. Granite.
e. Old Red Sandstone.
d. Flaggy gneiss.
c. Granite and gneiss.
b. Gneiss and grey quartz-rock.
a. White quartz-rock.

I here purpose to describe the rocks which occur in a traverse from the coast at Berridale, in Caithness, to Strath Naver, in Sutherland, the route being from the S.E. to the N.W.—a course almost directly across the strike of the metamorphic rocks, not only of this district, but also of those of the whole of Sutherland, with some slight local exceptions. Having likewise examined some of the stream-courses to the south of the Scarabin range, I shall allude to them as illustrative of the sequence of the strata which compose the metamorphic rocks of this district.

Commencing on the coast, we have, in the Langwell Burn, from its entrance into the sea to the Turnel rock, brown flags of the Old Red series, dipping N.N.E., and passing downward into the inferior conglomerates. A mass of granite then occurs, which is a portion of that forming the Ord of Caithness extended northward, and it cuts off the Old Red series from the metamorphic rocks on the N.W. at this locality. This granite continues for a short distance to Bean-na-aiglesh, where the metamorphic strata exhibit themselves. Here the beds consist of grey quartz-rocks which have a S.S.E. dip at 45°; and quartz-rocks of a similar character, and having the same inclination, are seen in the Langwell Burn at Alt-di-ba. The same features, as concerns lithological nature and dip, are seen in the Alt Begg to Tolbegg; and on the sides of Salvaich, one of the Scarabins, to the west of Alt Begg, grey quartz-rocks occur with the same inclination. The fine isolated Old Red

* On this occasion I was provided by Sir Roderick Murchison with his observations as recorded on the Duke of Sutherland's map of this county, and also the notes of Sir Roderick which had reference to this district; he also very kindly procured for me a note from the Right Honourable the Speaker of the House of Commons to his people at Langwell, and by this means I was enabled to avail myself of the services of Donald Ross, gamekeeper to His Grace the Duke of Portland, who accompanied me, not only over the Scarabins, but also into Strath Beg to Achintoul.

mountains, viz. Smechian, the Maiden Pap, Morven, and Little Morven, which generally lie to the north of the Scarabins, are made up of fragments of these quartz-rocks in the lower portion of their series.

Small Mount, one of the Scarabins, which is to the west of Morven, is made up of white quartz-rocks dipping towards the south. From Small Mount, a ridge of rocks of the same nature runs N.E. to Cnoc-na-neranach, also consisting of quartz-rocks, some of which are micaceous; and these also have a south dip. To the south of Cnoc-na-neranach lies Sudhe-voir-veig (*Child's Chair*), a very picturesque hill, differing in its outline from the Scarabins, and nearly allied in form to the isolated Old Red mountains to the north; and this, I learn from Donald, is composed of rocks similar to those of Morven, and is another isolated mass of Old Red among the metamorphic rocks of this region. South from Cnoc-na-neranach the country is covered by peat, and even in the courses of the high streams which flow into the Suisgill Burn no traces of rock can be seen *in situ.*

The head also of the Berridale Water, as regards exposures of rock, is in the same condition, as well as the tributaries to the Kinbrae Burn; but the lower part of this burn traverses granite, and no further traces of quartz-rocks can be seen to the westwards.

In the district which lies south of the Scarabins, and which is drained by streams which flow into the River Ullic, or Helmsdale, we have exposures of rocks as follows:—In the road along Strath Ullic, from Helmsdale, granite is prevalent to Kilphedric, where a quartzose gneiss appears. In the Torshish Burn this is seen dipping N.W. at 75°. Less than a mile west of this stream Alt Brackie occurs, in which grey quartz-rocks are seen inclining S.E. at 75°. Two miles further to the west we have Alt Duible, a small stream which flows over contorted grey quartz-rocks, with prevailing S.E. dips. A short distance westward from this is another small stream, not named on the map; and in this the grey quartz-rocks are seen almost horizontal.

About half a mile to the west is Kildonnan, in the stream of which the rocks are well displayed. At the bridge they consist of thin-bedded gneiss, with granite; and here the dip is E. at 45°. Up the stream, above the bridge, the thin-bedded gneiss passes into grey quartz-rocks, varying in the angle of the inclination; and these rocks, in their *strike,* seem to pass to the west of Cnoc-na-neranach.

Higher up Kildonnan Burn the dips have a disposition to become N.E.; and, where the Alt-na-nuan from the east joins the Kildonnan Burn, this direction obtains in gneiss which is very rotten, and which is associated with grey quartz-rocks. Following Alt-na-nuan eastwards, quartz-rocks, grey in colour and with east dips, are seen; but the higher portion of this stream is through peat—a circumstance which is common to most of the upper parts of the streams in this portion of Sutherland. Upwards, the course of Alt-na-nuan leads into the head of Alt-Brackie, the lower portion of which has been already alluded to. This stream, where rocks are exposed in its course, seems to flow altogether over quartz-rocks dipping S.E., with granite in them, and these form Den Duan. West from Kildonnan, granite becomes more abundant, and at Kinbrae it forms the rock of the country.

The district north of the Scarabins, for the most part, consists of members of the Old Red series. In the Berridale River they are seen associated with, and in some instances made up of, granite-fragments. Mr. Peach, who has examined in considerable detail the rocks traversed by this river, and who has furnished Sir Roderick Murchison with notes of his observations, which Sir Roderick has forwarded to me, finds in the course of this stream localities where white quartz-rocks, evidently an extension northwards of those of the Scarabins, "dip to the south at an angle of 50°."

In the bed of the same stream, Mr. Peach remarks that above the bridge of Dalsea "gneiss occurs, which soon becomes twisted and contorted in all directions, and penetrated by granite-veins. Higher up the stream it is less contorted, but vertical, the granite being very coarse, and enclosing large masses of talc, called here 'Sheep's silver,' and giving the name of 'Silver-rock' to this part. The gneiss may be traced to above the bridge of Corrachoich, where it is very full of mica, and breaks into flakes like micaceous schist, and it dips to the south at an angle of 60°. On it rests a small band of hard white quartz, like that of the Scarabins." Mr. Peach's notes also contain an account of the Old Red series, as this is seen in the Berridale section.

Westward from the Scarabins to Achintoul, the country, which is principally composed of granite, is for the most part moory, and affords no good sections.

In traversing the country in a N.W. direction from Achintoul to Strath Naver, the nature and the arrangement of the rocks which occur in this portion of Sutherland can be recognized. In the river, immediately west from Achintoul, gneiss is seen with a S.E. inclination; and in the flat moory country on the west side of the river, granite-bosses appear abundantly at intervals at the surface. In the course of the Alt-doura-damff, which flows from the N.W., granite and gneiss occur, the latter dipping also S.E.

Following up the course of this stream between Ben-griam-more and Ben-griam-beg (two mountains of Old Red Conglomerate, laid down in Sir Roderick Murchison's map), the country becomes boggy, and no exposures of rock are seen. At Loch Leune-a-chliaven, on the west side, granite and gneiss again occur, the latter having likewise the S.E. dip; and, like all the gneiss of Sutherland which is much associated with granite, it is of a very crystalline nature. Granite and gneiss are also seen at Loch Ganieu of a like character, the gneiss having the same S.E. inclination; and N.W. from this, at Coul-loch-more and Coul-loch-beg, the same rocks appear*.

* About a mile south of Coul-loch-beg, beyond a moory, swampy tract of country, occurs Ben Vaddu. The form of this hill differs altogether from those which are made up of granite and gneiss in Sutherland, and has a great resem-

Along the watershed to the N.W. of Coul-loch-beg the granite and gneiss are again exhibited; and at Maill Kean Loch Strathie and at Craggen-dhu-na-riavaig the granite and gneiss are also apparent, though the former is not so predominant as towards the S.E., but very well-developed masses of gneiss occur with S.E. inclinations. Gneissic rocks are also seen about Loch Feovaig, a small lake which forms the source of the Rivagill Burn, which flows into the River Naver. Along this stream-course, granite becomes rare, and the gneiss assumes a flaggy aspect, is much flatter in its inclination than the gneiss on the high ground to the S.E., and usually dips S.E. at about 20°. The gneiss, as seen in the Rivagill, so far as lithology is concerned, possesses all the features which mark the upper or flaggy gneiss overlying the quartz-rocks and limestones of West Sutherland.

The rocks on the east side of Strath Naver consist of gneiss, for the most part of a flaggy nature, having the same S.E. dips which obtain so abundantly in the country lying south-eastwards of this Strath. At Betty Hill this group is alluded to by Sir Roderick Murchison as being perpendicular, and pierced by granite; and of the rocks which occur between the Naver and Melvich, and from thence eastwards to the borders of Caithness, Sir Roderick remarks that they "must be classed with the newer gneissose flagstones, though they are penetrated at such numerous intervals by bosses of granite, that it would require much time and good detailed maps to ensure their correct delineation" *.

With reference to the coast section between the Naver and the Old Red Sandstones of the western margin of Caithness, although the gneiss is often perpendicular, it still abundantly exhibits S.E. dips. Gneiss having this inclination is well seen at Farr Bay, and also at Swordly Bay. At these localities it is accompanied by granite, and these rocks continue to Armadale, where the granite becomes more abundant; and between Strathie and Armadale the latter seems to occupy almost exclusively the whole country, the contour of which is comparatively flat and moory, features which usually mark the occurrence of granite in East Sutherland. Eastward from Strathie the Old Red Sandstone area alluded to by Sir Roderick Murchison is seen†. Beyond this, at Sandside, bosses of granite with crystalline gneiss occupy the face of the country to Reay, where the Caithness Old Red series commences.

The section of this coast, so far as the gneiss and granite are concerned, is very like that which is seen in the traverse between Achintoul and Strath Naver; and in both these sections, where the former is not vertical, it has S.E. dips. The coast-section only exhibits an extension north-eastwards of the strike of the rocks seen in the interior, and justifies the conclusion that, with the exception of a

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blance in contour to the two Ben Griams. In consequence of the swampy condition of this district I was unable to reach Ben Vaddu from the north; but, judging from its form, I am induced to look upon it as similar in composition to the Ben Griams, and consequently consider it as made up of Old Red Conglomerate.

* Quart. Journ. Geol. Soc., vol. xv. p. 237. † *Op. cit.*, p. 403.

few merely local dips, there obtains through Sutherland the south-east inclination of strata which prevails so extensively through the metamorphic rocks of the North of Scotland.

The metamorphic rocks of East Sutherland and the Scarabins exhibiting a dip which, on the whole, may be regarded as having a S.E. direction, the arrangement of the strata which compose these rocks is a question which now presents itself. Under ordinary circumstances a section from Strath Naver, south-eastward over the Scarabins, would furnish us with a sequence of rocks consisting of lower members composed of flaggy gneiss, having in the higher portions numerous granite-masses corresponding in direction with the strike of the altered sedimentary rocks, and with these the gneissic rocks assuming a more crystalline character. Upon these gneissic rocks would repose the quartz-rocks of the Scarabins, succeeded also by gneiss. That this is not the true sequence of the deposits may be inferred from the arrangements which rocks having a like mineral nature present in other parts of the North of Scotland, and in the Highlands generally. We have also, in many areas where the metamorphic rocks are seen in Scotland, a sequence and an arrangement which accord with those of the Scarabins and the East Sutherland rocks. The circumstances under which the rocks exhibit themselves in the section along the Banffshire coast have an intimate agreement with those of the area under consideration, and induce the conclusion that, so far from the flaggy gneiss forming the lowest member of the series between Strath Naver and the eastern flanks of the Scarabins, it occupies a position superior to the quartz-rocks. In this area we have another instance of those rolls in the strata which form axes of the inferior quartz-rocks, but which, in consequence of having the plane of the axis depressed towards the N.W., invert the superior gneiss on the N.W. side of the axis, and by so doing give to the superior gneissic strata a position which places them in the condition of apparently dipping underneath strata upon which they really repose. These circumstances being taken into consideration enable us to infer that the metamorphic rocks of this portion of Scotland are referable to the series which is so well developed in the western portions of Sutherland, and that here we have the quartz-rocks of the Scarabins succeeded by the "upper or flaggy gneiss" of Murchison as in the west parts of this country.

The mode in which the granites are associated with the metamorphic rocks in the area under consideration is a matter of considerable interest. The correspondence of the strike of the plutonic masses with that of the metamorphic rocks has been noticed in connexion with these several rocks in Banffshire. In Sutherland it is even more apparent, and supports the inference that here plutonic masses do not perform the office of axes. Their mode of occurrence rather tends to the conclusion that the sedimentary rocks were elevated, flexured, and contorted previous to the period when the granites made their appearance in the sedimentary rocks, and that these granites have conformed in their course to the strike of the previously elevated strata.

There are here abundant features which would support the conclusion that granite is, in this district, rather the result of an excessive amount of metamorphic action, than a plutonic rock, as regards its origin.

While the metamorphic rocks of the Highlands and of the North of Scotland have a prevalent S.E. inclination, the Lower Silurians of the South of Scotland have equally prevalent N.W. dips; and they are equally devoid of plutonic axes.

Although the rocks in these two areas of Scotland differ widely in their lithology, they have a very intimate relation in the *strike* of the beds; and such fossils as have been obtained from the North of Scotland and from the southern range indicate a great affinity in geological age. That the rocks in these areas are part and parcel of the same series has been inferred by Sir Roderick Murchison; and that they have been elevated at the same period may be concluded from the agreement in the arrangement of their respective *strikes*.

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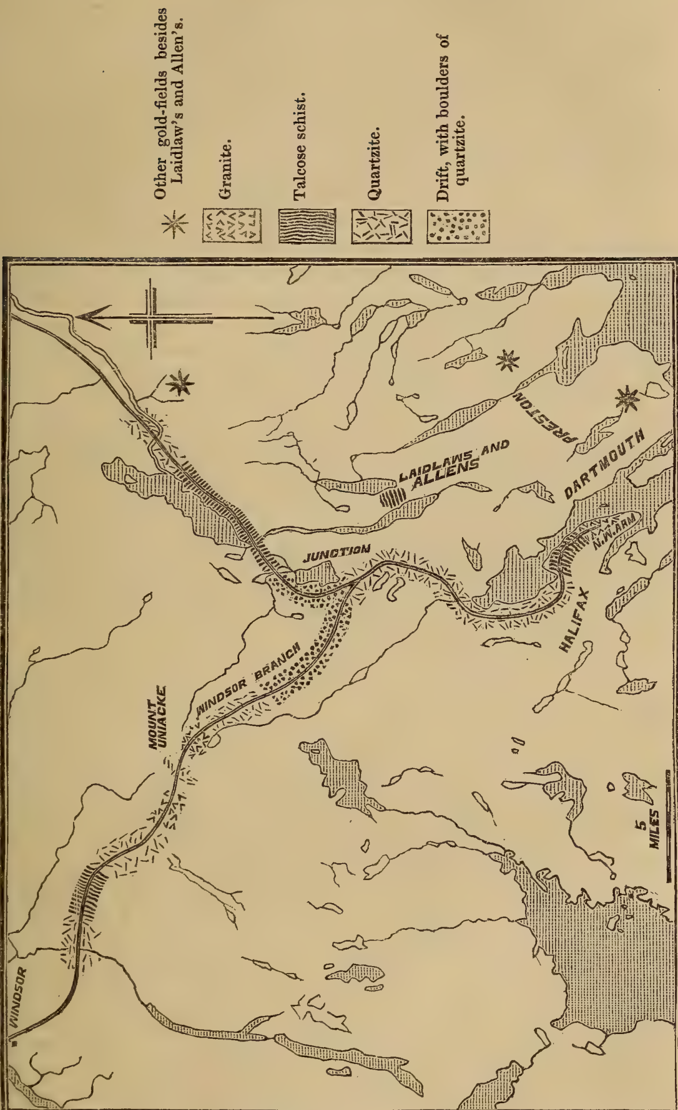
2. *On the* Geology *of the* Gold-fields *of* Nova Scotia. By the Rev. D. Honeyman, Corr. Mem. Nat. Hist. Soc. of Montreal, &c.

(Communicated by the President.)

[Abridged.]

The observations which are the subject of this memoir were made at the request of the Provincial Government Commmission for the International Exhibition. While engaged in their service, procuring a representation of the geology and mineral resources of the Province, I was specially directed, about the end of November last, to give some attention to the illustration of the geology of the gold-fields. The field of observation being very extensive, and the time fit for the work short, I deemed it most expedient to select, from the many, that locality which might appear to be the most interesting and instructive, and to examine it as thoroughly as time and circumstances would permit. The gold-fields known as "Allen's" and "Laidlaw's" appeared best to meet the above conditions. They are interesting beyond a doubt, and are contiguous to excellent sections of rocks on two lines of railway, and are therefore somewhat favourably situated for the purpose of observation. (See Map.)

In describing these gold-fields, we shall begin with the position that is lowest, geologically and otherwise; this is Allen's field. The rock *in situ* is dark-coloured clay-slate; it is often talcose. This contains abundance of crystals of mispickle. It is pervaded by a number of vertical veins of auriferous quartz. These are exposed on the sides and bottoms of pits and trenches. It is only from report that I can say that they are auriferous; I could not get any information on the spot. The top of the slate-rock was glacier-scratched; and in some cases from 7 to 10 feet of drift had been penetrated before the strata had been reached. Crossing the canal and main road, and climbing a hill, we come, in a few hundred yards



Sketch Map of a Part of Nova Scotia, to illustrate the Rev. D. Honeyman's Paper on the Gold-bearing Rocks of that district.

to the south-east, to "Laidlaw's field." Here some were clearing away the superficial drift, and uncovering the quartzite ("whinstone" of the miners); others were blasting the quartzite that covered the quartz-vein (or the "quartz-barrels" of the miners); others were breaking up the "quartz-barrels," removing the quartz, and storing it up for the crushing-machine. The rock exposed on the removal of the quartz is a chloritic slate. On this the quartz lies, nearly horizontal, slightly inclined to the west, somewhat like a stratum. This is composed of the said "barrels," which appear from above to be lying alongside of each other and unconnected; but the captain of the "Victoria Claim" assured me that they were connected at the underside. The shape of the ridges of quartz is irregular, being sometimes angular, sometimes more or less rounded. At the time of my visit the appearance in the "Victoria Claim" was very striking; all the uncovered "barrels" had been removed except one and small fragments of others. There the entire one lay, in length 150 feet, like a gently tapering, branchless tree, inclined at an angle of 1 or 2 degrees, with the butt-end highest. The vein inclines towards Allen's field. Overlying this great and almost horizontal auriferous vein of quartz is the "whinstone" of the miners, a hard quartzite, as I have already stated, or altered siliceous stratum. This quartzite is sometimes very thick, naked, and rugged; and at other times it is covered with drift, presenting, after being uncovered, a scratched surface; it gradually thins until it disappears. Wherever this covering of quartzite is preserved, the horizontal vein, as far as I could observe, was entire. Wherever the glacier has succeeded in removing the quartzite, the vein has disappeared.

A good illustration of this was shown. In the "Victoria Claim" the miners were engaged in removing the remains of a "barrel" which had proved very rich. Hence the miners in the adjoining claim, which belongs to a Company in London, were induced to make immediate search for a continuation of the "barrel." Although only a few feet intervened, they found that the "barrel" had disappeared, together with its quartzite covering; drift and fragments being in its place. The boulders, however, produced by the destructive glacial agent had led to the discovery of the vein itself.

In order to show the relation that appears to exist between these gold-fields and the adjacent rocks exposed in the Railway-sections to which we have already referred, we proceed to review the series in descending order. We have, first, the top or quartzite-rock of Laidlaw's, then the great auriferous quartz-vein, next clay-slate and chloritic-slate; beneath, going in a north-westerly direction, the dark-coloured clay-slate and talcose slate, with veins of auriferous quartz in Allen's gold-field. Proceeding in a straight course to the Railway-junction, we pass over drift with masses and boulders of quartzite, evidently derived from the underlying rock. Before reaching the Railway-junction, at a distance of $1\frac{1}{2}$ or 2 miles, we descend from elevated ground into a hollow, where large quartzite masses abound. At the junction the cuttings in the quartzite appear. Following the Windsor Line, the ground on either side of the Railway is very unequal, consisting of lakes, swamps, and banks of drift, with large quartzite-boulders. At about 12 miles from the junction, we pass through cuttings in quartzite, with little interruption, until we reach Mount Uniacke, 13½ miles (railway measurement) from the junction. The bottom of the series is now arrived at. I would here observe that from this station onward I had the valuable assistance of Mr. Marshall, who constructed this part of the road.

Having reached Mount Uniacke, we come to the intruding granite; passing through this for some distance, we come to quartzite; and, with this slight interruption, the granite extends to about 4 miles from the place of its commencement.

Passing onward, we now begin geologically to ascend. We pass through cuttings in quartzite for a distance of about 2½ miles; and then we come to clay-slate, resembling that of Allen's and Laidlaw's gold-fields. The cuttings through this extend about 2½ miles. We then come again to quartzite: there are about 2½ miles of cuttings through this rock, and then we reach the Lower Carboniferous formation; of this we have half a mile of sandstone, unconformable to the quartzite, and then gypsum, &c.

Thus much for the arrangement of the rocks on the Windsor Line. On the Halifax and Truro Railway we may commence our observations at the top of the series, and proceed in descending order:—Near the Elmsdale Station, about 30 miles from Halifax, we have the Lower Carboniferous gypsum; then occurs a space which is obscure, but is probably occupied by Lower Carboniferous sandstone. There is rising ground in the distance on either side, on one of which sides is the Elmsdale gold-field, about 4 miles distant from the Station. Proceeding along the line toward Halifax, we approach the Grand Lake, which is 22½ miles from the Terminus. Before we reach the lake, we come to quartzite; then cuttings in this rock succeed for probably 2 or 3 miles; then comes clay-slate, extending probably about the same distance; the next 3 or 4 miles are obscure, and then, in the vicinity of and at the junction, as was seen in the preceding course of observation, quartzite occurs; and from this onward to the Terminus there are deep cuttings, with masses and boulders of quartzite. At the Terminus, slate again occurs; but this evidently belongs to another series, whose granitic axis occurs in the direction of what is called the North-west Arm.

From the preceding observations I would infer:—that Mount Uniacke and the granitic range of which it forms a part is the geological centre of the series which I have been attempting to illustrate. This and the other granitic bosses occur somewhat irregularly throughout the formation to which the group under consideration belongs, and, as far as I have observed them, are inconsiderable in height.

That when gold occurs on the one side of a granitic mass in this formation, it may reasonably be expected to occur on the other side of the anticlinal axis.

That as the granite-bosses are irregularly distributed throughout the formation in question, a corresponding irregularity may be expected to exist in the distribution of the gold-fields. This irregularity is quite obvious on a comparison of the following authentic catalogue (drawn up by Mr. H. Poole) with a geological map of Nova Scotia.

Isaac's Harbour, Guysboro' County.
Country Harbour, ,, ,,
Wine Harbour, ,, ,,
Sherbrooke, ,, ,,
Sheet Harbour, Halifax County.
Pope's Harbour, ,, ,,
Tangier, Old, ,, ,,
——, New, ,, ,,
Elmsdale, ,, ,,
Douglas Bridge, ,, ,,
Grand Lake, ,, ,,
Allen's, ,, ,,
Laidlaw's, ,, ,,
Laurence Town, ,, ,,
Cole Harbour, ,, ,,
Halifax, Halifax County.
Gold River, Lunenburgh County.
Martin's River (at the mouth and 5 miles up), Lunenburgh County.
Ovens, ,, ,,
Long Island, ,, ,,
Petite River, ,, ,,
La Have River, ,, ,,
Five miles above Bridgewater, Lunenburgh County.
Five Rivers, Liverpool County.
Foote's Cove, Yarmouth County.
Cranberry Head, ,, ,,
Salmon River, Digby County.
Maxwell Town, ,, ,,

In Pictou County, N.E. of the gold-bearing districts above referred to, Dr. Dawson and the author have described fossiliferous rocks containing Upper and probably Middle Silurian fossils *. There are also fossils of possibly a lower group; and as these strata are higher in the series than the gold-bearing rocks, the latter may probably be referable to the Lower Silurian.

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3. *On some* Fossil Crustacea *from the* Coal-measures *and* Devonian Rocks *of* British North America. By J. W. Salter, Esq., F.G.S., of the Geological Survey of Great Britain.

(Abstract.)

[The Publication of this Paper is unavoidably deferred.]

One of the Devonian fossils is apparently allied to the Stomapods, and is named *Amphipeltis paradoxus* by Mr. Salter; it was obtained by Dr. Dawson near St. John's, New Brunswick, where it occurred with plant-remains; another Crustacean fossil from the same locality is a new *Eurypterus*—*E. pulicaris*. Other remains of *Eurypteri* have been sent also by Dr. Dawson, from the Coal-measures of Port Hood, Cape Breton, and of the Joggins, Nova Scotia; and with these a new Amphipod—*Diplostylus*, having some characters of alliance with *Typhis* and *Brachyscelus*.

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4. *On some* Species *of* Eurypterus *and Allied Forms.* By J. W. Salter, Esq., F.G.S., &c.

(Abstract.)

[The Publication of this Paper is unavoidably deferred.]

After alluding to the late and complete researches on *Eurypterus* by Dr. Wieskowski and Professor J. Hall, Mr. Salter explained

* Canadian Naturalist and Geologist, August 1860, vol. v.

some formerly obscure points in its structure, and proceeded to describe the *E. Scouleri*, Hibbert, from the Carboniferous limestone of Scotland, and the Upper Old Red Sandstone of Kilkenny; the *E.* (*Arthropleura*) *mammatus*, a new species from the Upper Coal-measures near Manchester; and *E.*? (*Arthropleura*) *ferox*, sp. nov., from the Coal-measures of North Staffordshire.

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5. *On* Peltocaris, *a new* Genus *of* Silurian Crustacea. By J. W. Salter, Esq., F.G.S., &c.

(Abstract.)

[The Publication of this Paper is unavoidably deferred.]

Of this form an imperfect individual, from the anthracite-shales (Llandeilo-flags) of Dumfriesshire, was formerly described by the author as *Dithyrocaris*? *aptychoides*. Better specimens have enabled him to distinguish it as a new generic form, still belonging to the Phyllopods, not far removed from *Hymenocaris* and *Dithyrocaris*. A fragment of another larger form, from the same locality, is described by the author as *Peltocaris*? *Harknessi*. Mr. Salter also explained his views of the relationship of the palæozoic *Phyllopoda* among themselves and with the recent forms, and illustrated them by a diagram in which they were arranged in chronological succession.

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6. *On a* Crustacean Track *in the* Llandeilo Flags *of* Chirbury, Shropshire. By J. W. Salter, Esq., F.G.S., &c.

(Abstract.)

[The Publication of this Paper is unavoidably deferred.]

This track consists of numerous, short, narrow, oblique, chisel-shaped imprints, on the ripple-ridges of the slab; and, according to the author, it must have been caused by a large undescribed Crustacean with a bifid or two-pronged tail. To a like agency, but to a distinct genus, Mr. Salter refers some curious markings described by M. Brébisson as occurring in the Lower Silurian sandstone of Noron in the Falaise (Normandy).

June 4, 1862.

The Rev. David Honeyman, Antagonish, Nova Scotia, and Alexander Macdonald, Esq., Aberdeen, were elected Fellows.

The following communications were read:—

1. *On the* Disputed Affinity *of the* Mammalian Genus Plagiaulax, *from the* Purbeck Beds. By Hugh Falconer, M.D., F.R.S., F.G.S., &c.

One of the most accurate observers and original thinkers of our time has discoursed with emphatic eloquence on the imperfection of the geological record *. Besides what is yet to be discovered, so much has been irrecoverably lost that we may never hope to write more than disconnected pages of the palæo-biography of nature. The truth of the assertion comes home to the conviction of all; but so far from discouraging, it only renders us the more eager to pursue what we may attain. Every now and then, in palæontology, an unknown form is discovered of so unexpected a character, that our habitual train of ideas is diverted by it into a new avenue of thought. It may confirm a position which has before been merely conjectural, or but faintly shadowed out; or it may shake the foundations of some cherished, but unsound, hypothesis. It is hailed with more especial satisfaction if it contribute to fill up any of the great gaps in our existing knowledge. The form itself is often presented to the first observer in such a mutilated or imperfect aspect, that at the best he can effect little beyond an approximative idea of the outline. From the same cause, or from a balanced conjunction of unusual characters, he may fail in his first attempt at the interpretation; but he has no reason to be ashamed of the failure, if he has devoted his powers fairly to the investigation; for a great part of the solid progress made in science is mainly effected by the later observer correcting the errors of those who have preceded him. Reproach can only be felt when we allow some bias unduly to influence our interpretation—when we strain facts to countenance a particular view. If the observer has guarded himself against this weakness, and with care used the proper means of investigation, whatever opposition his results may at first encounter, generally speaking, he may be at ease, in the assurance, that further research and future discovery will only confirm and extend them. If the conclusions are challenged, science is invariably benefited by the controversy. Different modes of analysis and different trains of ideas are brought into conflict; and landmarks are established for the warning and guidance of future observers.

Among the mammalian forms brought to light through Mr. Beckles's important researches in the Purbeck Beds, there was one which struck me with especial interest. I found in it a singular combination of characters:—the dentition modified by suppression to as great an extent as in any existing form; strong analogies, in some respects, with known genera, while in others it diverged from them very widely. Early in 1857 I communicated to the Geological Society an account of the genus *Plagiaulax*, which appeared in the 13th volume of the 'Quarterly Journal' (p. 261). About the same time an abridged description of the form, illustrated by figures, was brought out in the Supplement to the 5th edition of Sir

* Darwin, 'On the Origin of Species,' p. 287.

Charles Lyell's 'Manual of Geology' (1857, p. 17). On both occasions I arrived at the conclusion that "*Plagiaulax* may be regarded in the natural system as a Marsupial form of Rodent*, constituting a peculiar type of the family to which *Hypsiprymnus* belongs," although widely distinct from that genus.

The only comment impugning this determination that has come under my notice, appeared in the Article "Palæontology," by Professor Owen, in the 8th edition of the 'Encyclopædia Britannica†,' published in January 1859, and subsequently reproduced as a separate work‡. The two accounts differ in some unimportant particulars. I here cite the later in date, as presumably conveying the latest views of the author. The following are extracts:—

"Two specimens exemplified the shape and proportions of the entire jaw of this species [*Plagiaulax Becklesii*]. The foremost tooth is a very large one, shaped like a canine, but implanted by a thick root in the fore part of the jaw, like the large lower incisor of a Shrew or Wombat. The three anterior teeth in place have compressed trenchant crowns, and rapidly augment in size from the first to the third. They are followed by sockets of two much smaller teeth, shown in other specimens to have subtuberculate crowns resembling those of *Microlestes*. The large front tooth of *Plagiaulax* is formed to pierce, retain, and kill; the succeeding teeth, like the carnassials of *Carnivora*, are, like the blades of shears, adapted to cut and divide soft substances, such as flesh. As in *Carnivora*, also, these sectorial teeth are succeeded by a few small tubercular ones. The jaw conforms to this character of the dentition. It is short in proportion to its depth, and consequently robust, sending up a broad and high coronoid process, for the adequate grasp of a large temporal muscle; and the condyle is placed below the level of the grinding teeth,—a character unknown in any herbivorous or mixed-feeding Mammal; it is pedunculate, as in the predaceous *Marsupialia*, whilst the lever of the coronoid process is made the stronger by the condyle being carried further back from it than in any known carnivorous or herbivorous animal. The angle of the jaw makes no projection below the condyle, but is slightly bent inward, according to the Marsupial type."

"In the general shape and proportions of the large premolars and succeeding molars, *Plagiaulax* most resembles *Thylacoleo* (fig. 173, *pm*, 1 and 2), a much larger extinct predaceous Marsupial from tertiary beds in Australia. But the sectorial teeth in *Plagiaulax* are more deeply grooved; whence its name. The single compressed premolar of the Kangaroo-rat is also grooved; but it is differently shaped, and is succeeded by four square-crowned, double-ridged grinders, adapted

* I leave the words as they originally stood; but my meaning would have been more accurately conveyed by the expression "Rodent type of Marsupial,"—rodent being here used in the large sense, having reference to the plan of dentition, characterized by two collateral incisors in the lower jaw, as typically shown in the placental series by the *Rodentia* and *Cheiromys*; and in the *Marsupialia* by *Phascolomys*, modified in the *Macropodidæ* and the *Phalangistidæ* by the opposition, in the upper jaw, of several incisors. (See Cuvier, Oss. Foss., 4th edit. tom. v. p. 3.)

† Vol. xvii. p. 161.

‡ Palæontology, 2nd edit. p. 353.

for vegetable food; and the position of the condyle, the slenderness of the coronoid, and other characters of the lower jaw are in conformity to that regimen. In *Thylacoleo* the lower canine or canine-shaped incisor projected from the fore part of the jaw, close to the symphysis, and the corresponding tooth in *Plagiaulax* more closely resembles it in shape and direction than it does the procumbent incisor of *Hypsiprymnus*. From this genus *Plagiaulax* differs by the obliquity of the grooves on its premolars; by having only two true molars in each ramus of the jaw, instead of four; by the salient angle which the surfaces of the molar and premolar teeth form, instead of presenting a uniform level line; by the broader, higher, and more vertical coronoid; and by the very low position of the articular condyle.

"The physiological deductions from the above-described characteristics of the lower jaw and teeth of *Plagiaulax* are, that it was a carnivorous Marsupial. It probably found its prey in the contemporary small insectivorous Mammals and Lizards, supposing no herbivorous form, like *Stereognathus*, to have co-existed during the Upper Oolitic period"*.

We have here an opinion, professing to be founded on the high ground of a connected series of physiological correlations, that *Plagiaulax* was a carnivorous Marsupial; while the same materials led me to infer that it was phytophagous. These diametrically opposed inferences recall, in some degree, the discussion, famous in its day, respecting the disputed affinities of *Amphitherium*. The question then was, whether the fossil was mammal or reptile; and the foundations of Palæontology were supposed to be concerned in the issue. In the present instance the area of the field of difference is less, but the interests involved are still important. Are the indications of palæontology, more especially in its great stronghold in the Mammalia—the teeth and correlated organs—so unstable or so obscure, that of two palæontologists, the same dental and mandibular materials shall lead the one to infer that the fossil form was a vegetable feeder, and the other that it was a predaceous carnivore? Or does this conflict of opinion arise from different methods having been followed by the observers in dealing with the evidence?

As the Geological Society gave to my original communication a place in its Journal, I feel bound, in the interest of science, either to support the opinion which I then advanced, or frankly to admit the correction, if I am found to be in error. I am further impelled by my sense of self-respect, as an observer, to consider whether—apart from the conclusions—I have fallen into such errors of observation and description as would necessarily be implied, should Professor Owen's manner of viewing the objects prove correct; and if so, to explain the fallacious train of reasoning which led me astray; for I cannot plead the excuse that the account was written in haste, or without due consideration.

If the data, upon which the author of 'Palæontology' professes

* Palæontology, p. 353. I entertain strong doubts about the soundness of the deduction which makes *Stereognathus* to have been herbivorous.

to rest his physiological deductions, were sound, the demonstration would be complete. They are put together with an exemplary show of harmony, and, with a single exception, every link in the chain is supplied. But there are, in the case, considerations of paramount import in an argument of this nature, that lead me to question their soundness, and to dissent from the conclusions.

And first, as regards the admitted facts. Professor Owen agrees that the Purbeck remains establish two species of *Plagiaulax*; and, as he has adopted two of the wood-cuts given in my original description of these species, it is presumed that the correctness of the figures is not questioned. The marsupial nature of the forms is not disputed, nor is there any difference of opinion about the number or designation of the teeth.

In both species there is a solitary incisor on each side of the lower jaw, in the fore part of the incisive border, closely followed, without the interposition of a canine, by a series either of three or of four premolars. The rami converge to a narrow point in front, so that the tooth occupies the entire width of the incisive border on each side; and fig. 13, p. 280, of my former communication, representing the symphysial portion endwise, shows (what is confirmed by the other figures) that the two incisors were approximated and collateral, as in the rodent type, placental or marsupial. In *P. minor*, fig. 15, the tooth is procumbent. In the other and larger species, *P. Becklesii*, it is more robust, with a thicker root, and with a more decided curvature upwards, suggesting, at the first sight, some resemblance to the form of a canine. In both species the point is bevelled*; and I failed to observe in either any mark of the play of an opposed upper tooth.

What was the function of these incisors? Professor Owen's opinion is expressed thus: "The large front tooth of *Plagiaulax* is formed to pierce, retain, and kill." This conclusion arrived at, the other characters are naturally regarded in unison with it, until the genus is finally presented to us as a predaceous carnivore. It is therefore necessary to examine the evidence closely. Now, in solving a question of this kind, comparative anatomy supplies for our guidance fundamental principles, which govern the interpretation of mere form. Let us revert to the known marsupial genera, and see what light generalized observation upon them throws upon the question. In all the Carnivorous genera and species, fossil or recent, of which the dentition has been accurately determined, there are three or more incisors, followed by a canine, on each side of the jaw, above and below; and the empirically observed result is consistent with a rational interpretation of the arrangement, in reference to their food and the means of procuring it. On the other hand, in all the existing strictly phytophagous genera, there is only a solitary incisor (being that next the axis) on either side of the lower jaw, and no canine; or if, as among the Phalangers, additional teeth are developed, the *outer* incisors and canine are alike rudimentary. The pair

* Not in the sense of being denuded of enamel by wear; but the posterior surface is flattened near the apex, so as to yield a slightly bevelled point (*op. cit.* p. 268).

of developed incisors are approximated and placed collaterally, as in the placental Rodents; and commonly they are projected forwards with but a very slight upward inclination. They are unequally opposed in the upper jaw by two or more incisors on either side. Why there should be this plurality of incisors above, and only two invariably occupying the same position below, is wholly unknown to us; but the constancy of the structure makes it certain that there must be a sufficient cause for it in nature; and we employ the generalization, empirically arrived at, with as much confidence as we do the law of necessary correlation*. In many critical cases, where the evidence is limited or defective, the empirical is even a safer guide than the rational law, since it is freer from the risk of errors of interpretation. Applied to the instance before us, it is manifest that the principle on which the incisors in *Plagiaulax* are framed, in regard of number, order of suppression, collateral position, and relation to the premolars, corresponds exactly with the type of the Marsupial Herbivores, such as *Halmaturus*, *Hypsiprymnus*, and *Phascolarctus*, and that it is wholly at variance with the Carnivorous type.

Let us now test the opinion in its professed character as a physiological deduction. Throughout the *Mammalia*, where teeth perform the functions of canines, "to pierce, retain, and kill," they are held well apart through the interposition of a line of incisors,—the end being obvious: the points of penetration are doubled, the grasp is strengthened by widening the base, and the dilacerating and killing powers are multiplied. To arrange them collaterally in the axis would be to place them at a disadvantage to the end to be attained. But when a gnawing power is required, the middle incisors are powerfully developed, and placed collaterally in the axis of the jaws, one on each side, above and below, as typically exemplified in the placental Rodents and *Cheiromys*. Doubtless, a Rat when seized can inflict a smart wound on the hand: but the power is a secondary attribute, complementary to the main function. Regarded in this aspect, it is negatively stamped upon the incisors of *Plagiaulax* by their collateral position, that they are not constructed upon the Carnivorous plan of design, nor in rational correlation thereto.

It is obvious that this position of the teeth in *Plagiaulax* was not overlooked by the author of 'Palæontology;' for, on the first occasion, he describes the incisor of *P. Becklesii* as being "very large, shaped like a canine, but implanted by a thick root in the fore-part of the jaw, like the large lower incisor of a Kangaroo† or Wombat." But the shape of the tooth prevailed in deciding him to pronounce it carnivorous. Now, the form differs in the two species: and I ask any Comparative Anatomist to look at fig. 15 of my former communication (p. 281), and say whether the tooth there represented is formed to pierce, retain, and kill—being the attributes with which Professor Owen invests the incisor of *P. Becklesii*. It is projected forwards with a slight upward inclination, somewhat as in the vege-

* Cuvier, 'Discours Préliminaire,' p. 51.

† Encyclop. Brit., 8th edit. vol. xvii. p. 161. "Shrew and Wombat" are substituted in the 'Palæontology,' p. 353.

table-feeding Koala (*Phascolarctus cinereus*). The incisor of *P. Becklesii** is undoubtedly curved more decidedly upward; and, when viewed sidewise, it is not very unlike a canine. But the same may be said equally of the lower incisor of the Lemurine Aye-Aye (p. 368, fig. 20, *a*). In this remarkable form, the affinities of which were so keenly disputed by the great French anatomists, Cuvier and Blainville, the solitary incisors are collateral, on the Rodent type; compressed laterally, and very deep at the base, they sweep upwards in a bold curve, being scooped vertically behind, to terminate in a sharp edge; so that, regarded sidewise, so far as vertical direction goes, they are more canine-like than in either species of *Plagiaulax*. But the resemblance goes no further. In the former the incisor, which is only partially invested with enamel, is continued backwards below the molars, the pulp-nucleus being persistent, and the chisel-shaped edge is constantly maintained by use†—conditions which are wanting in the latter. Should the construction of the skull and other parts of the skeleton of *P. Becklesii* be ever discovered, there is little doubt but that modifications will be detected throughout, in conformity with those of its incisors, as in the felicitous instance cited by Cuvier, of the secret relation between the upper canine-shaped incisors of the Camel and the bones of the tarsus: this exceptional character does not remove the Camel from among the Ruminants, nor does the form of the incisor of *P. Becklesii* appear to me to be of sufficient weight to counterbalance the clear evidence of a phytophagous and rodent plan of construction.

Professor Owen draws an argument, in confirmation of his view, from the dentition of *Thylacoleo*. The statement is :—" In *Thylacoleo* the lower canine, or canine-shaped incisor, projected from the fore-part of the jaw, close to the symphysis; and the corresponding tooth in *Plagiaulax* more closely resembles it in shape and direction than it does the procumbent incisor of *Hypsiprymnus*"‡. But, on referring to his detailed description of *Thylacoleo*, we find that the body of the tooth, of which the shape and direction are adduced as terms of comparison, together with the fore part of the symphysis and incisive border, is wanting §:—" The symphysis (pl. 13. fig. 4, *s*) begins behind, at a vertical line dropped from a little in advance of the middle of the sectorial, *p* 4; it is of a wide and oval form. To judge from the cast, but little of the jaw appears to have

* *Loc. cit.*, fig. 1. p. 278.

† Blainville asserts that the incisors of the Aye-Aye are invested all round with a shell of enamel, and that the posterior facet is not the result of wear (Mémoire sur l'Aye-Aye, p. 23); while Dr. Sandwith, in his interesting account of the habits of this animal, affirms that the facet is denuded, as in the Rodents (Zool. Proc., Feb. 22, 1859, p. 111). In a finely preserved cranium, for the transmission of which to London I am indebted to the great courtesy of M. Édouard Verreaux of Paris, it is distinctly seen that the coat of enamel is limited to a belt which sheathes only the anterior half of the incisors.

‡ Palæontology, p. 353.

§ "Unfortunately, this morceau is much mutilated, the incisor being broken at its entrance into the alveolus; its form cannot therefore be precisely given; but it is evident that it was curved upwards."—Stutchbury, Report on the Discovery of Gold in Australia, 1855, p. 53.

been broken away from the fore-part of the symphysis. The upper and fore-part shows the alveolus and base of a tooth (pl. 11. fig. 3, *c*) which has projected obliquely upward and forward. It is separated by an interspace of 3 lines from the sectorial, and would seem to be the sole tooth in advance of it. If the ramus be really produced at the upper part of the symphysis further than is indicated by the present cast, *it may have contained one or more incisors, and the broken tooth in question may be the lower canine.* If, however, this be really the foremost tooth of the jaw, it would appear to be one of a pair of large incisors, according to the Marsupial type exhibited by the *Macropodidæ* and *Phalangistidæ*"*. "But in the lower jaw the carnassial is succeeded by two very small tubercular teeth, as in *Plagiaulax*; and there is a socket close to the symphysis of the lower jaw of *Thylacoleo*, which indicates that the canine may have terminated the dental series there, and afforded an additional feature of resemblance to the *Plagiaulax*" †.

In all this, it will be seen, the argument is within the domain of conjecture; the tooth oscillates between canine and incisor; and not merely so, but the principles which are followed as guides in this walk of investigation are set aside, to give place to the illusory indications of mutilated external form. If the tooth represented by a stump or socket proves to be a canine, the comparison will not hold; but if it be solitary with the position of an incisor, will it even then bear out Professor Owen's hypothesis, that *Thylacoleo*, which he infers to have been one of "the fellest and most destructive of predatory beasts ‡," may have had the laniary portion of its teeth in the lower jaw constructed on the type of the most meek and defenceless of herbivorous marsupials? Bearing in mind the sense in which the term "type" is accepted among naturalists, I must avow, that I have some difficulty in realizing the conception. But, should the unusual conjunction of characters assumed above be hereafter established, there are theoretical considerations which would prove to demonstration that the types of construction are still absolutely distinct. For in the supposed case the outermost incisor would be the one developed, the inner ones being suppressed; while, conversely, in the *Macropodidæ* it is the *innermost* incisor which is developed, the outer ones being suppressed. Morphologically, therefore, the types of construction would be radically different. If palæontological investigations were conducted in this manner, there would be no limit to conjecture; the landmarks which we profess to follow would be disregarded, and disorder would face us everywhere. But, happily, science furnishes unerring principles, which provide the corrective. I need hardly add that the argument drawn from *Thylacoleo* has, in my view, no bearing on the incisors of *Plagiaulax*, and gives no support to the carnivorous inference.

Next, as regards the premolars. From their peculiar characters, and remarkable development, they furnish the most striking features

* Phil. Trans., vol. cxlix. p. 318. † Palæontology, p. 432.
‡ Phil. Trans., vol. cxlix. p. 319.

in the dentition of the fossil genus. In *P. Becklesii* there are three, and in *P. minor*, four of these teeth, which diminish rapidly in size from the last to the first *. I here take the last as the most determinate in form, and in its nature the most constant. I compared it rigorously with the corresponding tooth of *Hypsiprymnus Gaimardi*, and I affirm now, as I did in my original paper, that these homologous teeth, in the two genera, are identical in every essential point of form and construction. In proof, I refer to figures 5 and 6 of the representations above cited, the former showing the last premolar of *Plagiaulax*, the latter of *Hypsiprymnus*. The resemblance is so manifest and direct, that I never contemplated that it could be called in question ; but, as it has been questioned, it is necessary to descend to particulars. In both, the crown viewed from the side is of a quadrately oblong form, the length exceeding the height; in both, it is compressed and trenchant, the sides sloping uniformly from the base to a thin edge like a wedge; in both, the basal part of the tooth presents a smooth surface, above which the crown is traversed by a series of close-set, uniform, and exquisitely defined parallel grooves, sharply angular, and bounded by linear ridges; in both, these grooves occupy both sides of the tooth; and in both, the channeled sides meet in a finely serrated edge. Not the least remarkable point in this striking list of agreements is the curious numerical coincidence, —these grooves being developed seven in number, alike in the homologous premolars of *Pl. Becklesii* and of *Hypsiprymnus Gaimardi.*

As to the points of difference: in *Plagiaulax* there are three or four of these teeth, while in *Hypsiprymnus* there is but one; in the former, they are presented with the *maximum* of development, in the latter with the *minimum*; in the former the grooves are diagonal, in the latter vertical. With this exception, and with some trivial details of difference in the proportion of the length of crown to its height, and in the amount of the basal surface free from grooving, the last premolar in *Hypsiprymnus* is identical in its characters with that of *Plagiaulax*. The two convey to my mind the impression of being typically alike.

The objects strike Professor Owen in a very different light. His statement is that, "in the general shape and proportions of the large premolar and succeeding molars, *Plagiaulax* most resembles *Thylacoleo,* a much larger predaceous marsupial, from the tertiary beds in Australia. But the sectorial teeth in *Plagiaulax* are more deeply grooved; whence its name. The single compressed premolar of the Kangaroo-rat is also grooved; but it is differently shaped," &c. Now, apart from the inferences, here is a conflict of description, which can be settled by an appeal to the original specimens. I have described the large premolar as essentially alike in form, in the Kangaroo-rat and in *Plagiaulax*. Professor Owen states that it is differently shaped in the two: if so, I invite him to show wherein the difference consists (I have failed to detect, and he as yet to indicate it),—bearing in mind that here it is not a question of slight difference,

* See Quart. Journ. Geol. Soc., vol. xiii. pp. 278–281, figs. 1–15.

such as a modification in the outline of the same organ in two nearly allied forms, but a difference of type—or of ordinal importance.

Next as regards the assertion that in the general shape the large premolar of *Plagiaulax* most resembles *Thylacoleo*. For convenience, I separate the two terms of the comparison in the sentence. Professor Owen has figured and described the sectorial teeth of this large Marsupial, in his late memoir on the "Fossil Mammalia of Australia"*. In *Thylacoleo* the inferior premolars are reduced to a single, but enormously large and massive, carnassial, with two small tubercular teeth behind it. This carnassial (figs. 16–19) consists of a long blade, high in front and lower behind, so that, if notched in the middle, the divisions would in some degree resemble the anterior and posterior lobes of the corresponding tooth in the placental Carnivora †; and the worn summit is distinctly concave lengthwise: conversely, in both species of *Plagiaulax* the corresponding tooth is convex, and the outline of the whole series describes a convex curve, of which the last premolar forms the most salient part. The base of the carnassial in *Thylacoleo* is "slightly grooved vertically" on the inside (fig. 16). These indentations disappear about half-way up towards the edge, where the surface becomes reticulately rugose, being precisely the reverse of what occurs in the last premolar of *Hypsiprymnus* and *Plagiaulax*. Besides the difference of their position upon the tooth, the grooves of the carnassial of *Thylacoleo* present the appearance of furrows, separating superficial undulations of the enamel. A transverse section of the basal part of the crown would yield a faintly crenated outline, wholly different from the salient and reentering angles of the close-set parallel grooves of *Plagiaulax* and *Hypsiprymnus*. These undulations are exhibited chiefly, if not solely, on the inner side; their presence on the outer is not mentioned. Further, if the indentations on the premolar of *Thylacoleo* are to count for anything as significant of affinity, it should be with *Hypsiprymnus* rather than with *Plagiaulax*, since the furrows are vertical in the two former. In fact, in the outline and proportions of the vertical section, the premolar of *Thylacoleo* differs less from *Hypsiprymnus* than it does from that of *Plagiaulax*. I have failed to realize the asserted resemblance between *Plagiaulax* and *Thylacoleo* in the form of the last premolars; and in the details of outline, section, curvature of edge, crenulation, surface-markings, &c., I am more impressed with the differences than with any one point of agreement.

Let us now consider the inference as to the function of these teeth. It is expressed thus:—"The large front tooth is formed to pierce, retain, and kill: the succeeding teeth are like the blades of shears, adapted to cut and divide soft substances like flesh," &c. Professor Owen has elsewhere described the premolar of *Hypsiprymnus* as

* Phil. Trans., vol. cxlix. p. 318, pls. 11 and 13.

† "The first molar is lunate, the cusps turning inwards, the anterior cusp rising at a salient angle, the edge is trenchant outwards; the second molar is triangular with a large anterior cusp, and a slight ridge passing to a small depressed posterior cusp."—Stutchbury, *loc. cit.*

trenchant *, and I have shown above that the tooth is essentially alike in *Plagiaulax*. If, therefore, the function is to be deduced with such facile certainty from the mere form, the premolar of *Hypsiprymnus* ought also to be carnivorous. But we know that the genus is so strictly herbivorous that the family to which it belongs has been regarded as representing in the *Marsupialia* the Ruminants of the Placental Mammals. With this fact before us, is it likely that the premolars of *Plagiaulax* were applied to cut and divide flesh? Does the serrated edge indicate a flesh-cutting function? The singular agreement between the two genera in their premolars, down even to the number of grooves, however trivial and unimportant the character may appear to be, has, I confess, weighed greatly with me in forming my opinion. No special function has, as yet, been connected with the peculiarly grooved tooth of the living Kangaroo-rat. The agreement is therefore purely empirical; but as the character, according to our present knowledge, is confined, among many hundred genera of Mammalia, to certain species of *Hypsiprymnus* and to *Plagiaulax*, those who have faith in the constancy of the manifestations of nature will not lightly believe that it was common to these two genera alone without implying affinity; and when this is coupled with the obviously phytophagous type of the incisors, the conviction will be confirmed. I need hardly add that I regard the carnivorous deduction from the shape to be arbitrary and untenable.

[William Hunter, a century ago, by a parity of reasoning, arrived at the conclusion that the *Mastodon* of North America, from the trenchant form of the transverse crown-ridges of its molar teeth, was an extinct, colossal, carnivorous animal, in short, a kind of predaceous flesh-eating Elephant †. The error in his case, as in the corresponding one of Leibnitz, was excusable, comparative anatomy having been then in its infancy. But it is not a little startling to see the same sort of unsound deduction reproduced, in regard of one of the most pigmy of Mammals, half a century after Cuvier, by his luminous demonstrations, had indicated the method by which such signal mistakes might be avoided in future.—Oct. 15th.]

Professor Owen perceives another indication of resemblance between *Thylacoleo* and *Plagiaulax* in the proportions of the large premolar to the succeeding molars. In both, there are but two molars, and in so far the agreement is clear; but no further. In *Plagiaulux* there are as many as four premolars; while in *Thylacoleo* the enormous development of the solitary premolar or carnassial is effected at the expense of the rest of the premolars, which are suppressed, and of the tubercular teeth, which are dwarfed. In the former, as pointed out in my earlier description, "the premolars are inordinately developed, while the true molars are dwarfed and rudimentary in proportion." The operation of the well-known law of *Anamorphosis* or *Balancement* is visible in both. But examples of it are everywhere seen throughout animated nature, in the same

* Odontography, vol. i. p. 389.
† Phil. Trans. 1767, vol. lviii. p. 38.

organ, without reference to affinity, as, for instance, among the *Mammalia*, in the canine of *Machairodus* and of the Musk-deer. *Thylacoleo* and *Plagiaulax* may be regarded as being as wide apart among the Marsupials as the two former are among Placental Mammals. The solitary trenchant premolar in some of the species of *Hypsiprymnus* is said to attain a very large development. We have the authority of Professor Owen for the statement, that in two Potooroos of New Guinea its antero-posterior extent nearly equals that of the three succeeding molars *. If the teeth of *Thylacoleo* and *Plagiaulax* had been on the same morphological plan of construction, the agreement in the number of molars would clearly have carried weight; but, as such does not appear to be the case, the coincidence ought not to overrule the other indications, more especially as the form of the crowns of the molars in the two genera is totally different. In *Thylacoleo*, the first tubercular tooth has the crown compressed, supporting two cusps on its axis, the anterior lobe being more or less conical, with a smaller lobe behind it, both on the usual carnivorous type of construction. The second tubercular is only known through its socket. In both species of *Plagiaulax*, the two molars present oblong crowns, supporting two opposed lines of marginal eminences, separated by a depression. In my original description, I referred to the fact that in *Dromicia* and *Acrobata* the molars are reduced from the ordinary number, four, to three. In *Plagiaulax* the suppression is carried still further, two only being developed. The agreement in this respect between the latter and *Thylacoleo* does not impress me with the idea of affinity, although admitting, as I do, that it ought to be duly weighed.

I have entered in such detail upon the dental characters, because, by the consent of all observers, they are of paramount weight in the solution of a question of this nature. If the type be distinctly indicated by them to be herbivorous or carnivorous, the other characters, however modified they may be, will ultimately be found to be in relation to the teeth. The author of 'Palæontology,' having formed his opinion on the teeth, then examines the characters of the lower jaw and finds them in conformity. He adduces the shortness of the horizontal ramus in proportion to its depth as indicative of robustness; also the broad and high coronoid process, and the pedunculate condyle placed below the level of the grinding teeth (above, p. 349). They are all regarded as proving a carnivorous type. They were not overlooked in my former communication:—"The characters of the jaw are so peculiar, and in some respects of so mixed and complex a nature, that they ought to be weighed with caution, in conjunction with the teeth, in forming any opinion of the affinities of *Plagiaulax*. The low position of the condyle is so pronounced, and the elevation of the coronoid above it so considerable, that, regarded *per se*, supposing no teeth had been discovered, they might have been considered to imply with some degree of certainty a predaceous animal"†. But there were other characters, which, taken in conjunction

* Odontography, vol. i. p. 389.

† Quart. Journ. Geol. Soc., vol. xiii. p. 273.

with the jaw, appeared to me to counterbalance these indications: namely, the moderate extent and low elevation of the coronoid above the grinding-plane of the teeth; the long neck and horizontal projection of the condyle behind the coronoid; the form of the condyle itself; and the absence of a stout angular process behind it. With one exception, I shall consider these mandibular characters briefly.

And first, as regards the shortness of the horizontal ramus in proportion to its depth. I refer my reader to fig. 20 of the accompanying illustrations, representing the side view of the lower jaw of the Aye-Aye. A glance will satisfy him that the horizontal ramus is much deeper in proportion to the length in this form than it is in *P. Becklesii*. The fact is so obvious that I do not think it necessary to enter upon the metrical details. Commonly we connect the idea of robustness in the lower jaw with the form and section of the mandible presented by the Hyæna and Tiger. If the sections, figs. 2 and 3, p. 278, of my original paper are referred to, it will be seen that they are totally different. The jaw of *Plagiaulax* in this respect also closely resembles that of the Aye-Aye *.

The coronoid process comes next for consideration. For the details of my description of it, I refer my readers to p. 268 of my former paper. It is there stated that "in general form the coronoid process in *Plagiaulax* resembles more that of the predaceous marsupials, and of the Ursine *Dasyurus* especially, than that of the herbivorous families. It differs very markedly from the elevated strap-shaped coronoid of *Hypsiprymnus* and the other herbivorous marsupials. It is to be remarked, however, that it is less elevated, and its surface of less area, than in the predaceous genera, whether marsupial or placental." Here, it will be observed, the comparison was restricted to marsupial forms, beyond which I did not then think it necessary to carry it. If extended to the Aye-Aye (fig. 20), additional light is thrown upon the character. In both, the anterior edge reclines at an angle of about 45°; in both, the summit is not much elevated above the grinding-plane of the teeth. The appearance of elevation, which is at first sight suggested by the coronoid of *Plagiaulax*, arises from the great depth of the sigmoid notch and the low position of the condyle. If fig. 1 of the illustrations of my former paper be referred to, it will be seen that the process itself is not raised much above the summit of the premolars. There is a further agreement between the Aye-Aye and *Plagiaulax* in the amount of area occupied by the surface of the coronoid. This is partly disguised in the lower jaw of the former, by the broad neck of the condyle, and the shallowness of the lunate notch between it and the coronoid; if the notch were deepened, as indicated by the dotted line, the resemblance would be complete. I do not, therefore, admit the force of Professor Owen's remarks, as significant of carnivore affinities, that "the lower

* In the Koala (*Phascolarctus cinereus*), in which the procumbent incisors, as already observed (above, p. 353), are projected with an inclination resembling that of *Plagiaulax minor*, the horizontal rami of the lower jaw present great depth in proportion to the length, with a compressed section. (Waterhouse, 'Mammalia,' vol. i. p. 264.) But the ascending ramus, in that genus, is on a totally different plan of construction.

jaw is short in proportion to its depth, sending up a broad and high coronoid process for the adequate grasp of a large temporal muscle"—seeing that all these characters are combined in an existing gliriform Lemur, which is not a carnivore. The descriptive terms applied to the coronoid would be suitable for that of a Tiger or Stoat, but they seem hardly applicable to the process of *Plagiaulax*.

The author of 'Palæontology' lays stress on the low position of the condyle, and its long horizontal neck: "The condyle is placed below the level of the grinding-teeth,—a character unknown in any herbivorous or mixed-feeding Mammal; it is pedunculate, as in the predaceous *Marsupialia*; whilst the lever of the coronoid is made the stronger by the condyle being carried further back than in any known carnivorous animal." But it is not a little remarkable that he is silent regarding the form of the condyle itself,—the most important of all the mandibular characters after the teeth; for the peduncle, on which he lays weight, is, like the fang of a tooth, but the stalk upon which the organ performing the function is borne. I think it necessary therefore to call attention to the remarks on the subject contained in my former paper. In the true Carnivorous type, the condyle shows more or less of a cylindrical or terete surface, having invariably a transverse direction, by which it is locked in the glenoid cavity of the upper jaw, thus constituting a pivot like that of a pair of scissors, which constrains the blades to a vertical motion. In *Plagiaulax* all these conditions are reversed, the condyle being convex, with its long diameter disposed subvertically; regarded endwise, it is narrow in proportion to the height, and the outline is ovate or pyriform, the broad end being uppermost. This is a form which is unknown among the *Carnivora*, but common in the Placental Rodents, with the difference, however, that in the latter, the condyle having to work backwards and forwards in a groove, its articular surface is disposed longitudinally. In the common Norway Rat, the articular surface of the condyle is partly vertical, with the pyriform outline of *Plagiaulax*, but more compressed; and in one of the American Marmots (No. 2259, Mus. R. Coll. of Surgeons) it still more closely resembles that of the fossil genus. I cite these instances, to show the undercurrent of Rodent analogy which pervades the jaw of *Plagiaulax* throughout. But a more conclusive and irresistible case of correspondence can be adduced in the condyle of the Aye-Aye. In the words of the celebrated French anatomist who first settled the affinities of the genus, "La forme générale de la mâchoire inférieure de l'Aye-Aye dénote une partie forte, large, ou mieux haute et très comprimée; la branche horizontale beaucoup plus longue que la verticale, qui est presque dans la même direction. Le condyle qui termine cette branche verticale, dans les autres animaux, est droite ici, et presque a l'extrémité postérieure de toute la mâchoire," &c.* The condyle of the Aye-Aye has the same ovate form as that of *Plagiaulax*, but reversed, the narrow end being uppermost (fig. 20); the articular surface is broader and somewhat flatter than in that genus, but the direction of the greater axis is the same, that is, longitudinal and

* De Blainville, 'Ostéographie: mémoire sur l'Aye-Aye,' p. 19.

subvertical *. The glenoid surface of the upper jaw is modified in correspondence—being broad and flat, and placed on an inclined plane that would intersect the tips of the nasals and the middle of the occipital foramen. Here, then, is a signal failure in the chain of physiological deductions requisite to prove that *Plagiaulax* was a marsupial carnivore.

Next, as regards the depressed position of the condyle—below the level of the grinding-teeth. The author of 'Palæontology' states that it is a "character unknown among any herbivorous or mixed-feeding animal." I again refer my reader to the figure (fig. 20) of the lower jaw of the Aye-Aye. In it, the articular surface of the condyle, although directed subvertically, or at the most diagonally, is wholly below the grinding-plane of the molars. It looks still more depressed in *Plagiaulax Becklesii*; but this is, in part, owing to the inflected margin of the angle being broken off in the fossil, while it is entire and salient in the recent form, thus elevating the condyle above the lower plane of the ramus, and leading to an appearance of a greater amount of difference than exists in nature †.

For my reasoning as regards the signification of the long neck or pedicle of the condyle, I refer the reader to my former communication (*op. cit.* pp. 269 and 275). It is there stated that the low position of the condyle "is counterbalanced by another character, of which, so far as I am aware, there is no example among any of the predaceous genera, either placental or marsupial, recent or fossil, namely, the long neck and horizontal projection of the condyle behind the coronoid," &c.; and further on I added that the "arrangement is equally without a parallel among the herbivorous or omnivorous tribes." This latter remark was premature. I was then acquainted with the Aye-Aye only through the figures given by Blainville ‡, in which the lower jaw is shown in opposition with the skull, thus concealing the coronoid, and its relation to the condyle. But if the accompanying figure (fig. 20) of the lower jaw detached be referred to, it will be seen that the condyle is not only below the level of the grinding-plane, but that it is projected a long way behind the posterior edge of the coronoid, exactly as in *Plagiaulax*, and on the same plan of construction, —the sole difference being that the sigmoid notch is shallow in the Aye-Aye, and deeply excavated in *Plagiaulax*. If the notch were deepened in the former, by removing the plate of bone behind and below the posterior edge of the coronoid, in the manner indicated by the dotted line (*f*), the resemblance would be complete. In order to place these facts of agreement beyond question, I give the following

* "La mâchoire inférieure, comme celle des autres rongeurs, se meut évidemment au moyen d'un condyle longitudinal, de manière à empêcher tout mouvement horizontal, si ce n'est de l'arrière à l'avant et *vice versâ*." (Sandwith, Zoological Proceedings, 1859, p. 113.)

† In some of the families of the *Rodentia* the condyle is barely elevated above the grinding-plane of the molars. See Blainville 'Ostéographie: genus *Cavia*,' pl. 2. Figs. *Cavia Cobaya* and *C. Capybara*; genus *Hystrix*, pl. 2, and *Sciurus maximus*, pl. 1, while in others, e. g. *Castor*, both condyle and coronoid are well raised above the same plane.

‡ Ostéographie: genus *Lemur*, pl. 5.

measurements of the relative proportions of the lower jaw in the Aye-Aye and *P. Becklesii* * :—

	Cheiromys Madagasc. inch.	*Plag. Becklesii.* inch.
Length of jaw from condyle to incisive border	2·3	2·0
From condyle to posterior edge of coronoid	·6	·5
Height of jaw to summit of coronoid	1·2	1·0
Height of ramus in front of first true molar	·7	·6
Height of ramus behind the incisor	·65	·45
Height from condyle to a line dropped vertically behind last molar	1·25	1·05
Height from the latter point to posterior edge of incisor at diasteme	·8	·75

From these proportions it will be seen that both in *Cheiromys* and *Plagiaulax* the condyle projects behind the edge of the coronoid to the excessive extent of about one-fourth of the entire length of the ramus. Professor Owen meets the argument in my paper, by the assertion that the condyle of *Plagiaulax* is "pedunculate as in the predaceous marsupials." If so, I invite him to adduce the instance, bearing in mind that the question here is one of degree. The lower jaw of a Tiger now before me measures 9·2 inches from the condyle to the incisive border, while the projection of the articular surface behind the fall of the coronoid does not exceed ·7 of an inch, or one-thirteenth of the length of the jaw. In *Dasyurus* and *Thylacinus* † the condyle projects behind the coronoid, but nothing approaching the extent seen in the Aye-Aye and *Plagiaulax*.

As regards the functional effect of the condyle being carried so far back behind the edge of the coronoid, it is a plain question of animal mechanics, which the author of the 'Palæontology' thus interprets: "It is pedunculate, as in the predaceous *Marsupialia*, whilst the lever of the coronoid process is made stronger by the condyle being carried further back than in any known carnivorous or herbivorous animal." As I regard it, a necessary effect would be to restrict the power of separating the jaws in front, essential to a predaceous animal having laniary teeth constructed to pierce, retain, and kill. And we have the direct proof in the Aye-Aye, that the same arrangement there is not applied to a carnivorous function ‡.

* It must be borne in mind that fig. 1 of my previous communication (*op. cit.* p. 278), from which the measurements of *P. Becklesii* are taken, is *magnified* two diameters; the dimensions are therefore doubled. But this does not interfere with the ratios of proportion. Further, in the Aye-Aye the posterior margin of the coronoid is assumed to be continued down vertically, in order to get corresponding measurements. The dimensions of *Cheiromys* are of the natural size.

† In the Ursine *Dasyurus* (No. 1900, Mus. R. Coll. of Surgeons) the length of the lower jaw is 4·2 inches, and the projection of the articular surface behind the deepest part of the sigmoid notch ·4 inch., or about one-tenth of the entire length of the jaw. In *Thylacinus* (No. 1903 A of the same collection) the projection of the condyle is about one-eighth the length of the jaw. But in both these forms the posterior edge of the apex of the coronoid overhangs the condyle; while both in *Pl. Becklesii* and the Aye-Aye the articular surface of the condyle is removed about one-fourth of the length of the jaw behind the fall of the coronoid.

‡ In the typical *Carnivora* the fulcrum is a fixed point, the form of the glenoid

With reference to the angular process, I have nothing to add to what is set forth in my former communication. This process, which is a very constant character of the carnivorous jaw, is wanting as a salient apophysis in *Plagiaulax*, although well developed in the minute insectivorous *Myrmecobius*.

I have one remark more to make in reference to the form of *Plagiaulax*. Fig. 15 of my original description gives a representation of what remains of the lower jaw of *P. minor*, magnified to a scale of four diameters. The entire length of the specimen, including the six molars and premolars, together with the procumbent incisor (according to the metrical line *e*), does not exceed ·4 of an inch, of which the six cheek-teeth united make only about two and a half lines (·25 inch). I ask any zoologist or comparative anatomist to look at it, and say whether the dental apparatus of this extremely minute creature is competent to perform the duties required of a predaceous carnivore. Magnitude in this case is an important ingredient, as it necessarily involves measure of force. Could *P. minor* have preyed on small Mammals and Lizards? Is it not more probable that this pigmy form was itself an object of prey in the Purbeck Fauna?

In the preceding observations I have gone *seriatim* into the objections raised against the view which I advanced of the affinities of *Plagiaulax*. In the work referred to, every detail of external form was regarded in a light different from that in which it was viewed by me; every inference was controverted; and the conclusion drawn from the whole was diametrically the converse arrived at by me. The verdict of Comparative Anatomists will decide which is right. I have reconsidered my first inferences, and tried to test their validity by the strongly contrasted and extreme view put forward by Professor Owen; and the result has been to confirm the opinion that *Plagiaulax* did not belong to a carnivorous type of Marsupials. Regarded morphologically, in the plan of its dental system,—rationally, through its condyle and correlated characters,—and empirically, by comparison with *Hypsiprymnus* and *Cheiromys*, it has led me, through every aspect, to this conclusion. Enough has been adduced in the foregoing pages to show that, to whatever family comparative anatomy may ultimately consign the genus, it must always be held to be a singularly modified form. I have directed attention to the numerous points of analogy between the lower jaw of *Plagiaulax* and that of the Aye-Aye, itself one of the rarest and most aberrant of existing

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cavity preventing protrusion or retraction of the lower jaw; and the muscular power being applied close to the condyle leaves the free part of the lever longer, or, in other words, admits of a wider separation of the jaws in front, for the canines and cutting-teeth to act. In the Aye-Aye and Rodents (e. g. *Cavia* and *Hystrix*) the fulcrum is moveable, the condyle playing on a flat glenoid surface; the point of insertion of the muscular power is more advanced, leaving a short portion of the lever free, and thus restricting the aperture of the jaws. These conditions, combined with the oblique direction of the temporal muscle, implied by the reclining coronoid, conspire to produce the antero-posterior and lateral motions required by the regimen of these forms. The same reasoning applies to *Plagiaulax*.

Mammalia. They agree in the collateral position and upward direction of their strong incisors; in the depth and shortness of the horizontal ramus; in the backward continuation of the ascending ramus in the same horizontal line with the body of the jaw, and in the terminal position of the condyle,—the two latter characters not being found, so far as is at present known, in any other *Mammalia*, fossil or recent. They agree further in the form and direction of the articular surface, in the reclinate coronoid, and in the backward projection of the condyle behind it. The two jaws are on the same plan of construction. Starting from the deep narrow incisors of the Aye-Aye, carried back below the molars, the great depth of its jaw, and the other associated characters, can be seen to be in necessary correlation. In *Plagiaulax* they are all presented in a less degree of development. The resemblance goes no further. I doubt if in the fossil genus the lower incisors were opposed in the upper jaw by only two chisel-shaped teeth as in the Aye-Aye. In all the other dental characters they are widely distinct. In *Plagiaulax* the force of the dental system is manifested in the great development of the premolars, of which there are none, at least in the adult state, in *Cheiromys*, but a vacant bar instead. In the latter there are three molars, in the former only two. While, therefore, admitting that the common construction of the jaw involves some trait of habit common to the two and essential to their existence, it does not impress me with the idea of affinity. For the reasons which have led me to regard the nearest relationship of the fossil genus as being in the direction of *Hypsiprymnus*, I refer to my former communication *passim*, and to the preceding pages. Both genera appear to be Marsupial: their incisors are on the same morphological plan, and their premolars are in the main identical, except in point of number. The Aye-Aye is a nocturnal animal, which uses its strong incisors as a nipping-apparatus, for breaking and detaching bark and wood in pursuit of the larvæ upon which, in part, it is said to feed. One of the live specimens procured by Sonnerat, on the first discovery of this form, lived in captivity two months fed on boiled rice *. The species of *Hypsiprymnus* are strictly vegetable-feeders.

I shall adduce a celebrated case to show how little we should be authorized to pronounce with confidence on the nearest affinities of *Plagiaulax* from the small measure of evidence we now possess. The Aye-Aye (*Cheiromys Madagascariensis*) was discovered by Sonnerat before 1782. The elder Geoffroy and Cuvier placed it among the Rodents. In 1816, Blainville submitted the skull and teeth, together with the bones of the fore-arm, to a rigorous examination, and convincingly pronounced the Aye-Aye to be a Lemurine Quadrumane.

* "Il a vécu près de deux mois, n'ayant pour toute nourriture que du riz cuit; il se servait, pour le manger, de ses deux doigts comme les Chinois, de baguettes." (Sonnerat, quoted in Buffon, Supplement, tom. vii. p. 268.) The early account of the French traveller has been confirmed by the later and excellent observations of Dr. Sandwith, who fed his captive Aye-Aye upon bananas and dates, the latter of which he took to with great relish, gnawing the larvæ of insects out of the branches of trees, and feeding on them when he had the opportunity. (Sandwith, Zoological Proceedings, 1859, p. 113.)

Notwithstanding the evidence supplied by the brain-case, teeth, and bones of the fore-arm, Cuvier persisted in regarding the animal to be a Rodent, and in the 'Règne Animal,' of 1829*, he places it between the Squirrels and Marmots. If, with such a full measure of evidence before him, the position of *Cheiromys* in the natural system was so long erroneously contested by Cuvier, how little warranted should we be to pronounce dogmatically upon the food and habits of *Plagiaulax* from the slender evidence of the lower jaw! Supposing that *Cheiromys* were only known to us through its mandible, what would now be its inferred position among the *Mammalia*? While, therefore, regarding *Plagiaulax* to have been of a phytophagous type in its affinities, we should not be justified in affirming that it may not have been a mixed-feeder; it may have fed on buds or fruits, like the Phalangers; or on roots like *Hypsiprymnus*; or on a mixed regimen of fruits and insects, like the Aye-Aye.

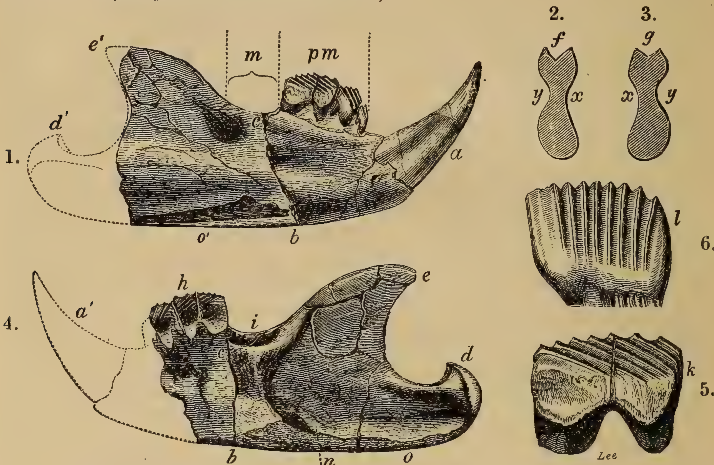
But I maintain that every argument which has been adduced by the author of 'Palæontology' to prove that *Plagiaulax* was carnivorous has been met in the preceding pages. The methods by which the opposite conclusions have been arrived at are as different as the results themselves. Professor Owen, in so far as his method is disclosed to us, has gone direct from the indications of form to the supposed function; and he claims for the inferences, that they are physiological deductions. Comparative anatomists will decide how far they are entitled to the name. Mere external form must be handled with caution as an instrument of research; signal mistakes in Palæontology have been committed through too confident reliance upon it. On the other hand, the method which I have attempted to pursue was, first to ascertain upon what morphological plan the teeth of *Plagiaulax* were constructed, and, having determined this, to supply the rest empirically by comparison with known forms, using at the same time rational analysis where it could be applied, *e. g.* to the condyle. The case is of sufficient interest and importance to test the sufficiency of the respective modes of analysis.

In the general remarks appended to my former communication, I called attention to the contradictory bearing of the dental system of *Plagiaulax* upon the assumption that the earliest Mammals had the full complement of teeth. To that fact may now be added the further evidence of specialization, in the analogy of its mandible with that of the Aye-Aye, one of the most exceptional of Mammals. If we cast a glance over the instructive table given in Lyell's 'Supplement' (page 23), and reflect on the interpretation of the hiatus between the Upper Oolitic beds and the 'Sables de Bracheux,' how vast the interval in time by which they are separated, and how modern in comparison the earliest of Tertiary Mammals! If, on the other hand, *Plagiaulax* be regarded through the medium of the view advocated with such power by Darwin, through what a number of intermediate forms must not the genus have passed before it attained the specialized condition in which the fossils come before us! What a variety of Mammals may we not hope to disentomb from

* *Op. cit.* p. 195.

Figs. 1–6.—Plagiaulax Becklesii (figs. 1–5), *and* Hypsiprymnus Gaimardi (fig. 6).

Figs. 1 & 4 *show the entire Right Ramus of the Lower Jaw of* Plagiaulax Becklesii, *in two pieces, on reversed slabs of the same piece of matrix.* (Magnified two diameters.)



[Figs. 1 & 4 represent the same right ramus of the lower jaw seen on the opposite surfaces of a split stone, the two taken together affording data for a complete restoration of the jaw.]

Fig. 1. *a b e′*. Outer side of the anterior portion of the right ramus of lower jaw; magnified two diameters. *a b*, outer side. *b o′ d′ e′*, impression of inner side.

a. Incisor.

b c. Line of vertical fracture behind the premolars.

d′. Impression in the matrix of the condyle.

e′. Impression of top of coronoid process.

o′. Broken-off inflected fold of inner margin buried in the matrix.

m. Place of the two molars.

pm. Three premolars, the third or last divided by a crack.

Fig. 2. *f.* Section of the anterior piece of the jaw at the fracture *b c*; *x*, inner surface; *y*, outer. The notch at the top is formed by one of the sockets of the double-fanged true molar.

Fig. 3. *g.* Section of the hinder piece near *b c*; *x*, inner surface; *y*, outer surface.

Fig. 4. *a′ d.* Inner side of the posterior portion of the same lower jaw on the opposite slab of stone; *b d e*, inner side; *b a′ h*, cast and impression of outer side.

a′. Outline of the incisor restored.

b c. Line of vertical fracture.

d. Condyle.

e. Coronoid process.

h. Impression of the three premolars on the matrix.

i. Empty sockets of the two true molars.

n. Orifice of dentary canal.

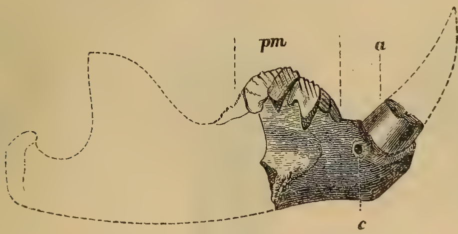
o. Indication of the raised and inflected fold of the posterior inner margin.

Fig. 5. *k.* Third or largest premolar, showing the seven diagonal grooves; magnified $5\frac{1}{2}$ diameters.

Fig. 6. *l.* Corresponding premolar in the recent Australian *Hypsiprymnus Gaimardi*, showing the seven vertical grooves; magnified $3\frac{1}{2}$ diameters.

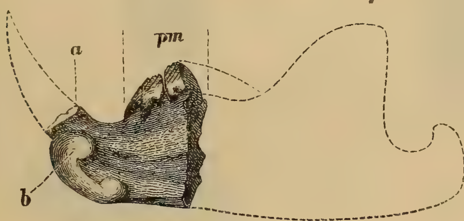
Figs. 11, 12, & 13.—Plagiaulax Becklesii. *Fragment consisting of the anterior portion of the Right Ramus of the Lower Jaw.* Magnified 2 diameters.

Fig. 11. Outer surface.
Fig. 12. Inner surface.
Fig. 13. Vertical view, seen from above.



11.

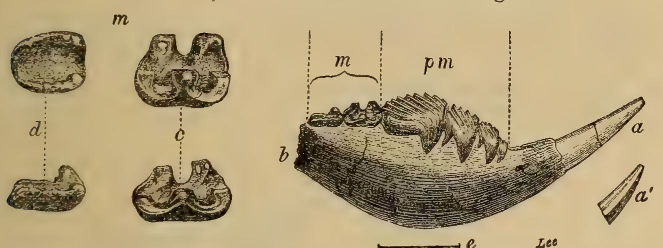
13.



12.

a. Incisor. *pm.* Premolars.
b. Symphysial harmonia. *c.* Mentary foramen.

Fig. 15.—Plagiaulax minor. *Outside of the Right Ramus of the Lower Jaw; and the two Molars.* Magnified.



[All the teeth in this specimen are in place and well preserved. The hinder part of the jaw-bone, with the ascending ramus and posterior angle, are broken away.]

a b. Right ramus of lower jaw, with all the teeth; magnified 4 diameters.
a. Incisor with point broken off. *a'*, impression of same, showing that the inner side near the apex was hollowed out in a longitudinal direction.
b. Offset of coronoid, the rest of which is wanting.
m, m. The two true molars.
pm. The four premolars.
c. The first molar; magnified 8 diameters. Upper figure, the crown. Lower figure, side-view.
d. Second molar; the crown and side-view.
e. The length of the jaw, natural size.

Figs. 16–19.—*Posterior half of a Carnassial Tooth* (pm 4) *from the left side of the Lower Jaw of* Thylacoleo Carnifex. (Preserved in the Museum of the Royal College of Surgeons.)

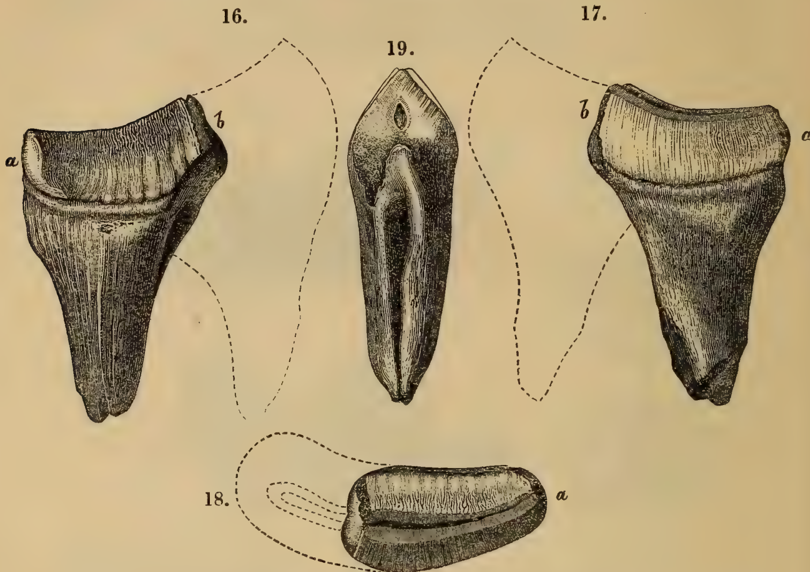
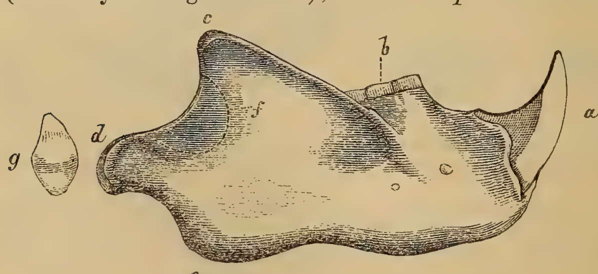


Fig. 16. Inner side. *a*, hinder end, showing the undulations of the enamel-surface on the base of the crown, and the rugosely reticulate surface below the summit. For comparison with figs. 5 & 6 (page 366); the same teeth in *Plagiaulax* and *Hypsiprymnus.*
Fig. 17. Outer side. *a*, hinder end.
Fig. 18. Top aspect, showing the undulations. *a*, hinder end.
Fig. 19. Section, showing the broken edge of the middle of the crown.

Fig. 20.—*The Right Ramus of the Lower Jaw of the Aye-Aye* (Cheiromys Madagascariensis); *the outer aspect.* Nat. size.



a. Incisor.
b. Molar teeth.
c. Coronoid process.
d. Condyle, having its articular surface below the grinding-plane of the Molars.
e. Angle of Jaw.
f. Conjectural dotted line.
g. End-view of condyle.

the buried Oolitic fauna, should Mr. Beckles resume his explorations, or another Beckles take his place!

The remote antiquity of the fossil as a mammalian genus must alone invest the discussion of its affinities with an interest which will prevent the question from resting in its present disputed state. Other palæontologists will examine the evidence, and give their verdict. Mr. Beckles's specimens have long since passed out of my hands; and I have deferred my rejoinder in the expectation that they might ere now have found their way into some public collection, where I could have again submitted them to examination and comparison; but, as that has not yet taken place, I have thought it full time to reply, lest my silence should be construed into a tacit acquiescence in the carnivorous character attributed to *Plagiaulax*, which I do not accept—nor the reasoning on which it is founded.

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2. *On Certain* Fossil Plants *from the* Hempstead Beds *of the* Isle of Wight. By the Rev. O. Heer, Ph.&M.D. *With an* Introduction, by W. Pengelly, Esq., F.G.S.

(Communicated by W. Pengelly, Esq., F.G.S.)

[Plate XVIII.]

Introduction.

Geologists are perhaps aware that not long since a systematic and careful exploration was made of the deposit of lignite, clay, and sand at Bovey Tracey in Devonshire, in the hope of determining its age; that a large number of fossil plants, of various kinds, were found, and all submitted to the Rev. Dr. O. Heer, Professor of Botany at Zurich; and that two papers, embodying the results of the investigation, were recently presented to the Royal Society.

From Professor Heer's determinations, it appears that forty-nine species of fossil plants occur in the Bovey beds, of which twenty-nine are new to science, whilst the remaining twenty are well-known Miocene forms of Continental Europe; that, following the subdivision of the Miocene beds adopted by some geologists on the Continent, sixteen of the twenty species occur in the Tongrian or lowest stage, nineteen in the Aquitanian, twelve in the Mayencian, five in the Helvetian, and eight in the Oeningian; that those common to the Aquitanian and any other stage are found, in almost every instance, in a greater number of localities in the former than in the latter, and in only one case (that of *Vaccinium acheronticum*, Ung.) in fewer; and that the only one of the twenty species (*Celastrus pseudoilex*, Ett.) not found in the Aquitanian stage occurs in the Tongrian below and the Mayencian above, but only in a single locality in each, and may therefore be looked for, sooner or later, in the Aquitanian also. Accordingly the Bovey deposit is considered to belong to this stage of the Lower Miocene.

This decision receives confirmation in the fact that the *new* species found at Bovey are closely allied to well-known Continental forms on this horizon.

The most remarkable Bovey plant is *Sequoia Couttsiæ*, Heer, a new species of fossil Conifer. Since its discovery at Bovey, Professor Heer has ascertained that it occurs also at Armissan, near Narbonne, in France.

The work at Bovey was performed, under the superintendence of the author, by Mr. H. Keeping, of Freshwater in the Isle of Wight, well known as an efficient and reliable fossil-collector. It is probably unnecessary to add that he takes a lively interest in the problems which it is hoped his labours may help to solve, and readily understands the nature of the evidence required. In recognition of this, I wrote to him as soon as the chronology of the Bovey beds was settled, informing him that they were Lower Miocene, and probably on or very near the horizon of the Hempstead series, with which I knew him to be well acquainted. It may not be out of place to remark here, that I had come to this last conclusion on the principle that things which are contemporary with the same are contemporary with one another, and not from the fact that Bovey and Hempstead possessed any fossils in common.

In acknowledging my letter, Mr. Keeping stated that he had recently found Bovey fossils, especially *Sequoia Couttsiæ*, in the Hempstead beds. I immediately wrote, requesting him to devote some time, as soon as possible, to these beds on my account; to send me all the fossils he could find; to be very particular respecting their situations in the deposit; and directing him to "take his departure" from the *Black* and *White Bands* of Professor E. Forbes*.

In a few weeks he sent me a good series of fossil plants—seeds, cones, leaves, and twigs; amongst them certainly *Sequoia Couttsiæ* and *Folliculites Kaltennordheimensis*. Being fully aware, however, that my opinion on such a point must necessarily be valueless, and believing the discovery, if fully established, to be one of considerable interest, I dispatched by far the greater number of the specimens to Professor Heer, requesting him to prepare a short paper on the fossils, if he thought the subject of sufficient importance, which I might present to this Society.

Whilst waiting his reply, Mr. Keeping sent me, from the same beds, two fine portions of undoubted Palm-leaves, one of which I had no doubt was *Sabal major*, Ung.; the other, not so perfect, appeared to be also a decided *Sabal*, but less identifiable specifically. These were also forwarded to Professor Heer, from whom I have just received the accompanying paper, which I beg to present to the Society in his name, in the hope that some geologist may be induced to take up the subject and thoroughly examine it. "How important," says Professor Heer, "it would be to examine this (the Hempstead) flora as carefully as possible, and likewise that of the Bembridge series, and the pipe-clay of Alum Bay, where I collected last autumn a number of beautiful leaves! These floras would give

* Tertiary Fluvio-marine Formation of the Isle of Wight, pp. 43, 44.

us important conclusions about the relation of the Miocene to the Eocene flora, and clearly show us the changes which have taken place in this land; for the forests particularly give the physiognomy of the country."—W. P.

Fossil Plants from Hempstead, Isle of Wight.

The plants sent to me by Mr. Pengelly, from the Hempstead Series of the Isle of Wight, are of great interest, because the geological position of the deposit was exactly determined by the late Prof. E. Forbes, and it is very important to know in what degree the flora of this division of the Tertiary formation is referable to that of the pipe-clay of Alum Bay and that of the lignite of Bovey Tracey.

The number of species is indeed very small, undoubtedly too small for an exact settlement of this question. However, they give us some important points of comparison. The plants sent to me belong to ten species. Four of these (*Sequoia Couttsiæ*, *Andromeda reticulata*, *Nymphœa Doris*, and *Carpolithes Websteri*) have also been found at Bovey Tracey; all these, except the *Nymphœa*, are species which appear also in the Lower Miocene of the Continent. *Nelumbium Buchii* is known from Mount Promina, from the Paudeze, and Günzburg, localities belonging to the Lower Miocene, and is also accompanied by *Chara Escheri*. We know, therefore, six species of the Lower Miocene (Tongrian and Aquitanian).

Prof. E. Forbes says (in his 'Tertiary Fluvio-marine Formation of the Isle of Wight,' p. 47), when speaking of *Folliculites thalictroides* Br., var., "This form appears to be the same as that found in the Bembridge and Headon series:" he certainly means the *F. thalictroides*, var. *Websteri*, Br.; but this, on account of its obtusely rounded end, must be separated as a species from *F. thalictroides*, and is identical with the *Folliculites Kaltennordheimensis*. If this species, indeed, appeared in the Bembridge beds, and not the *F. thalictroides*, Br., Hempstead would have one species in common with the Bembridge series. Prof. Forbes mentions, besides, three species of *Chara*; but at present we cannot lay much stress upon these, as I shall show in my notice of *Chara*, because we must submit them to a new and careful examination.

Hempstead has no species in common with the pipe-clay of Alum Bay. As far as the deficient materials enable us to judge, the fossil flora of Hempstead has more reference to that of Bovey Tracey, and thereby to the Lower Miocene flora, than to the Eocene flora of the Bembridge series and Alum Bay.

A further observation which these plants suggest concerns the local conditions which they announce. We perceive amongst them a *Nelumbium* and a Water-lily (*Nymphœa*); also two species of *Chara*, which likewise lived in the water; and a plant nearly related to *Cyperus*, which undoubtedly grew on the bank, where an *Andromeda* had its place too. The seeds of *Nymphœa Doris* are very numerous; and from the *Nelumbium Buchii* we have not only portions of leaves, but also numerous rhizomes with the fibres; we may therefore almost with certainty affirm that this plant really lived there.

The *Nelumbium* and the Water-lily demand the presence of fresh water and exclude any idea of salt water; therefore one can easily explain the appearance of *Paludina, Cyclas, Unio,* and *Planorbis* at this place. Accordingly we admit the existence of a freshwater lake there, the Water-lilies and Lotos spreading their leaves over its waters, and the Sequoias, the Palms, and the Andromedas surrounding its banks.

The lake could not have been far from the sea, nor much above it, because these freshwater formations alternate with those of brackish water,—a circumstance which shows that the sea broke in at times, and changed the fresh water into brackish, and finally into salt water; so that the plants confirm the conclusions formed by Prof. Forbes from the animals.

The exact sections in Forbes's memoir give us very interesting indications of these events; and perhaps it may be possible, by a careful study of the plants these beds contain, to arrive at conclusions not only respecting the change of the freshwater and brackish formations, but also as to the seasons in which they took place. The "Black Band" forms the basal stratum of the Hempstead series; and the next succeeding stratum shows us that already, in the beginning of the formation, a lake of fresh water existed there; for it is particularly in this portion of the deposit that rhizomes and leaves of *Nelumbium* are found, and with them the freshwater shells. An influx of salt water seems to have taken place before the formation of the "White Band," as here there occur some brackish-water shells. During the formation of the "middle freshwater marl" of Forbes (*op. cit.* p. 42), the freshwater conditions were predominant, and the Water-lilies appear represented by a quantity of seeds, with *Unio* and *Paludina*. The "upper freshwater and estuary marls" of Forbes are nearly always a freshwater formation; and we only get a true marine stratum in the "upper Corbula-bed." It seems, therefore, that from the beginning to the end of the Hempstead Series there was a lake which received fresh water from a river, but that from time to time it was supplied with salt water, which at last became predominant, by which the freshwater population was supplanted by an exclusively marine one.

To these general remarks I add the following observations on the species.

1. Sequoia Couttsiæ, Heer. Pl. XVIII. figs. 1–7.

Heer, Fossil Flora of Bovey Tracey, Phil. Trans., pls. 8, 9, 10.

Most of the specimens are from a bed 7 feet above the "Black Band" of Forbes; but one specimen was found about 2 feet 6 inches from the top of the "second division" of Forbes (*op. cit.* p. 41).

This species wholly agrees with that of Bovey Tracey. It has thin twigs (figs. 2, 4) which are covered with imbricated leaves. The leaves are alternate, acuminate, and mostly have a somewhat curved point; they are either pressed against the twigs (fig. 2), or spread in the upper part (fig. 4), like the Bovey plant. The cones are also of equal size, and formed by peltate, many-edged scales (figs. 1, 2 *b*, 3). The seeds (figs. 5, 6, 7) have flat wings and a *curved* nucleus, like that of the Bovey plant; and in this they differ from the seeds of *Sequoia sempervirens.*

Prof. E. Forbes mentions from Hempstead (Tert. Form. Isle of Wight, p. 47) *Taxites* (or *Glyptostrobites*) *Parisiensis,* Brongn. (*Muscites squamatus,* Brongn. Végét. Foss. pl. 10. figs. 5, 7); he has certainly taken the plant in question for it. It appears, indeed, to be a species much resembling it. Brongniart says of his *Muscites squamatus,* "foliis rhomboideis *obtusis*;" whilst our species has, on the contrary, *acuminate* leaves. Our species appears, however, in France, viz. at Armissan near Narbonne, whence I have received some twigs.

2. Cyperites Forbesi, sp. nov. Pl. XVIII. figs. 20, 21.

The fruits are 2 millims. long and 1½ millim. broad, oval, and furnished with a fine point. They occur in great numbers together in the upper three feet of the "third division" of Forbes.

They are small black fruit, which are broadest in the middle, and equally, obtusely rounded at both ends, but provided with a small point at the top, which is the termination of the style. The side is flat, without an edge; therefore they were not triangular. Sometimes there are two lines (fig. 21 *g*) above the middle, because it sprang up there; the edge is often split (fig. 21 *e, f*). The fruit agrees in size and form with that of *Cyperus Monti,* L.; and it probably belongs to the genus *Cyperus.* The fruits of *Scirpus* are always tapered at the base and thickest above the middle; those of *Carex* are beaded, whilst those of *Cyperus* are shaped like the fruits represented of the natural size in fig. 20, and magnified in fig. 21. They belong perhaps to *Cyperus reticulatus* (Heer, Flora Tertiaria Helvetiæ, vol. i. p. 80; vol. iii. p. 165), whose ears resemble that of *Cyperus Monti,* L.; but we have not found the fruits of this species.

3. Sabal major, Ung., sp. (?)

Only a portion of a leaf of the middle of the fan; it cannot be determined with certainty. The rays are 10–12 millims. in breadth, with a projecting edge in the middle; they have numerous longitudinal veins, and between every two there are four finer ones. Found seven feet above the "Black Band."

4. Andromeda reticulata, Ett. Pl. XVIII. figs. 12, 13.

Ettingshausen, Tertiäre Flora von Häring, p. 65; *Heer,* Fossil Flora of Bovey Tracey, Phil. Trans., pl. 17. figs. 10, 11.

From a bed seven feet above the "Black Band."

These are coriaceous leaves, provided with a petiole, and gradually tapering towards the base. They are distinguished by their reticulated venation (fig. 12 *b*). Like the leaves of this species from Bovey, the secondary veins project very little from the fine reticulation which covers the surface of the leaf. It is very like *Andromeda protogæa,* Ung., but has a shorter petiole and a finer reticulation, and is more tapered at the base; but it is still doubtful if these differences suffice to separate them. The leaves figured by Ettingshausen in his 'Flora von Häring,' pl. 22, figs. 1–8, under the name of *Andromeda protogæa*, belong, I think, to *A. reticulata*.

5. Nymphæa Doris, Heer. Pl. XVIII. figs. 8–11.

Heer, Fossil Flora of Bovey Tracey, Phil. Trans., pl. 19. figs. 32-37.

The seeds appear in great numbers in the upper three feet of the "third division" of Forbes. These are probably the seeds which he mentions as *Carpolithes ovulum*, var.

They are brilliantly black, short oval, at both ends obtusely rounded, 2½–4 millims. long, and 2–3½ millims. broad, agreeing in form and sculpture with those of *Nymphæa*. In many of the specimens the fine stripes are to be seen with the aid of a lens, whilst in others they are rubbed out; they agree so well, however, in all other points with the rest that they cannot be separated.

It is undoubtedly the same species as that of Bovey; it differs from *Nymphæa Charpentieri* (Heer, Flor. Tert. Helvet. pl. 155, fig. 20 *b, c, d*) and *N. Arethusæ*, Br. (*Carpolithes ovulum*, Br.) by the somewhat broader and shorter seeds. The *Nymphæa doliolum**, Ludwig, is the *N. Charpentieri*, Heer.

6. Nelumbium Buchii, Ett. Pl. XVIII. fig. 19.

Ettingshausen, Flora des Monte Promina, p. 36, pl. 11. fig. 1; pl. 12.

Heer, Flora Tertiaria Helvet. p. 31, pl. 107. figs. 2–5.

Rhizomes and portions of leaves abundant, seven feet above the "Black Band;" one rhizome in the upper three feet of the "third division."

Several large portions of leaves have been found, but no entire leaves. They show us that the leaf was peltate, like that of *Nelumbium*. Fig. 19. Pl. XVIII. represents a portion of a young leaf where the petiole was attached; its venation is very indistinct; one sees, however, that one of the principal veins was stronger than the others, which distinguishes *Nelumbium Buchii* from other species. Other portions belong to large, full-grown leaves, with well-preserved veins, but do not show either the edge or the middle. The principal veins are forked, the forks forming acute angles; they are forked again a little higher (Pl. XVIII. fig. 19 *b*, where a small portion of a leaf is represented). Delicate veins unite the principal ones; and the areas they include are filled up with a fine reticulation.

There is no doubt that the rhizomes represented in Pl. XVIII. figs. 19 *c, d, e* belong to *Nelumbium*. The rhizomes of this genus partly form knots, which are provided with a bunch of long fibres. They show, therefore, quite another structure than the rhizomes of *Nymphæa*. These rhizomes occur in the same bed with the leaves of *Nelumbium Buchii*, and therefore confirm the explanation given

* I received the seeds from M. Tasche of Salzhausen.

of them. The rhizomes are from 10 to 14 millims. thick, and at the knots 23 to 24 millims.; they represent brilliant brown or brownish black bands. The large, thickened knots are provided with long and thin fibres, which bear finer fibrils. The fibres have fallen away in places, and scars appear, which are numerous and densely crowded. Fig. 19 *d* represents the lower end of the rhizome; fig. 19 *c*, a knot in the middle of it. These beautifully preserved rhizomes enable us to explain some enigmatical portions which were formerly sent to me from Rochette and Günzburg. In my 'Flora Tertiaria' I have represented in pl. xxi. fig. 13 *a* some fibres ranged in a circle, which at all events belong to *Nelumbium*. Rhizomes have been found at Günzburg, which are as large as those of Hempstead. I took them formerly for *Cyperites dubius*, A. Br. At Rochette and Günzburg there appear with the roots, at the same place, the leaves of *Nelumbium Buchii*, which confirms their belonging to the same species.

The Typha-like leaves mentioned by Prof. E. Forbes (*op. cit.* p. 44) are probably the rhizomes of our plant.

7. Carpolithes Websteri, Brongniart.

Carpolithes thalictroides, var., A. Brongn., Mémoires du Muséum, vol. viii. pl. 14. fig. 6.
Folliculites Kaltennordheimensis, Zenker et Auct.
Folliculites minutulus, J. D. Hooker, Quart. Journ. Geol. Soc., 1855, vol. xi. p. 567.

Abundant at two feet below the "White Band." It wholly agrees with the specimens from Bovey, Kaltennordheim, the Wetterau, Rochette, and elsewhere.

8. Carpolithes globulus, sp. nov. Pl. XVIII. figs. 14, 15, 16.

Globose fruits (or seeds ?), 4 to 5 millim. in diameter, smooth somewhat depressed at both ends.

In the upper three feet of the "third division" of Forbes.

They have a rather thick, coal-black rind, which easily peels o from the pyritized nucleus (fig. 16 *b*; magnified, fig. 16 *c*). Thus we have golden-yellow grains, surrounded by a black rind. This gold-coloured nucleus has at one end a small round aperture, or circular place (fig. 14); the other end has an impression (fig. 15).

It is perhaps the fruit of a Palm.

Var. b. Natural size, figs. 17, 18; magnified, figs. 17 *b*, 18 *b*.

Besides these globose, smooth fruits, there are at Hempstead, at the same place, short oval fruits (or seeds ?), which are densely and finely dotted. They are 6 millims. long, and 5 millims. broad. They have also a golden-yellow nucleus of pyrites, and a rather thick black rind. These fruits belong perhaps to another plant.

9. Chara Escheri, A. Brongn.

Heer, Flora Tert. Helvet. vol. i. p. 25, pl. iv. fig. 5.

From the upper three feet of the "third division" of Prof. E. Forbes.

I cannot distinguish these from the species which I described and figured in my 'Flora Tert. Helvet.' They are very small, oval fruits, with 9 to 10 whorls; these are partly flat, partly concave, where the spirals project more sharply. The coronula is formed by five very small warts or points. This differs totally from *Chara medicaginula*, Brongn., by its oval (not globose) fruits, and by the greater number of whorls.

Chara Escheri is abundant in our Lower and Upper Miocene, from the Aquitanian to the Oeningian stages.

10. Chara tuberculata, Lyell, var. (?).

It appears to be different from the real *Ch. tuberculata*, Lyell (Manual of Elementary Geology, p. 210, fig. 189; and Salter, in Forbes's Tert. Form. Isle of Wight, pl. 7. figs. 11, 12). The pieces I received (there were but a few, and not well preserved) are somewhat smaller, and have but eight or nine whorls; and they have also larger and fewer tubercles than the fruits of *Ch. tuberculata*. They may form another species, as these differences are also to be seen in Salter's figures of *Ch. tuberculata*, var., from Hempstead (*op. cit.* pl. 7. fig. 13). Original specimens of *Ch. tuberculata* from Bembridge are wanting. I am unable to decide this question with certainty. We must have well-preserved fruits from the Hempstead and Bembridge series.

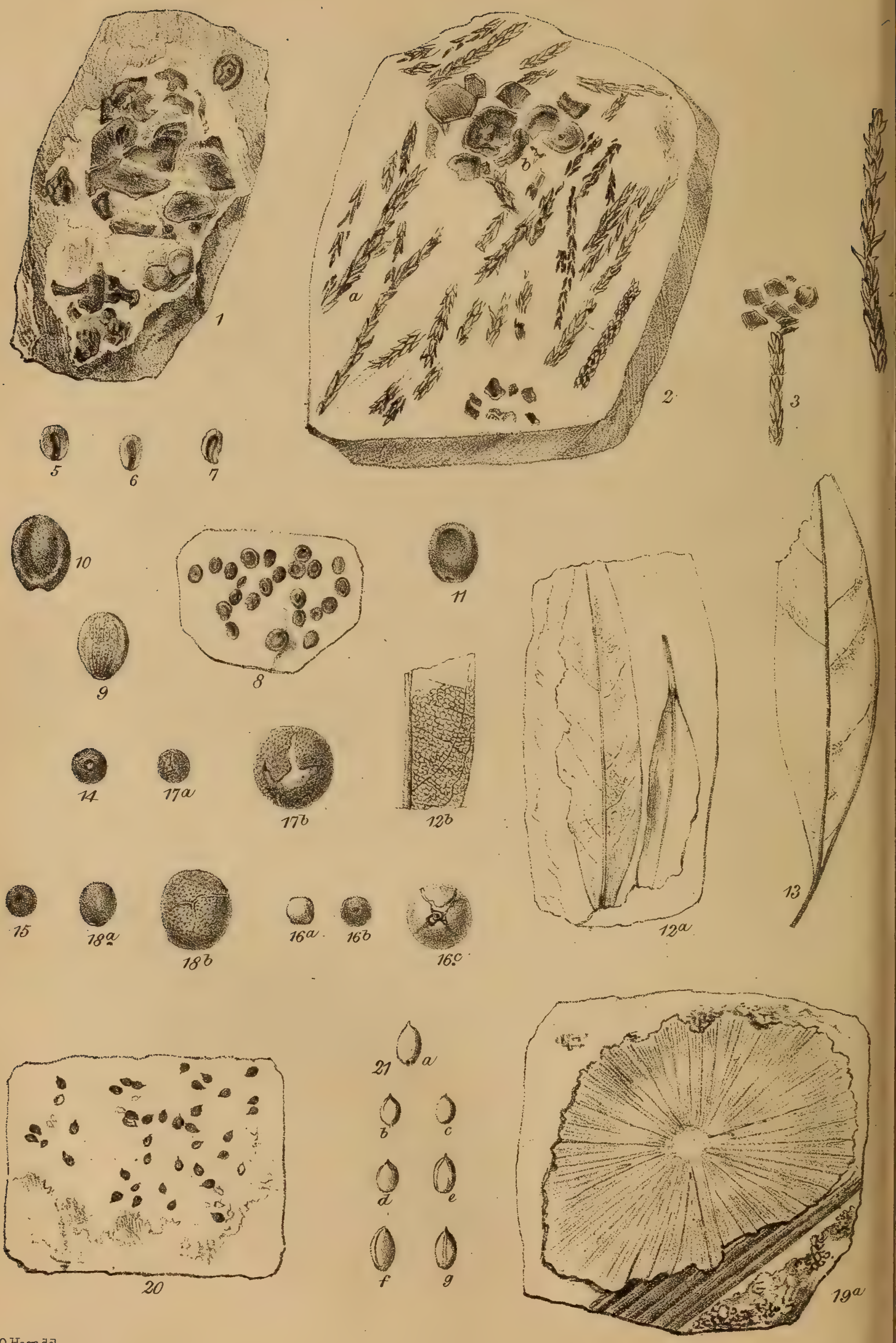
Prof. Forbes mentions *Chara helicteres*, Brongn., and *Ch. medicaginula*, Brongn.; but Salter (*op. cit.*, p. 159) seems to doubt the appearance of these species at Hempstead, and says that no specimen from this locality has been found in the collection. In pl. 7. figs. 3–5, he only repeated the figures of Brongniart; therefore we are not yet quite sure whether these two species appeared at Hempstead. Accordingly we are obliged to omit these species of *Chara* in the comparison of this locality.

Postscript.—I have just received several specimens of the Palm of Hempstead from Mr. Pengelly. They undoubtedly belong to *Sabal major*. Two of the specimens have still the end of the petiole and the base of the leaf. The rachis is 44 millims. broad at the base, very long, and gradually tapering (as the specimen figured in my 'Flora Tertiaria,' vol. i. pl. 36. fig. 2). The rays are attached on both sides; they wholly agree, in the insertion, form, and venation, with *Sabal major*, and indeed with the large form which Unger had called *Flabellaria maxima* (Chloris Protogæa, pl. 12). This species wholly differs from *Flabellaria Lamanonis*, Brongn., and therefore belongs to a Palm which extended over the whole of Europe in the Lower Miocene Period.—O. H.

EXPLANATION OF PLATE XVIII.

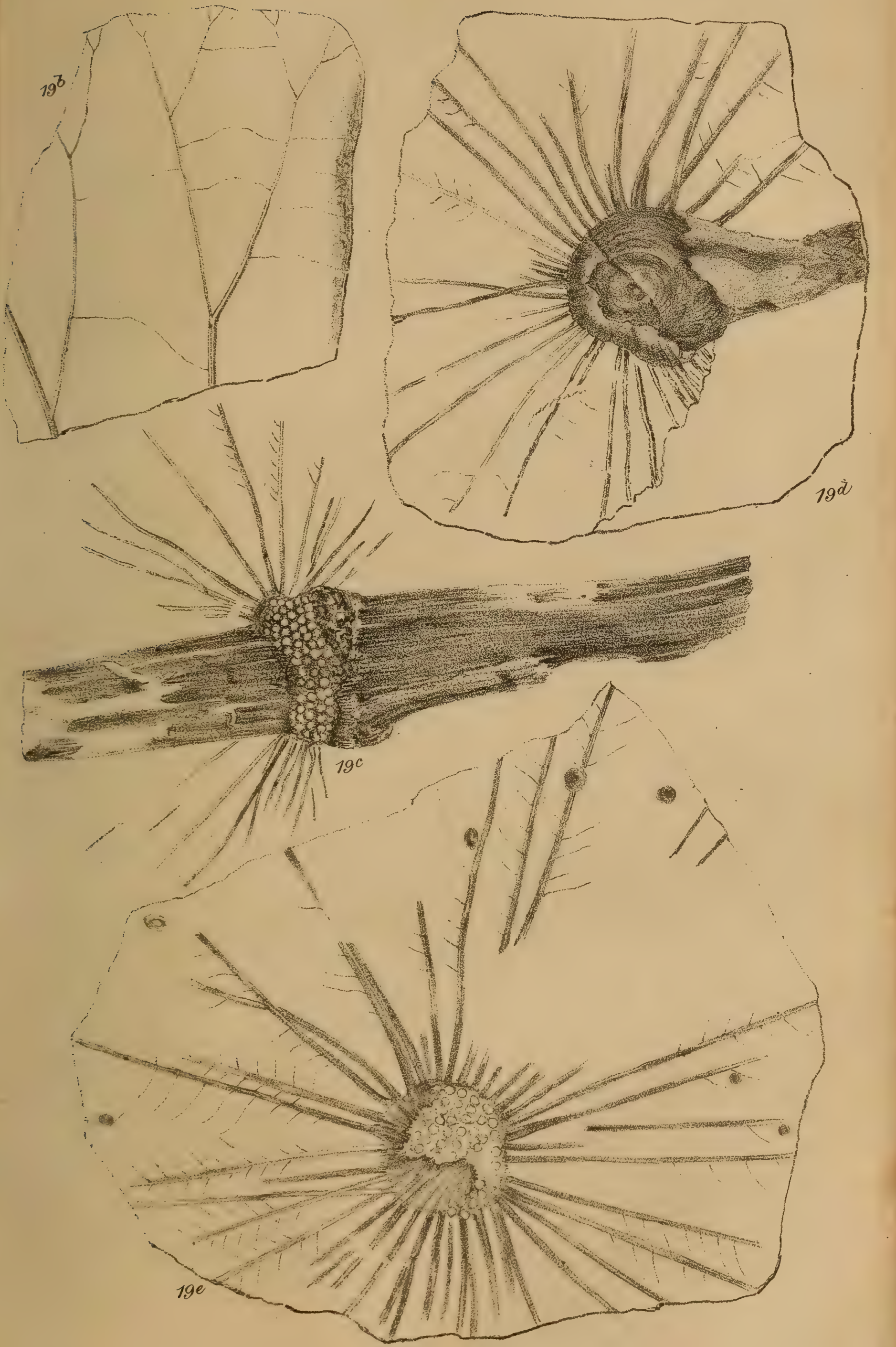
Illustrative of Plant-remains from the Hempstead Beds of the Isle of Wight.

Fig. 1. Remains of *Sequoia Couttsiæ*. Fragments of cone.
2. ——— ———. Fragments of twigs and of cone.
3. *Sequoia Couttsiæ*. Fragments of cone and twig.
4. ——— ———. Twig.



O.Heer del.

FOSSIL PLANTS FROM THE HEMP



W. West lith.r

AD BEDS OF THE ISLE OF WIGHT.

O Heer del.

W. West lith^r.

FOSSIL PLANTS FROM THE HEMPSTEAD BEDS OF THE ISLE OF WIGHT.

Fig. 5, 6, 7. *Sequoia Couttsiæ.* Seeds.
8, 9, 10, 11. *Nymphæa Doris.* Seeds, natural size and magnified.
12 *a*, *b*, 13. *Andromeda reticulata.* Leaves.
14, 15, 16 *a*, *b*, *c*. *Carpolithes globulus.* Natural size and magnified.
19 *a*. *Nelumbium Buchii.* Young leaf.
19 *b*. —— ——. Portion of a large leaf.
19 *c*. —— ——. Rhizome, with knot and fibres.
19 *d*. —— ——. Lower end of a rhizome
19 *e*. —— ——. Transverse view of the fibres at a knot in the rhizome
20, 21 *a–g*. *Cyperites Forbesi.*

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3. *On* Glacial Surface-Markings *on the* Sandstone *near* Liverpool. By G. H. Morton, Esq., F.G.S.

Towards the end of 1859, I gave an account to the Literary and Philosophical Society of Liverpool of certain indications of ice passing over and grooving the rocks in Toxteth Park. Since that time I have found the same appearances in two other places, and that a far greater interest is attached to the discovery than was at first anticipated; it seems therefore desirable that the particulars should be made known through the Geological Society.

Toxteth Park.—The first locality which was noticed is between Park Hill Road and the Dingle. It is near a quarry in the "Pebble-beds" of the "Bunter" formation, where the strata dip 10° E. The surface of the rock inclines 5° N.E. The direction of the striations is N.W. by N., or more correctly N. 42° W., allowing for variation. After the discovery, I employed a labourer to clear away some more of the "Boulder-clay" which originally covered the surface of the rock to the depth of about 9 feet, until at least 20 square yards were visible; and no doubt the appearances extend over a considerable extent. The elevation is about 120 feet above the level of the sea.

Boundary Lane, Kirkdale.—The second locality is in the brick-fields, about 50 yards north of Boundary Street, and 150 yards west of Gore Street, where 10 square yards of striated surface have been exposed for several years. The sandstone belongs to the base of the "Keuper" formation; the surface inclines about 5°, in the same direction as the grooves and furrows, N. 15° W. The elevation above the sea is about 80 feet.

New Road, Kirkdale.—The third locality is also in the brick-fields, about 600 yards S.W. of Kirkdale Gaol, and about the same distance from that last referred to, with which it may possibly communicate. The sandstone belongs to the base of the "Keuper;" and the striated surface exposed is fully 500 square yards, inclining throughout at an angle of 7½°, in the direction of the striæ, which is the same as in the contiguous example, N. 15° W. The elevation above the sea is 80 feet, or perhaps a little less.

At each of these places the sandstone is smooth, but with numerous longitudinal grooves and furrows of varying distinctness. The most prominent are about an inch wide, and extend several yards in a perfectly straight line. In appearance they seem to have been caused by the passage of some heavy body across the rock; and as ice seems the only agent possible to produce the result, the grounding of icebergs in the "Glacial Sea" is probably the cause.

Polished striated boulders and small stones are common in the overlying "Boulder-clay," and shells very rare.

Note.—Since making the above communication, I have found very distinct ice-grooves at Oxton, Cheshire, half a mile S.E. from Flaybrick Hill. The direction of the striations is N. 30° W., and the elevation is *about* 120 feet above high-water level.—October 8, 1862, G. H. M.

June 18, 1862.

John Cumming, Esq., 7 Montagu Place, Russell Square, and William Topley, Esq., of the Geological Survey of Great Britain, Colchester Villas, Lewisham Road, were elected Fellows.

The following communications were read:—

1. *On the* Mode of Formation *of some of the* River-valleys *in the* South *of* Ireland. By J. Beete Jukes, Esq., M.A., F.R.S., F.G.S., Local Director of the Geological Survey of Ireland, &c.

[Plates XIX. & XX.]

Contents.

Introduction.—The determination of the method by which the surface of the land has been carved out of the subjacent rock into its present form is a geological problem which has not yet been solved, except in a very general way. The most important contribution towards this solution is the paper by our President, Professor Ramsay, "On the Denudation of South Wales and the adjacent Counties of England," in the first volume of the 'Memoirs of the Geological Survey,' in which the amount of denudation is proved by means of the accurate sections constructed by the Survey.

When Sir Roderick Murchison became the Director-General of the Survey, and ordered that descriptions, or "Explanations," to accompany each sheet of the map, should be prepared, he pointed to the *form of ground* as one of the things to be described. I had often previously thought of examining this question, and was therefore not sorry to find it brought directly before me in the course of my official duties as the Local Director of the Irish branch of the Survey, one of which duties is, of course, the editing of these "Explanations." The following notes on the formation of some of the river-valleys of the southern part of Ireland contain some conclusions at which I have arrived in the course of the last few years, while engaged in that duty; and they are here offered as a contribution towards the solution of this problem.

Part I.—Physical Structure of the South of Ireland.

Ireland may be divided into two nearly equal parts by a line drawn from Dublin Bay to Galway Bay. This line would traverse a broad belt of low, very nearly level ground, the immediately subjacent rock of which is almost entirely Carboniferous Limestone. It would run from the basin of the Liffey into that of the Barrow, and then crossing that of the Shannon between Lough Ree, the surface of which is about 125 feet above the sea, and Lough Derg, which is about 17 feet lower, would pass into that of Galway Bay, which, excepting the Corrib, receives only a few marginal streams.

The watershed between the basin of the Liffey and that of the Barrow cannot be higher in some parts than 279 feet above the sea, which is the height of the summit-level of the Grand Canal near Robertstown, about six miles west of Salins. One of the trigonometrical points on the watershed, south of Robertstown, is only 290 feet above the sea.

The watershed between the basin of the Barrow and that of the Shannon passes over ground, near Phillipstown, which is in some places not higher than 261 feet, the level of the Grand Canal there, one of the trigonometrical points on the watershed being only 295 feet.

The great Bog of Allen, which is an ill-defined assemblage of large bogs, separated from each other chiefly by gravel-mounds and esker-ridges, lies on the flat country about the watershed between the basins of the Barrow and the Boyne and the adjacent parts of those of the Liffey and the Shannon; so that there is a broad belt of land here, in the centre of Ireland, no part of which, except perhaps an occasional gravel-mound, exceeds 300 feet above the sea.

The summit-level of the Royal Canal, which runs from Dublin to the Shannon above Lough Ree, derives its water from Lough Owel, the height of which is 327 feet above the sea.

On the west of the Shannon basin, the watershed between it and Galway Bay is certainly not higher in some places than 300 feet above the sea; for this is the maximum height of the Great Midland

and Western Railway about Woodlawn, which is the highest ground it crosses*.

This great limestone plain, which stretches, thus unbroken, across the centre of Ireland, is interrupted towards the south by five chains of hills, which run along bearings more or less nearly N.E. and S.W. When, however, we get as far south as Waterford, Tipperary, and Limerick, we meet with other ranges of hills, which run more nearly due E. and W.

Of the first five ranges of hills, two are made of Coal-measures, resting conformably on the Carboniferous Limestone, and forming irregular table-lands, of which the summits rise to heights of about a thousand feet above the sea, and are generally near the edges of the escarpments which look down in every direction on to the low limestone ground around them.

The other three ranges of hills are made of Lower (or Cambro-) Silurian rocks (with or without Old Red Sandstone), rising up from beneath the limestone, and attaining often to much greater elevations than the Coal-measures which rest upon it. The Old Red Sandstone, where it appears, always rests quite unconformably on the denuded edges of the Lower Silurian rocks, and passes up conformably into the base of the Carboniferous Limestone, through a narrow band of black shales.

Of these three ranges of hills, the most eastern is the Wicklow and Wexford † range, made of Lower (or Cambro-) Silurian slates and traps, with a great mass of intrusive granite, and only coated by Old Red Sandstone towards its southern termination. Its loftiest point is Lugnaquilla (3039 feet), in county Wicklow.

The next of the three ranges consists of the hills called Slieve Bloom (1733 feet), the Devil's Bit (1583 feet), and the Keeper (2278 feet), and their connecting ridges. They are all composed of Lower Silurian rocks, with an unconformable envelope of Old Red Sandstone round their base, patches of the same rock being sometimes left on the summits of the hills.

The third range may be said to be formed of the Slieve Aughta (1243 feet), the Slieve Bernagh (1746 feet), and the Slieve Arra (1517 feet), which are of precisely similar constitution with the hills of the second range. Slieve Arra, indeed, is only separated from the Keeper group by a narrow limestone valley, not so wide, in fact, as the one which intervenes between Slieve Bernagh and Slieve Aughta.

Of the two groups of high lands which are composed of Coal-measures, the one lies between the Wicklow and Wexford hills on the east and those of the Slieve Bloom and Devil's Bit on the west, being separated from them, and entirely surrounded, by a tract of low limestone ground, which spreads round them from the great plain on the north. The other Coal-measure high land is that which stretches

* I am indebted to Sir R. Griffith, Bart., for a confirmation of the correctness of the position and altitudes of these and some of the following watersheds.

† There is, in fact, no commonly received name for the whole of this range,—a peculiarity which often makes it difficult to speak succinctly of the mountain-ranges in Ireland.

from the county Cork, through Kerry and Limerick, into Clare. It is cut in two by the broad estuary of the Lower Shannon. Towards the northern part of Clare, a thin coating only of Coal-measures is is left on the high land, which is there formed of the Carboniferous Limestone,—hills of limestone, more than 1000 feet in height, forming the Barony of Burren, and looking down upon Galway Bay.

These limestone and Coal-measure hills are separated from the Slieve Aughta and Slieve Bernagh by a low limestone tract, spreading from Galway, past Gort and Ennis, to the Lower Shannon, the watershed of which is in the neighbourhood of Gort, and is in some places not higher than 150 feet above the sea. It is a branch of this low limestone country which runs out to Lough Derg by Scariff, between the Slieve Aughta and Slieve Bernagh hills.

The part of the limestone plain lying on the east side of Lough Derg forms a similar country, and sends a branch down the Kilmastullagh valley, between the Slieve Arra and the Keeper group, to the Shannon at O'Brien's Bridge, and another smaller one through the Gap of Roscrea, between the Devil's Bit range and the Slieve Bloom.

This latter branch, which thus connects the limestone plains on each side of the central ridge of Slieve Bloom, is traversed by the main watershed of Ireland at a level not higher in some places than 360 feet above the sea. This part of the main watershed runs between the basin of the Shannon and that of the Nore.

To the south of the hills just described the limestone country again expands into a plain, in parts of Limerick and Tipperary, between the extension of the two Coal-measure high lands, embracing, however, several minor east and west ranges of lower rocks. The watershed on this plain, between the basin of the Shannon and that of the Suir River, is not higher in some parts, near the Limerick Junction Railway-station, than 330 feet above the sea.

The most important of the east and west ranges that rise hereabouts is that of the Galty Mountains (3015 feet) and their subordinate groups. These are surrounded by branches of the limestone plain, which meet about Castletown Roche, and conduct us into the valley of the Blackwater. The watershed between the basins of the Suir and Blackwater, in the western branch, is about Castle Harrison, near Charleville, at a height of about 374 feet; that in the eastern branch is about the Caves of Mitchellstown, and is about 400 feet above the sea.

The valley of the Blackwater River again enables us to cross Ireland wholly on the Carboniferous Limestone, in a nearly straight line from sea to sea, starting from Dungarvan Harbour, and ascending the Blackwater, past Cappoquin, Lismore, Fermoy, Mallow, and Millstreet, and then descending into the basin of the Flesk, and continuing out by Killarney and Killorglin into Castlemaine Harbour in Dingle Bay. Between Millstreet and Killarney, however, the limestone is entirely concealed for some miles by great accumulations of drift, probably not less than 200 feet in thickness; and the watershed between the Blackwater and the Flesk basins rises in consequence to a height of 550 feet at the lowest point. This is the greatest height for the lowest point of a watershed * anywhere, over any limestone ground, in the south of Ireland.

Thus far the Carboniferous Limestone is continuous from the great plain between Dublin and Galway, spreading *round* the hills of Lower Silurian and Old Red Sandstone rocks, and *beneath* the hills of Coal-measures.

On the south side, however, of this limestone valley, which stretches from Dingle Bay to Dungarvan, the limestone is entirely cut off, and we meet with one continuous range of Old Red Sandstone running from the headlands of Kerry, near Valentia, out to Helvick Head, on the south side of Dungarvan Bay.

All the Carboniferous Limestone to be found south of this long ridge consists of detached outliers, forming valleys and low grounds in the long synclinal hollows of the Old Red Sandstone. These, with their intervening anticlinal ridges, run along lines bearing at first due E. and W., but gradually curving round as we go westwards, so as to run E.N.E. and W.S.W. The intervening ridges of Old Red Sandstone are of moderate height in Waterford and the eastern part of Cork, ranging from 400 to about 800 feet above the sea; while no parts of the limestone valleys rise to more than 200 feet, and their general level is less than 100 feet above the sea. As we proceed westward, however, towards Kerry, the ridges rise higher, and the limestone valleys become narrower and shallower, until the Old Red Sandstone alone, but bent into similar curves, forms the well-known mountainous district west and south of Killarney, between Dingle and Bantry Bays.

All the hills, indeed, to the south-west of a line drawn from Wexford Harbour, past Cashel to Limerick, run from east to west; and most of them rise gently from the east, with their culminating points towards the west. Not only does the present surface of the ground rise higher towards the west, but the beds themselves that form these ridges, while they almost always dip at high angles either to the north or south, nevertheless rise imperceptibly towards the west, so that each bed gradually crops out towards the west, in the bottom of the synclinal or on the crest of the anticlinal folds, those folds being still apparent westwards, but in successively lower beds. We may express this structure by saying that the axes of the curves are gently inclined, so as to sink towards the east, or rise towards the west.

All the large open valleys of this south-western corner of Ireland, too, run E. and W. along the strike of the rocks, having been excavated along the uppermost beds as they dip into the synclinal folds. The lateral, or north and south, valleys are narrow and precipitous, and either shallow and at high levels, or else deserve the name of glens or ravines, rather than that of valleys.

As far south as the latitude of Cork, the Carboniferous Limestone is separated from the Old Red Sandstone only by the beds of black

* Some definite term is wanted to express the lowest point of a watershed between two adjacent basins of drainage, or that point which would first connect them if one or both had their present mouths completely blocked up. Perhaps the phrase, "lowest connecting gap," might be used to express this.

shale before mentioned. These may be called the Lower Limestone Shale; and they rarely exceed 200 feet in thickness. South of that latitude, however, beds of black argillaceous matter and of grey quartzose grit come in beneath the Lower Limestone Shale, forming the Carboniferous Slate of Sir R. Griffith, with the Coomhola Grits of the Survey, making a group which rapidly thickens towards the south, until it is 5000 or 6000 feet thick. This group there takes the place of the Carboniferous Limestone in the synclinals, the valleys generally running along its softer upper parts, while the lower, or Coomhola Grit, portion of it forms the ridges, either alone or in conjunction with the Old Red Sandstone. (See Map, Pl. XIX.)

A few instances occur, in the Carboniferous Slate country, of the highest ground rising over a synclinal curve. Shehy Mountain (1797 feet), north of Dunmanway, is the most conspicuous of these; but a few other minor cases occur.

Former extension of the Upper Palæozoic Rocks.—It has been stated that, in the district north of the Blackwater valley, the Carboniferous Limestone forms one continuous sheet, with the exception of those parts where the Lower Palæozoic rocks or the Old Red Sandstone appear through it. As the beds of the limestone always rise on all sides towards these protruded mounds, and are cut off successively as they approach them, no one can, I think, fail to recognize in these local protrusions the character of accidental holes of erosion in the once continuous sheet, and that the limestone beds formerly stretched horizontally across the areas where these holes occur. In other words, the limestone once spread continuously in horizontal beds over the spaces where we now find the hills of Slieve Bloom and the rest.

When, moreover, we come to examine the isolated Coal-measure districts which rest on the limestone, and find them all made of precisely similar beds, with similar fossils, and find also that wherever the uppermost bed of the limestone dips beneath the present surface of the ground, or wherever a hill rises to sufficient elevation above the limestone plain to take in the top bed of the limestone beneath its surface, the lowest beds of the Coal-measures always come in over that bed, with these invariable characters, we are similarly led to the conviction that the Coal-measures were formerly continuous over the whole of the limestone.

Similar reasoning holds good for the former persistence of the limestone over the district south of the Blackwater Valley, inasmuch as we always find the limestone coming in wherever the uppermost bed of the Old Red Sandstone dips beneath the present surface, so as to allow of the whole of the black shales to sink beneath it also and the lowest bed of the limestone to appear in its natural position.

Where the Carboniferous Slate comes in with so great a thickness as it does in the south-west of Ireland, it of course precludes the appearance of the limestone, which could only come into the ground in one of two cases—either if that ground had been much loftier than it is, the folds of the rocks remaining the same, or if, the outline of the ground remaining the same, the dip of the beds had been more steadily persistent in one direction, so as to bring the limestone down beneath its surface. There is no reason to suppose that the limestone or Coal-measures would not have appeared if either of those two circumstances had occurred.

I have, indeed, as the result of ten years' examination and reflection, arrived at the full belief that, wherever in the South of Ireland we now find Old Red Sandstone, the Carboniferous Limestone and Coal-measures once existed over it—and not only so, but that the upper rocks once spread far beyond the limits of the lower. I am, in fact, unable to escape the conviction that at the close of the Carboniferous Period one great plain of Coal-measures extended horizontally over all Ireland, with the exception perhaps of the loftier peaks of Connemara, Donegal, Down, and Wicklow, even if any parts of those mountains remained uncovered by the highest Coal-measure beds.

It is also quite clear that, from the base of the Old Red Sandstone to the highest bed of the Coal-measures, all the Upper Palæozoic rocks were originally horizontal, and that at the end of the Coal-measure Period they were all under water.

It can be shown that all this vast series of beds was deposited on the slowly subsiding and rather irregular surface of a previously existing land, made of the Lower Palæozoic rocks, and that the depression commenced first on the south or south-west, and continued there for a long time, during the deposition of the great mass of the Old Red Sandstone, before it began to affect the centre of Ireland, where the Old Red Sandstone is comparatively thin or does not exist at all. It then went on again during the deposition of the Coomhola Grits and the chief part of the Carboniferous Slate, without much affecting any part north of the latitude of Cork. It was not until after the deposition of the Carboniferous Slate that the depression became more general, so as to allow of the regular deposition of the Lower Limestone Shale and Carboniferous Limestone.

The partial nature of the earlier deposits, of course, necessitates a want of strict parallelism between their beds and those which spread over and beyond them. The departure from strict parallelism, however, would be too slight to be perceptible. In the wedge-shaped mass of the Carboniferous Slate, for instance, the angle included between the planes of the uppermost and lowermost beds would be less than 5°, since the distance between two planes inclined to each other at 5° will in the course of 18 miles exceed 8000 feet. (See Explanation to sheet 194, &c., of the Maps of the Geological Survey of Ireland.)

Part II.—The Existing River-valleys of the South of Ireland.

Having thus given a sketch of the form and structure of the country at the present day, and stated generally what they must have been towards the close of the Carboniferous Period, I now proceed to examine the relation between some of the chief river-valleys and the subjacent rocks.

1. *The River Shannon.*—The Shannon, soon after issuing from the northern hills on to the limestone plain, forms the expansion called Lough Ree, from which it slowly winds over another part of the same plain, through great bogs, until it forms the similar expansion called Lough Derg. From the south end of Lough Derg it runs with a rather more rapid current past Killaloe, between the Slieve Arra and Slieve Bernagh hills, through a valley excavated out of the Lower Silurian and Old Red Sandstone rocks. Supposing a dam of 150 or 200 feet in height to be thrown across the narrowest part of the valley at Killaloe, the Shannon, instead of overtopping this dam, and thus seeking to pour down past Killaloe, would inevitably find a passage for its waters round the outside of the hills over the low limestone ground, either by Scariff to the Fergus, or by Nenagh and the Kilmastullagh valley to O'Brien's Bridge.

The Shannon, therefore, has certainly not excavated the valley at Killaloe since the limestone ground attained to its present low level. Moreover, if these three modes of escape were all blocked up, the Shannon, after forming a great lake in the centre of Ireland, including Lough Derg, Lough Ree, and the adjacent country, together with a large part of the great bog of Allen, would find an exit for its waters down the valley of the Barrow, the Boyne, or the Liffey, or even into Galway Bay, rather than down its present course. It is, therefore, exceedingly difficult to understand how the ravine at Killaloe could have been excavated either by the Shannon, or by any other water, supposing it not to exist and the rest of the ground to have an outline at all approximating to its present form and low level.

2. *The Rivers Barrow, Nore, and Suir.*—The Barrow issues from a glen on the northern flank of the Slieve Bloom Hills on to the limestone plain, where it is separated from some of the tributaries of the Shannon by elevations just sufficient to turn it to the eastward. Then, after winding round the northern termination of the Coal-measure hills of Carlow, it flows down, between them and the Silurian and Granitic hills of Wicklow, over low limestone ground as far as Gores Bridge. Here, however, it leaves the limestone plain, and traverses the Lower Silurian and Granite hills in a deep and sometimes a wide valley until it flows into Waterford Harbour. Near a little place called St. Mullins, its waters become affected by the tide, whilst Granite hills, exceeding 1600 feet in height, rise on each side of it; and both above and below this, it cuts across the Granite and the aqueous and other rocks indifferently, without any regard either to their "lie" or their composition.

The Nore and the Suir both flow from the Devil's Bit range; the Suir from Borrisnoe Mountain, and the Nore from the ground two miles north of it. They diverge, however, on entering the limestone plain,—the Suir flowing to the south by Cahir, and then, after a detour, past Clonmel to Waterford; while the Nore, after curving to the north, traverses the limestone plain to near Abbeyleix, and then cuts by a deep valley through the Coal-measure hills near Ballyragget and Freshford, from which it issues out on to the low limestone ground of Kilkenny. Passing over this, it makes for the high

Silurian ground beyond Thomastown, cuts directly across the strike of the Old Red Sandstone, which rises from beneath the Limestone at that place, and then winds, in a deep and picturesque ravine with steep banks, between hills of slate and granite from 600 to 800 feet high. It receives the influence of the tide at Inistiogue, in the heart of these hills, and, passing through them, falls into the Barrow above New Ross, and flows with it into Waterford Harbour. The Suir*, on the other hand, flows constantly over low limestone ground to the foot of the Knockmealdon Mountains, which deflect it into the limestone valley of Clonmel; so that it only cuts across the rising beds of the Old Red Sandstone into the contorted Silurian rocks close to the town of Waterford itself, where those rocks seem to have formed originally lower ground than in other parts of their range. It has, however, immediately after leaving the limestone, steep banks of 250 feet on each side of it.

In the case of each of these rivers, if the gorges by which they enter the Lower Palæozoic country were now to be blocked up to the level of the adjacent hills, or even to a height of only 300 or 350 feet above the level of the rivers, their pent-up waters would not flow over the dams so formed, but would be poured into the Shannon, either to the north of the Slieve Bloom, or out to Limerick along the line of the railway; or, if those passages were blocked up, they would escape down the basin of the Liffey or the Boyne. This is proof that these gorges were not excavated by the rivers since the limestone ground attained its present low level, at all events.

The origin of these gorges, as of that of the Shannon at Killaloe, had been for a long time inexplicable to me. I think, however, that I have found traces of an explanation in the district that I shall now proceed to describe.

3. *The River Blackwater.*—I have already mentioned the narrow limestone valley that runs across Ireland, from Dungarvan to Dingle Bay, which is for the greater part of its course drained by the River Blackwater†. (See Map, Pl. XIX.)

* Spenser, in his poetical description of the British rivers, in the 'Faëry Queen,' after speaking of these three rivers as three brothers,

> "Which that great gyant Blomius begot
> Of the faire nymph Rheusa..."

alluding probably to traditional tales now forgotten, thus proceeds to describe them:—

> "The first, the gentle Shure, that, making way
> By sweet Clonmell, adornes rich Waterford;
> The next the stubborn Neure, whose waters gray
> By faire Kilkenny and Rosse ponte boord;
> The third the goodly Barow, which doth hoord
> Great heaps of salmons in his deepe bosome:
> All which, long sundered, doe at last accord
> To ioyne in one ere to the sea they come;
> So, flowing all from one, all one at last become."
>
> *Faëry Queene*, B. iv. cap. xi. stanza xliii.

The "great heaps of salmons" have, I fear, become almost as scarce in the Barrow since the days of Elizabeth, as the "gyants" were previously to that period.

† It will be recollected that there are several other Blackwater Rivers in Ireland—one, for instance, which falls into the Boyne.

The Old Red Sandstone ridge which rises immediately to the south of this valley, invariably presents to it a steep slope with an undulating, but generally unbroken summit-ridge. The bottom of the limestone valley rises very slowly as we proceed from Dungarvan towards the interior of the country, until we arrive at its summit-elevation of 550 feet on the borders of county Kerry; and the average height of the summit of the ridge to the south of it increases in at least an equal ratio.

The mean height of the ridge in Waterford is about 400 or 500 feet above the sea, with summit-elevations rising to 780 feet, while the highest parts of the limestone attain at one point only to so great an elevation as 200 feet. Between Fermoy and Mallow, where the summit-elevations of the limestone on the plain of Castletown Roche rise to 270 feet, the Old Red Sandstone attains, in the Nagle Mountains, to 1340 feet in height. Between Millstreet and Killarney, where the watershed of the Blackwater and Flesk Rivers occurs at 550 feet, the Old Red Sandstone is an unbroken mountainous ridge, with summits, such as Caherbarnagh and the Paps, between 2200 and 2300 feet high. Beyond this, where the level of the limestone descends again to the Lower Lake of Killarney, the Old Red Sandstone forms the range of which Mangerton, the Reeks, and Carantuohill (3414 feet, and the loftiest peak in Ireland) are the summits.

The crest of this ridge, between Cappoquin and Mangerton, is in a few places deeply indented by transverse valleys or gaps, of which the level-floored Pass of Glenflesk, leading from Killarney out into the Kenmare valley, is one of the most remarkable examples. The valley through which the Cork Railway runs from Mallow is the next greatest depression; and the valley south of Fermoy is the third. In Glenflesk a very little deeper cutting towards Morley Bridge would divert the waters of the Flesk into the valley of the Roughty River, and allow of the drainage of some of the ground on the north of the ridge flowing right through it down to Kenmare. This deeper cutting, however, has not taken place; and the range preserves its character of a watershed between the rivers on the north and those on the south all the way from the headlands of Kerry to those south of Dungarvan Harbour, with the very remarkable exception of the Dromana gorge, south of Cappoquin, which I am now about to mention.

The River Blackwater is first formed by brooks draining the high Coal-measure ground near King Williamstown, on the borders of Kerry. It runs due south to the foot of the high land near Caherbarnagh, which deflects it at right angles, to the east, down the narrow limestone valley before mentioned. It runs eastward down this, past Mallow, Fermoy, and Lismore, for a distance of fifty-five miles to Cappoquin. Beyond Cappoquin the valley is continued out to Dungarvan Harbour in the same straight line, with the same general low level, and with the same Old Red Sandstone ridges on both sides of it. Instead of following this obvious course, however, the River Blackwater turns suddenly at Cappoquin due south, crosses the limestone valley, and runs, by means of a deep and picturesque ravine, the sides of which rise steeply to heights of 300 or 400 feet, right across the Old Red Sandstone ridge, which is there a mile and a half broad. Having crossed the first ridge, it comes into another E. and W. limestone valley, that of the Tallow outlier, where it receives a large tributary from the west, called the Bride River. It crosses that valley, and cuts through another Old Red Sandstone ridge by a ravine like that of Dromana, but larger, the ridge being $3\frac{1}{2}$ miles broad, and rising in one point, called Carnglass, to a height of 650 feet, not far from the river. (See sections, Pl. XX. figs. 1, 3 & 4). It then enters the smaller limestone valley of Clashmore, and cuts across another smaller Old Red Sandstone ridge into a fourth limestone valley—that immediately above Youghal, and issues out into Youghal Bay through a fourth ridge of Old Red Sandstone, between cliffs 100 feet in height, and through ground that rises to more than double that altitude.

This latter ridge is the termination of the one that bounds the northern side of the Cork Valley.

The section, Pl. XX. fig. 1, shows the form of the main limestone valley just above Cappoquin, before the river turns to leave it; and the section, fig. 2, shows its form $4\frac{1}{2}$ miles below Cappoquin, at the part where the watershed occurs between the brooks flowing towards the Dromana ravine and those flowing towards Dungarvan. The latter exhibits, of course, the greatest obstruction that now exists to the course of the Blackwater in the direction of Dungarvan, if the ravine at Dromana were to be blocked up.

Figs. 3 and 4 show the ravines at Dromana, 3 miles S. of Cappoquin, and at Carnglass, 4 miles still further south, along the course which the Blackwater now follows. It is remarkable also that the tide now flows up these ravines as far as Cappoquin, and that the distance from Cappoquin by the valley to Dungarvan is only ten miles, while through the ravines to Youghal Harbour it is 15 miles.

If a dam only 80 or 90 feet high were now to be constructed at the ravine of Dromana, the River Blackwater, after forming a lake on the flat lands about Cappoquin and Lismore, would inevitably pour its waters along the valley into Dungarvan Bay, and excavate a bed for itself in that direction, instead of flowing over and eating away the dam at Dromana.

This then is proof that it is impossible for the River Blackwater to have formed the ravines across the Old Red Sandstone ranges since the limestone acquired its present low level, or indeed anything at all approaching that level.

4. *The River Lee.*—The River Lee issues from Lough Gouganebarra, which has a height of 520 feet above the sea, and works its way through valleys and hills of Old Red Sandstone, and along one little outlying limestone valley, until it breaks forth into the large longitudinal limestone valley in which the city of Cork stands. It there receives from the west a large tributary called the Bride River (like that in the Tallow Valley), which has come in a straight course from Crookstown, at the western end of this long limestone valley,


GEOLOGICAL MAP
of parts of the Counties of
CORK & WATERFORD,
Reduced from the published Maps
of the Geological Survey of Ireland.
To illustrate Mr. Jukes's paper on the mode of formation of some of the River-Valleys of the South of Ireland.
The figures are those of the heights given in the Ordnance Maps.
Coalmeasures.
Carboniferous Limestone.
Lower Limestone Shale and Carboniferous Slate with Coomhola Grits.
Old Red Sandstone.
Lower or Cambro-Silurian.
Scale = 8 Stat: Miles to 1 Inch.
Knockmealdown Mountains
Nagle Mountains
Kanturk
Buttevant
Castletownroche
Mallow
R. Blackwater
Kilworth
Fermoy
Cappoquin
Lismore
Dromana Forest
Whitechurch
Dungarvan
Helvick Hd.
Mine Head
Ardmore Bay
Tallow
R. Bride
Carnglass
Watergrass-hill
Youghal
Youghal Bay
Capel Id.
Knockadown Head
Mt. Hilary
Macroom
R. Lee
Dripsey
Blarney
Cork
Glanmire
Middleton
Castlemartyr
Lough Mahon
Great Island
Queenstown
Cork Harbr.
Cloyne
Ballycottin Bay
Ballycottin Islands
Crookstown
R. Bride
R. Brinny
Carrigaline
Ringabella
Power Head
Flat Head
Inishannon
Bandon
R. Bandon
Ballyneen
Kinsale

ten miles above the point where it falls into the Lee. The united waters then run due east down to the city of Cork, where they begin to be affected by the tide, that would naturally flow further up, but is prevented by mill-dams. Just below Cork the river crosses from the north to the south side of the limestone valley, through a low limestone ridge in its centre, and then forms a wide expansion of brackish water which goes by the name of Lough Mahon.

The limestone valley of Cork is bounded on the north and south by ridges of Old Red Sandstone running from W. to E., and terminating in the latter direction on the coast on each side of Youghal Bay. The distance from Crookstown to Youghal is more than 40 miles, and the strike of the rocks is due east and west throughout that distance. The form of the limestone valley, and of the Old Red Sandstone ridges, which follow the strike of the rocks, is exactly similar the whole way, but all gradually lowering towards the east. Near Crookstown the highest points of the limestone are sometimes over 200 feet, while the Old Red ridges rise to 600 or 700 feet. Near Cork the limestone reaches occasionally to 150 feet, while the Old Red attains to 400 and 500. Near Castle Martyr the limestone has only one eminence of so much as 118 feet, and the heights of the Old Red Sandstone ridges do not exceed 300 and 400 feet.

The height of the southern ridge is generally inferior to that of the northern one; and a few miles to the S.E. of Cork this southern ridge is cut across by two ravines with precipitous sides, like those described on the Blackwater, but not so high or extensive. These two ravines are known as Passage West and Passage East; and the part of the Old Red Sandstone ridge between them is called the Great Island,—Cove or Queenstown standing on its southern slope. To the south of that ridge we again find ourselves in a longitudinal limestone valley running E. and W. across Cork Harbour, from Carrigaline by Cloyne, into Ballycottin Bay. This, however, is more broken and irregular than those to the northward, in consequence partly of the coming-in of the Carboniferous Slate, and partly of the more rapid folding of the rocks. It is, however, bounded on the S. by another anticlinal ridge of Old Red Sandstone, which strikes due east from the interior of the country, and terminates at the Ballycottin Islands. (See Map, Pl. XIX.)

This ridge is also cut across in the middle by a north and south ravine with precipitous sides, forming the entrance to Cork Harbour; and it is through this that the sea gains access to that harbour, and from that through the two Passages into Lough Mahon.

As in previous cases, if we were to fill up the ravines of the two Passages, the Lee must inevitably flow down the limestone valley past Middleton and Castle Martyr into Youghal Bay. Similarly, if the ravine that forms the mouth of Cork Harbour were to be closed, whatever water ran into the basin must then proceed down the valley to Ballycottin Bay; and neither of the three ravines that thus cut at right angles into the limestone valleys could have been formed by any rivers running down these valleys while they had anything at all approaching to their present low level.

5. *The River Bandon**.—The Old Red Sandstone ridge which forms the southern boundary of the Cork Valley extends right across Ireland, from Knockadoon Head, inside Capel Island, to Sheep's Head, between Bantry and Dunmanus Bays. It has a valley all the way along its southern side, part of which we have already described as the Carrigaline and Cork Harbour Valley. To the west of Carrigaline, it is drained by a brook called the Owenboy River, running into Cork Harbour, but between Bandon and Dunmanway by the River Bandon. There is a watershed in the valley, about Upton, between the Bandon basin and that of the Owenboy, the "lowest connecting gap" of which is about 140 feet above the sea, the highest point in the valley hereabouts being one of 180 feet.

The River Bandon issues from the neighbourhood of Shehy Mountain into the valley near Dunmanway at a level of 190 feet, and runs along it a little north of east for 20 miles. It has a level of 54 feet above the sea at the town of Bandon, but then cuts deeply into the ridges on the south, and becomes tidal at Inishannon. From this point the river winds in a deep and often precipitous ravine, with banks rising to heights of 200 feet and more, across a succession of ridges that reach to heights of more than 400 feet, until it works its way out by a circuitous and surreptitious course into the south-west corner of Kinsale Harbour. Here again we see that, if the ravine at Inishannon were closed up to the level of the hills on each side of it, which are there from 280 to 300 feet above the sea, the lake that would then be formed would not be drained along the course of the present river-valley; for, long before the water could flow over the dam in that direction, it must run over the watershed at Upton, which is only about 140 feet high, and the River Bandon would then follow the course of the Owenboy out to Carrigaline and Cork Harbour.

The case of the Bandon River is, however, by no means so striking as those previously described; and to the west of Dunmanway the longitudinal valley becomes very irregular and sometimes ill-defined, being broken up by subordinate ridges and transverse valleys, especially that of the River Ilen, until we approach Dunmanus Bay, where it again assumes its normal form of a straight longitudinal E. and W. valley. These irregularities are probably attributable to its having the Carboniferous Slate instead of the more homogeneous Limestone for its subjacent rock.

Part III. Formation of the Transverse Ravines.

In seeking for the explanation of the mode of formation of the valleys of the three rivers now described, it appears that the first question to be answered is, How were these transverse ravines formed which thus tap the valleys of the rivers far above their natural mouths by bringing tidal canals into them, at right angles to their

* "The pleasant Bandon, crown'd with many a wood,
The spreading Lee, that, like an island fayre,
Encloseth Corke with his divided flood."
SPENCER, *Faëry Queene.*

course, and across ridges of hills that elsewhere rise unbroken far above the level of the valleys? This question I now proceed to endeavour to answer.

A. *The Ravines not caused by Disturbance.*—These ravines are not fractures caused by internal disturbance. Transverse fractures do occur in some places in the neighbourhood of some of the ravines, forming N. and S. faults, and they may possibly have had some indirect influence in determining the position of the ravines in their neighbourhood. Faults, however, never produce open gaping fissures two or three hundred yards in width, and could only operate towards the production of such ravines by inducing the erosive agencies to act along their line rather than elsewhere.

The ravines were not caused by fissures that opened at the surface without producing any dislocation; for such fissures must end gradually below and extend to an indefinite depth. There is no appearance of fracture in the rocks, which strike directly across the ravines from side to side, and appear to be quite unbroken in the bed of the river. The ravines are evidently mere squarish gaps, worn down or eroded across the edges of the highly inclined beds to a certain depth, and there terminating abruptly, their depth being in reality slight compared to their width from side to side and their length from end to end.

The ravines, moreover, are often tortuous, precisely like the bed of a river worn by its own action into the rock below.

There is also no appearance of any crack or fissure in the low lands between one ravine and another along the course of the same river; but if we look to a deep-seated fracture as the origin of these ravines, that fracture should be apparent all along; for the undulations of the surface must be so slight, compared with the depth of its origin, that we may feel sure they could not make any difference in the different parts of its course.

B. *Relations between the actions of Denudation and Disturbance in the production of the Form of the Surface of the Ground.*—I think we are entitled to assume the truth of the following propositions as regards the mutual action of disturbance and denudation, with respect both to this district in particular and the surface of all other lands.

1. Denudation is of two kinds, marine and atmospheric.

2. Marine denudation is effective only about the sea-level and along the margin of the land. It acts with a broad horizontal movement, tending to plane down the land to its own level. If the land be long stationary, it produces long vertical cliffs about its margin; if the land rise slowly and equably, it forms gentle slopes upon it.

3. Marine denudation cannot produce ravines or narrow winding valleys, except as gaps or passes upon the crests of ranges of hills when the neighbouring summits were islands and the present gaps or passes were "sounds" or "straits" between them, traversed by strong tides and currents, and a narrow arm of the sea was thus made to assume a river-like action.

4. Atmospheric denudation acts vertically, either by the weathering and disintegration of rock over the whole surface of land, or by

the vertical cutting and grooving of ice in glaciers, and of running water in rills, brooks, and rivers.

All glens, ravines, and narrow winding valleys, then, except passes on the crests of hill-ranges, have been formed either by the grooving action of glaciers, where they have existed, or by the erosive action of rivers, whether great or small.

5. The present surface of the ground*, where it differs from the original surface of deposition of the immediately subjacent rock, is in all cases the direct result of denudation, either atmospheric or marine, the internal forces of disturbance having only an indirect effect upon it, and having ceased to act long before the present surface was formed.

It is perhaps necessary to support the latter proposition by a few considerations referring to our present district. In the South of Ireland the internal forces of disturbance have thrown the rocks into long parallel folds, to which the external features of the present surface show a certain degree of conformity. There never is an absolute conformity, however, between them, inasmuch as the present surface of the ground never exactly coincides with the surface of a bed of rock, except perhaps for a few feet on a steep bank, but is always formed across the edges of the beds.

The limestone of the valleys lies in a hollow of the Old Red Sandstone; but the horizontal surfaces of the valley-grounds have often highly inclined beds of limestone below them. The Old Red Sandstone of the hills rises into long ridges; but the ground never rises so steeply as the beds do, since in ascending the steepest hills we walk across the edges of successive beds, and generally find the lowest beds at the surface near the summits of the hills.

The rocks were certainly not first denuded, so that their present surface-terminations should be exposed while they were still horizontal, and then rolled into their present inclined position. Let us look at section fig. 5, Pl. XX., the lowest and darkest-coloured part of which represents the form and structure of the ground from Youghal Bay to the Knockmealdown Mountains, and suppose the rocks to be all extended into a horizontal position. In such a case the limestone would form long tabular hills and ridges, and the Old Red Sandstone longitudinal valleys. But, as the present hill-tops are formed of the ends of beds that lie 2000 or 3000 feet deep in the Old Red Sandstone, they must, if horizontal, be great irregular hollows or rock-basins of that depth, excavated by some inexplicable process out of the Old Red Sandstone; and the subsequent movements of disturbance must have inverted the surface of these basins by some process still more inconceivable, so that the bottoms of the basins became the summits of the hills.

The hypothesis of the surface being first denuded and then disturbed thus lands us in utter absurdity and confusion, and is therefore quite inadmissible. The simple and natural hypothesis is evidently that which supposes that, some time after the formation of the

* Volcanic districts and those now subject to earthquakes are here excepted, as to include them would require some slight change in the phraseology.

highest beds of the coal-measures, the rocks of the district became affected by movements acting from below, which gradually bent them into great longitudinal synclinal and anticlinal folds, and that the denuding agencies subsequently acted on these folded rocks, and eventually produced the present surface of the ground. It is possible that, as one result of the disturbing action, some of the upper beds were immediately raised into dry land, and began to suffer from both marine and atmospheric denudation. The two actions of denudation and disturbance may therefore have been in simultaneous operation throughout an unknown period of time. It is, however, clear that the disturbing forces eventually ceased to operate, and the folding of the rocks became as complete as we now find it. The denuding agencies, however, are still in operation, and have never ceased to operate upon every portion of the country as long as it has been at or above the level of the sea.

The denudation will of course act upon the rocks unequally, in accordance with the inequalities in their chemical composition or physical structure, and will of course produce a form of ground in accordance with these inequalities. The surface of the country, then, while it originates from denudation alone, will yet be modified by the previous action of disturbance which has placed differently constituted rocks in different positions and at different levels, where the denudation found them when it succeeded in wearing down to them. In this district, then, at all events, the internal disturbing forces have had only an indirect effect, while the external denuding action has been the direct agent in the production of the form of ground.

There is, however, nothing exceptional in the circumstances of this district, and the very same arguments might be applied, *mutatis mutandis*, to all other countries.

C. *Proposed Explanation of the Formation of the Transverse Ravines.*—It would appear from the foregoing considerations, that the only possible way in which the transverse ravines on the present courses of the Rivers Bandon, Lee, and Blackwater could have been formed is by the erosive action of running water over dry land,—in other words, by river-action.

But we have already seen that no rivers could now commence to erode these ravines, supposing them not to exist and the adjacent ground to retain anything approaching to its present form and relative levels. We are, therefore, driven to the conclusion that the commencement of the erosion of these ravines took place upon a surface that had a different form and level from those which the present surface has.

I had been for many years at fault for an explanation of the origin of these ravines, when, during the last winter, I was led to perceive a connexion between them and some of the lateral brooks which come towards them from the higher slopes on the north; and I will now describe this connexion for each of the three rivers.

a. *River Bandon.*—A little below the point where the River Bandon commences to turn from its wider E. and W. valley and to cut by a ravine into the ridges on the south side of that valley, it is joined by a large brook, called the Brinny, which cómes into it from the northward. This brook springs from the summit of the Old Red Sandstone ridge which strikes across Ireland from Sheep's Head to Knochadoon Head (see Map). It cuts deeply into the south side of that ridge, and, soon after it issues from it on to the valley, it receives some large brooks from the west, and then runs through another ridge, by a deep glen, to its junction with the Bandon River. The river-valley below this junction is in fact merely a continuation of the valley of the Brinny, with the same features which it has above the junction; and the Brinny receives the Bandon from the west out of the main longitudinal valley as a tributary, nearly in the same way that other brooks come into it as tributaries from the west, out of the smaller longitudinal valleys, while none but the most insignificant streams fall into it from the east. (See Explanation of Sheets 194, 200, and 201 of the Geological Survey of Ireland.)

We are therefore led to look upon the valley of the Brinny as the primary valley, that was first formed, or at least first commenced, by the running of a stream from the dominant ridge on the north, southwards towards the sea, and that that valley intercepted all the drainage of the country that ultimately ran towards it from the west.

It will be recollected that it was stated at p. 382, that the anticlinal and synclinal folds of the rocks strike E. and W., but that their axes generally rise towards the W., so that the bottoms of the limestone troughs were pinched out, and the lower rocks (the Old Red Sandstone) formed the higher ground in that direction. While, then, the beds dip almost invariably either N. or S. at high angles, the whole mass of the contorted rocks has had, as it were, a gentle tilt downwards towards the east, or upwards to the west, sufficient apparently to turn the drainage of the surface generally in that direction as soon as any longitudinal valleys began to be formed on the surface. It is for this reason that all the larger lateral or N. and S. valleys receive their principal tributaries from the west, while that of the country to the east of them is carried still further eastwards.

The Brinny Brook, then, first commencing to run over a surface considerably above any part of the present surface, formed a lateral N. and S. channel before any of the longitudinal E. and W. valleys and ridges became prominent, and thus marked out the winding southerly course it has ever since followed. As the longitudinal valleys were gradually formed by atmospheric denudation, the running waters of this brook always cut down across the intervening ridges faster than the general denuding agency lowered the longitudinal valleys; so that it was continually receiving more and more of the western drainage, and turning the water down its own transverse ravine.

None of the other lateral brooks springing from this Old Red Sandstone ridge for a considerable distance to the westward had equal power with the Brinny, until we reach the River Ilen, which, in like manner, cut through the ridges to the south, and formed a basin of drainage of its own distinct from that of the Brinny and the Bandon.

It is obvious that this proposed explanation involves the supposition that, after the production of the land-surface over which the Brinny first commenced to run, all the subsequent denudation of the country and the excavation of all the valleys have been the result of atmospheric agencies alone.

b. *River Lee.*—About 3 miles to the east of Cork there issues from the Old Red Sandstone ridge that lies to the north of that valley a large brook, formed by the junction of several minor streams on the higher parts of the ridge. (See Map, Pl. XIX.) It cuts deeply down into the Old Red Sandstone, forming picturesque glens, the lowest and deepest of which is called Glanmire.

Nearly opposite the mouth of the Glanmire Valley, but a little to the E. of it, is the cut across the limestone ridge which separates Blackrock from the Little Island, and leads into Lough Mahon. Turning still further to the S.E. down the central channel of Lough Mahon, which alone has deep water in it at low tide, we are led to the ravine, called Passage West, that cuts across the Old Red Sandstone ridge to the S. of the Cork Valley; and, passing through that, and turning again to the east, we are brought into Cork Harbour.

About 8 miles to the east of the Glanmire Valley, we arrive at another precisely similar deep glen issuing out of the Old Red Sandstone ridge at Ballyedmond, and bringing the Owenacurra and other brooks from the high land on the north on to the limestone valley about Middleton. This brook crosses the limestone valley at Middleton, and runs into the eastern end of Lough Mahon; and turning a little to the west, we are led by its channel to the ravine of Passage East, through which we also arrive at the basin of Cork Harbour.

The deep-water channels from the West and East Passages unite in Cork Harbour, to the east of Queenstown, and lead out thence due S. to the ravine which forms the entrance to the harbour and conducts us into the open sea.

When once pointed out, the relation between these lateral brooks flowing from the dominant ridge on the north, and the north and south cuts through the lesser ridges on the south, becomes so obvious that I think the belief must be at once impressed on the mind that the latter are only the continuation of the former.

As in the case of the Brinny, I believe that on some former surface considerably above the present one, a river, made up, like all other rivers, of a union of lesser streams, ran down the slope from N. to S. over Glanmire, and that, as it wore down its channel, it intercepted the western drainage of the Lee which was poured into it down the ever-enlarging longitudinal valley. The united waters were always turned down the transverse ravines, because, at whatever rate the ground in the longitudinal valleys sank, the erosion of these rivers was able to keep the bottom of the ravines sufficiently below it; while other brooks, being unable to effect this, were ultimately drawn down into the longitudinal valleys, and their water carried out to the ravines. As before, this must have been an atmospheric action upon dry land. That the land happens now to stand at such a level that the sea flows into the part occupied by Cork Harbour, no geologist will consider as more than a temporary and accidental occurrence which may produce, or may have produced, its own modifying effects, according to its power and duration.

c. *River Blackwater.*—If we look northward from the ravine of Dromana towards Cappoquin, where the Blackwater turns at right angles towards the south, we find two very large brooks issuing into the valley from the far loftier Old Red Sandstone ridge on the north, which is in fact one of the flanks of the Knockmealdown Mountains. One of these brooks is that which comes out opposite Lismore, $3\frac{1}{2}$ miles to the north-westward of Dromana; and the other is the Glenshelane River, which comes out about three miles north by east of Dromana. These brooks may have very readily united their waters somewhere about the northern end of the Dromana ravine.

There is also a third lateral valley which descends the Old Red Sandstone ridge still further to the eastward, and now brings the River Finisk to the Dromana ravine; but I believe that this formerly crossed the Dromana ridge further to the east, where there is a depression in the ridge opposite its glen. It was gradually deflected into the Blackwater, in consequence of its not being able to wear down its channel over the ridge fast enough to keep it below the bottom of the gradually sinking limestone valley.

The ravines of Dromana and Carnglass, and the others between Cappoquin and Youghal, I believe to be the remnants of the channel of a river that ran southwards over the old loftier surface of the ground from the dominant ridge of the Knockmealdowns on the north. As in the previously cited instances, I suppose this river to have deeply trenched all the rocks in its course; and, as the whole country suffered from atmospheric degradation, and became lowered in consequence, it still kept eating deeper into the land, so that its channel was always below the level even of the limestone valleys, and always kept open the passage across the ridges on the south, so as to turn all the drainage it received into that passage.

The section in fig. 5, Pl. XX., will serve to illustrate the explanation I propose with regard to the Blackwater. In this the lower, darkly coloured part represents the present ground, with the rocks lying in their present position beneath the surface,—the heights, for the sake of distinctness, being drawn to a scale of four times the lengths. The fainter tints above suggest the former extension of the rocks removed by denudation. Of these I suppose the uppermost, lightest-coloured parts to have been probably removed by marine denudation, which produced a surface approximately represented by the line A A A. The part below that, which is coloured with tints of intermediate strength, will give us the approximate form of the ground over which I suppose the lateral brooks to have run down to the sea, before the commencement of the formation of the longitudinal valleys. I believe that the line A A A marks out the limit of the marine denudation, and that all the intermediate part between that line and the present surface of the ground has been removed by atmospheric degradation alone. So long as the district remained dry land, the features first impressed upon it by the atmospheric influences would be deepened and intensified by their vertical action, which may be likened to the artificial processes of carving or graving deeper and deeper lines or features once traced out. Had the denudation been that of the sea, it would have tended to cut down and plane off all these features to one uniform level, so far as its influence extended; the termination of that influence being marked by abrupt vertical cliffs, like those which now form so much of the present coast-line.

The rain and the weather have disintegrated and lowered to some extent even the highest of the ridges left by the original marine denudation, and have impressed upon them the character of their own action, instead of that of the sea; but they have had still greater effect on the slopes, and the greatest of all on the channels of the streams that first commenced to drain the land. This influence has always been proportionate to the power exercised, and the nature of the material on which it worked. When exercised on the quartzose ridges of the Old Red Sandstone, its greatest effect was confined within narrow limits, where the water ran rapidly, and thus produced glens or ravines. When the influence acted on the softer and more easily disintegrated argillaceous beds of the Carboniferous Slate, and still more when brought to bear on the soluble beds of the Carboniferous Limestone, it produced broader effects, and formed the larger longitudinal valleys.

The fact that the limestone ground is now everywhere so much lower than the ground formed of other rocks is evidently due to the solubility of that rock. The siliceous rocks have suffered chiefly from mechanical disintegration and attrition alone; the calcareous rocks, equally exposed to that action, have also been destroyed by the chemical action of the carbonic acid of the atmosphere, and much of their mass has been carried away in solution.

The limestone of the plains and valleys has, in fact, sunk in its bed past the other rocks, like the ice of a glacier under a summer sun. This image was brought to my mind (quite independently of this explanation) when one day, during the summer of 1861, I was traversing the limestone hills of Burren, in county Clare, with my colleague, Mr. F. J. Foot. The bare floors of limestone in that district consist often of loose blocks, each block being deeply furrowed at its edge by channels formed by the rain-water running over its surface. Many of them look as if they had been artificially carved all round into deep indented mouldings, in order to produce an ornamental pattern. In other places, the whole of the blocks that once formed a bed two or three feet in thickness have been so wasted away that a layer of mere cakes, an inch or two thick, is all that is now left to represent them. All the joints that divide the rocks into blocks, instead of being mere planes of division, with their walls still closely touching, are near the surface made into open fissures, several inches, even a foot or more, in width, and frequently 5 or 6 feet in depth.

Not only there, but in all the limestone country, the same facts may be observed, wherever the rocks are sufficiently well exposed. On first baring the rock for a limestone-quarry, its surface may often be seen to be furrowed by the rain into gullies and channels a foot or more in depth, full of fine soil. All large limestone districts, both in Ireland and elsewhere, are, as everybody knows, always full of caverns, and all the lesser rivers continually sink at one spot and reappear at another after subterranean courses through such caverns, of sometimes several miles in length. In the country between Ennis and Galway, it is often difficult to decide upon the connexion which the detached streams of running water, that just show themselves here and there in partial valleys at the surface, may have one with another.

Still, making every allowance for the efficiency of the action of the weather to lower the surface of a limestone country, and extending it in a lesser ratio to ground where its mechanical action operates alone, I am fully aware that it will have rather a startling effect on some persons' minds, to be called on to believe that mere rain and other atmospheric influences can have washed away a thickness of some hundreds of feet of rock from off the surface of a whole country. It is evident that, if the explanation, for the formation of the ravines of the Blackwater, Lee, and Bandon be a true one, it must be extended over the South of Ireland generally, and applied to those of the Shannon, the Barrow, and the other rivers. Neither will it stop there; for if true for this country, it will be true for all other lands.

I can only say that the truth of the explanation has so forced itself on my own mind that it will, I think, remain a conviction until I hear from some one a better explanation of the facts than that which I have here laid in outline before you.

The time required for such an action to have accumulated such an amount of effect is, of course, vast beyond all human effort at conception. The South of Ireland, however, seems to have been exposed as dry land to the atmospheric influences ever since the close of the Palæozoic Epoch, with the single exception of the depression which it suffered beneath the sea during the Pleistocene or Glacial Period.

However long the duration of that Glacial Period may have been, it is clear that it was comparatively short, and the effect of marine denudation during that time comparatively trifling in modifying the form of ground previously elaborated.

The time that has elapsed since the Glacial Period seems also to have been comparatively short, inasmuch as we have still upon the surface of many of the rocks the marks of ice-action not yet obliterated by the weather. Whether, however, we are to take as the units of comparison between these times and those which preceded them thousands, hundreds of thousands, or millions of years, or any other conceivable quantity, I do not now pretend to discuss.

D. *Application of this Explanation to the Ravines of the Shannon and the Barrow, Nore, and Suir.*—I will now assume the approximate truth of the following history:—After the subaqueous formation of the great sheets of the Upper Palæozoic rocks over the whole of Ireland, the subterranean forces began to act upon them, bending them into the curves in which we now find them.

Soon after the commencement of this action of disturbance, the Coal-measure beds that were over those points or lines which were most bent upwards rose in consequence above the sea, and suffered denudation by its waves. This action went on until the whole country, and probably a much wider district than Ireland or even than the British Islands, was raised into dry land, and its upper portions partially destroyed during the process.

All this took place, and probably a considerable amount of atmospheric denudation also, before that subsequent partial depression of the British area which brought it down again beneath the sea, in which the Permian and New Red Sandstone beds were deposited.

No part of Ireland, except the north-east quarter, suffered from this depression, sufficiently, at all events, to be brought beneath the sea, either in the Triassic or any other period except the Glacial or Pleistocene.

The surface left by the original marine denudation was considerably above the present one, and the upper part of the limestone especially was far more extensive then than it is now. The Coal-measures, which now form high lands, were then valleys in the hollows of higher limestone ground, the beds of which, of course, always dip towards the Coal-measures; and the general level of this limestone country was above the level of the old depressions in the Silurian rocks over Killaloe, over Graiguenemanagh and St. Mullins, over Inistioge, and over Waterford.

The Shannon, the Barrow, the Nore, and the Suir, when the original rivers first began to run over this high surface, sought of course the lowest levels that then existed for their courses, and those lowest levels were nearly above the lines of their present channels. The Nore ran across the Coal-measure valley, which was then in the ground over Abbeyleix and Kilkenny. The ridge over the Knockmealdowns was high enough to deflect the Suir; and the gaps at either end of the Galty group did not then exist, but were occupied by high limestone ground. High limestone ground also separated the basins of the Liffey, the Barrow, the Boyne, and the Shannon; and the high limestone ground of the Burren of Clare was then continuous over the adjacent parts of Galway, rising still higher over the Slieve Aughta and over the Granite on the north side of Galway Bay.

The rivers trenched this higher surface nearly above their present courses, running then with a more rapid and powerful stream than they do now; and as the whole country slowly wasted and sank under the wearing influence of the weather, their streams were strong enough always to cut their channels downwards, through whatever rocks became exposed, faster than the general degrading influences could lower the general surface of the country, although those general influences lowered the limestone country to a greater extent than they were able to lower the country composed of other rocks which the river-channels traversed.

It is remarkable that the limestone-shale ground immediately at the foot of the Old Red Sandstone and Lower Silurian ridges is often lower than the limestone ground beyond. I attribute this to the action of the rain running down the slopes of the hills, and dissolving the limestone immediately at the foot, at a greater rate than where that limestone was merely acted upon by the rain falling directly from the heavens.

Thus have been produced the present low limestone plains of the centre of Ireland and the longitudinal limestone valleys of the south; and simultaneously with their production the ravines have been cut through the ridges of other rocks by which the drainage of these plains and valleys has always escaped to the sea.

Postscript.—The ravine of the Avon at Bristol, those of the Wye, and others in South Wales, as also numerons deep erosions in the Palæozoic rocks of the north of England, many of which were complete before the Triassic Period, as shown by the horizontal beds of New Red Sandstone that lie in them, naturally occur to the mind in connexion with this subject.

Atmospheric denudation, however, has produced marked effects, not solely upon Palæozoic rocks, but, as I believe, upon all formations, in proportion to their age, their composition, and their duration as dry land.

My acquaintance with the Weald of Kent is too superficial to allow me to express an opinion; but perhaps I may venture to ask the question whether the Chalk, when once bared by marine denudation, which perhaps removed it entirely from the centre of the district, has not been largely dissolved by atmospheric action, and whether the lateral river-valleys that now escape through ravines traversing the ruined walls of Chalk that surround the Weald may not be the expression of the former river-valleys that began to run down the slopes of the Chalk from the then dominant ridge that first appeared as dry land during or after the Eocene Period? If this question be answered in the affirmative, as I suspect it may, I think it reasonable to suppose that the mode of action in the production of river-valleys, which I have here endeavoured to establish, will ultimately be found applicable to all river-valleys in all parts of the world. Atmospheric denudation or degradation will then have to be taken into account as one of the most important geological agencies in the production of the "form of ground" on all the dry lands of the globe.

I may also be allowed to ask whether it will not turn out to be a general law in all mountain-ranges in the world, that the lateral valleys are the first formed, running directly from the crests of the ranges down the steep slopes of the mountains, while the longitudinal valleys are of subsequent origin, gradually produced by atmospheric action on the softer and more easily eroded beds that strike along the chains.

I may venture perhaps to instance the Upper Rhone as an illustration. From the central mountain-mass traversed by the Furca Pass, the Rhone runs in a nearly straight line E.S.E. for about 67 miles, to Martigny, in a deep valley between the mountains of the Oberland and those of the main Alpine watershed, of which Mont Blanc and Monte Rosa are the most conspicuous eminences. At

Martigny the Rhone Valley suddenly turns at right angles to its former course, and runs N.N.E. for 38 miles into the Lake of Geneva.

Above Martigny the valley runs along the strike of the rocks, and seems to have been chiefly excavated in some comparatively soft black slates lying between the hard crystalline rocks of the Oberland on the north and those of the Main Chain on the south. But these comparatively soft slates appear to continue in the same straight line to the E.S.E. from Martigny through the hills crossed by the Col de Balme, and down the Valley of Chamouny, and into the hills at the further end of that valley. Why, then, was not the valley of the Rhone continued along this straight line into the Valley of Chamouny, instead of turning at right angles at Martigny, and running for nearly 40 miles across the strike of all the hard rocks on the north of it? Because, as I believe, a lateral valley formed by the Dranse and Durance and their tributaries, running directly from the main watershed down the original northern slope of the chain, was commenced before the excavation of the longitudinal valley of the Upper Rhone was begun; and the waters of those rapid rivers had always sufficient power to cut that lateral valley deep enough to deflect the waters that ultimately came into it from the west and carry them them along it.

Suppose all the valleys and hollows of the Alps to be filled up, so that the present peaks shall be merely the summits of gently swelling hills rising but little above the slightly undulating, smooth, general surface of the mountain-chain. This smooth swelling surface will be the limit of marine denudation. The first rains that fall upon it will run directly off from the main watershed to the right and left down the easiest and steepest slopes they can find, and commence to form a number of lateral brooks along the bottoms of these slopes, those rivulets running across the strike of the rocks. As these lateral rivers deepen their channels, the waters running into them on either side will also deepen and enlarge theirs; and thus will be commenced a number of valleys running along the strike of the rocks parallel to the length of the chain, and therefore called longitudinal valleys. When one of these coincides with a band of soft rock, or rock more easily eroded by water than those on each side of it, it may readily happen that the longitudinal valley may ultimately become much larger than the lateral one by which its contents are carried off. It cannot, however, become deeper, because it is the drain originally caused by the excavation of the lateral valley which is the only motive power for excavating the longitudinal one. When once a lateral valley has succeeded in cutting a sufficiently deep channel, the waters of the longitudinal valleys that are afterwards poured into it cannot cross it, or overmount the walls opposite to their own mouths, because they are inevitably deflected down the lateral valley, and help to excavate it deeper and deeper below their junction with it. Hence the longitudinal valley and the part of the lateral one below their junction may be equally wide and deep, and appear to be the result of one action, whilst the lateral valley above the junction may be a narrow and broken ravine with a much smaller and apparently insignificant brook, although in reality the prime mover, the "*fons et origo*" of the whole excavation.

This longitudinal soft band, moreover, as it is worn down by the weather * more rapidly than the rocks on each side of it, may, as soon as an outlet is established for the carrying off its disintegrated particles, be readily conceived to extend across some of the minor lateral brooks, and thus deflect their waters towards the principal one.

This is the explanation, as I believe, of the relations between the Rhone and the Durance and Dranse at Martigny, and of those of the Upper Rhine and the rivers that come into it at Chur, where the Rhine turns at right angles towards the Lake of Constance, and of all the other valleys and rivers of the Alps, and of all other mountain-chains, as the inspection of any good map of any one of them will be sufficient to prove.

It is not necessary to suppose that the whole mountain-chain was dry land before the process commenced: it may have gone on, with infinite slowness, as the mountains gradually rose above the sea; it may have been interrupted by the depression of the mountains, and renewed on their re-elevation. It is, however, essentially a subaërial action, and one that only commenced after the termination of the marine denudation which gave to the mountains their general form and outline as that form would be if all their valleys and hollows were filled up and their summits connected by gently sloping plains.

The principal part of that marine denudation must have been effected long before the commencement of the formation of the river-valleys; but it would be a very difficult task to undertake to explain the mode of action of the marine denudation, and the precise relations either in time or effect between the marine and the atmospheric denudation.

I can only hope to have established this general conclusion, that, while the removal of the vast masses of rock under which our present mountain-chains were formerly buried may be most reasonably referred to the action of the sea ("*μέγα σθένος Ὠχεανοῖο*"), we must look chiefly to the "weather" as the producer of the glens, ravines, and valleys by which our mountains and plains are traversed.

Note.—In the section fig. 5. Pl. XX., the line AAA is bent; but in the original section drawn on the true scale it forms one straight line from the summit of the Knockmealdowns to the sea, just touching the top of all the intervening hills, and giving the idea of a sloping plain, below which the valleys have been excavated. Professor Ramsay, at the Meeting of the British Association at Oxford in 1847, exhibited a precisely similar section across a part of Cardiganshire, and read a paper on it, attributing the origin of the valleys to excavation below an old plain, although he looked to the sea as the excavator, while I now believe it to have been the atmospheric waters. (See Report of the British Association, vol. xvi. Sect. p. 66).

* Under the term "weather" I would include glacial action and every other atmospheric agency. The Rhone valley has obviously been completed by glacier-action.

Fig. 1.

Section across the Valley of the Blackwater River about 2/3rds of a mile west of Cappoquin; drawn on a scale of 1½ ins. to the mile horizontal & 3 ins. to the mile vertical.

Fig. 2.

Section across the valley 4 miles east of Cappoquin, drawn on the same scales as Fig 1: but along a winding line in order to follow the highest ground or watershed between the brooks running out to Dungarvan & those running westerly towards Dromana.

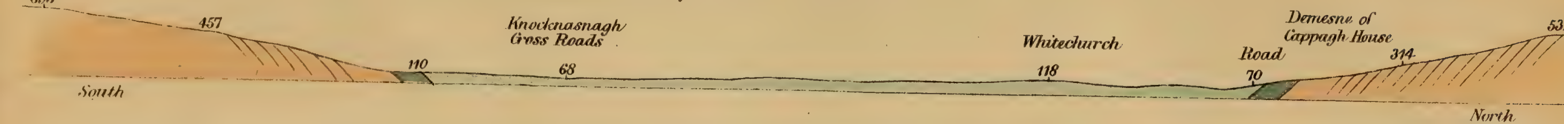
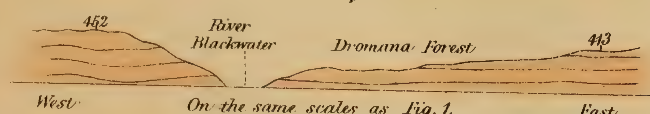


Fig. 3.

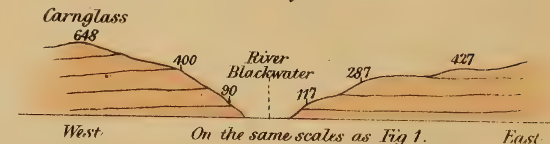
Section across the ravine at Dromana, 3 miles south of Cappoquin.



On the same scales as Fig. 1.

Fig. 4.

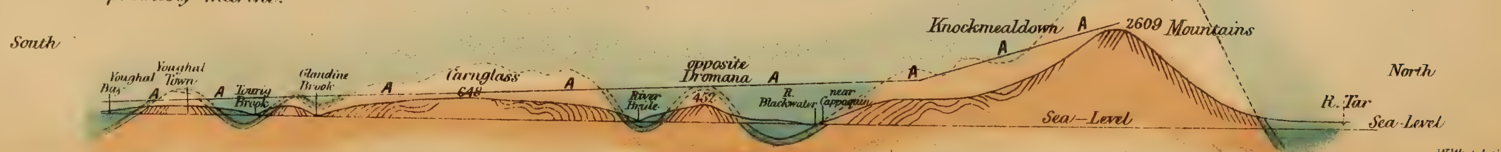
Section across the ravine at Carnglass, 7 miles south of Cappoquin.



On the same scales as Fig 1.

Fig. 5.

Section from Youghal Bay along the west bank of the Blackwater River below Cappoquin and thence over the Knockmealdown Mountains, drawn on a scale of ¼th of an inch to a mile horizontal & 1 inch to a mile vertical; the heights consequently being four times too great for the lengths. The lower darkest coloured part represents the present ground, the part coloured of an intermediate tint between that and the line A, A, A, represents the minimum amount of ground supposed to have been removed by atmospheric denudation, the lighter part above that, having previously been removed by a denudation which was probably marine.



W West, Lith.

After this paper had been sent in to the Society, I learned, from the 'Proceedings of the Royal Society,' that Mr. Prestwich attributed the deepening of the valleys of the Somme and Seine and other rivers of France and England, below the level of the high freshwater gravels, to the same subaërial action that I had appealed to for the formation of the valleys of the South of Ireland.—J. B. J., Oct. 2nd, 1862.

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2. Experimental Researches *on the* Granites *of* Ireland. Part III. *On the* Granites *of* Donegal*. By the Rev. Samuel Haughton, M.A., F.R.S., F.G.S., Fellow of Trinity College, and Professor of Geology in the University of Dublin.

Contents.

I. *Geographical Position of the Granite of Donegal.*—The granite axis of Donegal extends for sixty miles from Malin Head to the neighbourhood of Ardara, in a direction 43° south of west (true), well marked by the two great, though not continuous, valleys of Glenveagh and Gweebarra, which occupy a nearly central position in the granite band, nine miles wide, that traverses the County from N.E. to S.W., from Glen to Doocharry Bridge, opposite which latter place the Gweebarra valley ceases to be central, as the granite expands out to a breadth of eighteen miles, of which three miles lie to the south-east, and fifteen miles to the north-west in the direction of Dunglow. At the south-western extremity of the granite axis, it is separated from the granite of Ardara by the intervention of metamorphic slates; and at its north-eastern extremity, it is separated by quartz-rock and the sea from the granite of Dunaff Head and Malin Head, with which it is evidently continuous.

To the south-east of the granite axis, there is an isolated patch of granite, divided into two portions by the Barnesmore, or Great Gap, through which the road from Donegal to Stranorlar and Strabane passes. The bearing of this important pass is 42° 15′ south of west; and the granite-mass which it divides has its greatest diameter in a direction 40° south of east, and its least diameter in a direction coinciding with that of the Barnesmore Gap.

Still further to the S.E., at Beleek and Castlecaldwell, in the Co. Fermanagh, on the borders of the Co. Donegal, the metamorphic slate becomes gneissose, and is traversed by numerous veins of the granite, which evidently lies beneath it.

II. *Physical Structure of the Granite of Donegal.*—The granite of Donegal possesses a stratified structure, in beds which are nearly

* For Parts I. and II., see Quart. Journ. Geol. Soc. Lond. vol. xii. p. 171; and vol. xiv. p. 300.

vertical, and the direction of which coincides, in a general way, with the geographical axis formed by the two great valleys of Gweebarra and Glenveagh just described. In addition to this stratified or cleaved structure, it is traversed by many joints, which run nearly at right angles to the directions of the planes of the cleavage-structure. The following Tables, which are constructed principally from data collected in the Gweebarra district, show the directions both of the cleavage- and the joint-planes.

TABLE I.—*Azimuth of Cleavage- and Joint-planes in the Granite of Donegal.* (*Magnetic bearings.*)

Locality.	Cleavage-planes.	Joint-planes.
1. Between Glenties and Gweebarra River...	10° South of West.	10° West of North.
2. Gweebarra Valley South	30° S. of W. Dip vertical.........	10° W. of N.
3. Gweebarra Valley, Doocharry Bridge	15° S. of W. Dip 80° N.	10° W. of N. Dip 80° E.
4. Sheskina-roan: Veins of Beryl and Quartz	....	10° E. of N.
,, Sheskina-roan...........	....	10° E. of N. Dip 80° E. N.S.
5. Meen Bannad...........	....	15° E. of N.
6. Anagarry Hill...........	E.W. Vertical ...	7° E. of N. Vertical. 10° W. of N. ,,
7. Lough Anure	....	5° W. of N. ,,
8. Between Dunglow and Doocharry Bridge	....	10° W. of N. 45° E. of N. (Secondary.)
9. Between Doocharry Bridge and Fintown..................	10° N. of W. Fine plane	10° W. of N. Vertical.
10. Glenlehen	10° S. of W.	5° W. of N.
11. Fintown Gap: Gneiss	....	15° W. of N.

From the preceding Table, it appears that of the 15 joint-planes observed, 9 lay to the west of north, 1 was due north and south, and 5 lay to the east of north: they may be thus arranged:—

TABLE II.—*Joint-planes in the Granite of Western Donegal.*

West of North (B).	East of North (B).	Secondary (A′).
10°	10°	45° E. of N.
10	10	...
10	15	...
10	7	...
5	0	...
10	...	...
10	...	...
5	...	...
15	...	...
9° 28′ W. of N.	8° 24′ E. of N.	45° E. of N.
Mean =3° 4′ W. of N.		

The joint-planes east of north are confined to the district around Sheskina-roan, Meen Bannad, and Anagarry, which is limited in extent, as compared with the entire district examined.

The following Table shows the arrangement of the observed cleavage-planes, according as they were found to lie south or north of west.

TABLE III.—*Cleavage- or Stratification-planes in the Granite of Donegal.*

South of West (B′).	North of West (B′).	Secondary (C).
10°	10°	30° S of W.
15	...	...
10	...	...
0	...	...
8° 45′ S. of W.	10° N. of W.	30° S. of W.
Mean =5° S. of W.		

Neglecting the secondary planes of structure, which have not been as yet sufficiently observed to found any statement upon, it would appear, that in the granite of Donegal there is one system of Conjugate* planes, having the following direction:—

Cleavage B′.	Joints B.	Angle.
5° 0′ S. of W.	3° 4′ W. of N.	88° 4′ N. to E.

The magnetic variation in the part of Donegal examined was 26° 40′ W. Applying this correction to the preceding results, we find in true bearings—

B′. Cleavage-planes...... 31° 40′ S. of W. or N. of E.
B. Joint-planes .... 29° 44′ W. of N. or E. of S.

In the Co. Waterford I succeeded in establishing the existence of four conjugate systems, the most prominent of which is found in Donegal only as a secondary system—viz. 33° 31′ N. of E. (mag.).

The conjugate system in Waterford, which is second in importance, rests upon 130 observations, and is nearly coincident with the most prominent system of Donegal, viz.—

B′=7° 46′ N. of E. (mag.) =32° 26′ N. of E. (true).
B =6° 57′ W. of N. (mag.)=31° 37′ W. of N. (true).

In making the reduction from magnetical to true bearings, the variation in the south of Waterford is assumed to be 24° 40′ W.

It will be observed that the geographical axis of the Donegal

* For the definition of this term, and an account of the conjugate systems ot cleavage- and joint-planes in the Old Red Sandstone of the Co. Waterford, see the Author's paper published in the Phil. Trans. vol. cxlviii. p. 333, 1858.

granite, indicated by its great central valley, differs by 11° 20′ from the principal system of cleavage-planes developed in this granite, which lie 31° 40′ S. of W., while the geographical axis lies 43° S. of W.

III. *Geological Relations of the Granite of Donegal.*—The granite of Donegal appears to be interstratified with the quartz-rock, mica-slate, and limestone with which it is associated; but it is probably subsequent to them in age, and in its central portions is perhaps of igneous origin, originally deriving its cleavage-planes and gneissose character from the pressure exercised upon it by the stratified rock, which has been lifted, to the north and south, to a nearly vertical position.

On the boundary of its outcrop, both north and south, it is intimately interstratified with the aqueous rocks. For example, at Glenlehen, between Fintown and Doocharry Bridge, near its southern boundary, but still well within the granite-border, I made the following note, in company with Mr. Robert H. Scott and Mr. Athelstane Blake:—

"August 5, 1861.—Glenlehen, summit-level. Observed vertical beds of quartzose mica-slate and of gneiss lying in granite, with which they are interstratified, also beds of sphene-rock, and one bed (3 ft. thick) which seemed to be an altered quartzose limestone, containing garnet and chalcedony. The sphene-rock is composed of quartz and orthoclase, with crystals of sphene, running in veins and scattered. [At Anagarry Hill, where this rock is abundant, it consists of a white paste of felspar (orthoclase), with crystals of hornblende and large crystals of sphene: it is said always to lie *next* to the altered limestone.]"

The joints of the granite bear	N. 5° W.	
Its gneissose structure bears	E. 10° N.,	vertical.
The stratified rocks bear	E. 10° N.,	„

Still nearer to the southern boundary of the granite, a thin bed of limestone has been traced, lying nearly vertically for several miles. At the northern edge of the granite, it passes by equally insensible gradations into stratified rocks.

At Lackagh Bridge and Ballygihen, in company with Mr. James Wood and Captain Montgomery, I made the following notes:—

"August 19, 1856.—North of Lackagh Bridge, observed fine alternations of micaceous quartz-rock (flaggy), hornblende-slate, and gneiss, with pockets of black mica and nests of large felspar- and quartz-crystals. The pink felspathic granite appears at the other side of the river (south), and graduates into a grey variety of felspathic gneiss, with black mica."

"August 22, 1856.—In Dunlewy quarry the crystalline limestone, forming a coarse statuary-marble, associated with thin bands of quartz-rock, is greatly contorted, and rests on contorted hornblendic micaceous slate, penetrated by thin vertical dykes of felspathic granite, containing garnets. From this quarry, by the Poison Glen to Ballygihen, the transition from gneiss to granite is finely exhibited; the granite ultimately retaining planes or joints parallel to the deposition-planes of the gneiss, and having its crystalline facets of black or green mica set in the same direction. The gneiss exhibits good examples of the development of particular minerals, felspar, mica, &c., in nests or pockets. The veins in the granite, up to the summit of the pass, consist of quartz, orthoclase (white), and black mica: beyond the summit, on the slope of the mountains towards Glenveagh, the veins consist of quartz, orthoclase (white), and white mica. At the opposite side of the valley (south of Lough Veagh), the veins are pink orthoclase and quartz; and the granite itself either grey or pink (with nests of black mica developed in the grey granite), passing, towards Kilmacrenan, into gneiss, in the same manner as at Lackagh Bridge on the north."

In many places the metamorphic slates are penetrated by coarse veins of granite, as at Fintown Gap, Lough Mourne near Barnesmore Gap, the Black Gap near Pettigo, and at Castlecaldwell in the Co. Fermanagh; and in some of these localities, the granitic material even seems as if formed in the bosom of the rock, without any connexion with a vein or dyke of granite. Thus at Lough Mourne I made the following note, in company with the Rev. William Steele:—

"September 8, 1856.—In a quarry east of Barnesmore Gap, observed isolated nodules ($1\frac{1}{2}$ ft. in diameter) of white milky quartz, with large crystals of red felspar and micaceous oxide of iron; also veins of the same composition, which cut across the strata of the rock, which is a fine-grained, hard mica-slate, tending to a gneissose character from the development of felspar-crystals: the plates of mica in the rock are small, black, and well defined."

At Castlecaldwell, the granite-veins which penetrate the gneiss are of two totally distinct kinds:—

A. Veins composed of quartz, pink orthoclase, white mica, black mica, and schorl; all the crystals being large.

B. Veins composed of quartz, pink orthoclase, yellowish-green waxy finely striated oligoclase, black mica, sulphuret of molybdenum, and copper-pyrites; crystals moderately large.

At Fintown Gap and at Black Gap, the veins of granite are of the first kind (A).

The stratified rocks resting upon the granite appear to be divisible into four groups, which, in an ascending order, are as follows:—

1. Quartz-rock, associated with limestone containing garnets in dodecahedral crystals, and idocrase, and accompanied by sphene-rock.—Mamore quartz=7600 ft.

2. Slate-rock, formed chiefly of hornblende- or anthophyllite-slate, associated with beds of limestone, potstone, and steatite, with contemporaneous stratified syenite.—Buncrana slate=5400 ft.

3. Flaggy quartz-rock of Culdaff=3000 ft.

4. Micaceous slates and gneiss, with numerous beds of blue and white crystalline impure limestone.—Thickness unknown.

Total probable thickness=16,000 ft. to 20,000 ft.

IV. *Chemical Composition of the Granite of Donegal.*—The following Table contains the analyses I have made of the granitic axis of Donegal from N.E. to S.W.

Table IV.—*Chemical Composition of Donegal Granites.*

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. Unismenagh	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. Anagarry	73·04	15·20	...	...	1·60	0·07	2·88	7·32	...	...	100·11

I. *Ardmalin, near Malin Head.*—Coarse-grained granite, composed of
(*a*). Quartz; very conspicuous ($\frac{1}{4}$ in. crystals).
(*b*). Red orthoclase felspar ($\frac{1}{4}$ in. crystals).
(*c*). Green mica; in small nests, resembling chlorite.

II. *Unismenagh, near Dunaff Head.*—Medium-grained granite, containing—
(*a*). Quartz; not very visible.
(*b*). Pink felspar; probably orthoclase ($\frac{1}{8}$ in. crystals).
(*c*). Grey felspar; probably oligoclase ($\frac{1}{8}$ in. crystals).
(*d*). Black mica; $\frac{1}{16}$ in. crystals; occasionally passing into a dark blackish-green mica, in small nests, and resembling a mixture of chlorite and hornblende.

III. *Glen.*—Coarse-grained gneissose granite, containing—
(*a*). Quartz; scarcely visible, broken, transparent, grey.
(*b*). Red felspar; probably orthoclase, forming large crystals (partly made up of pink translucent felspar, with bright reflexion), dull waxy lustre, opaque.
(*c*). Whitish translucent felspar; probably oligoclase, and quite distinct from (*b*).
(*d*). Green mica; abundant in streaks, alternating, as in gneiss, with crystalline sheets of red and pink felspar.

IV. *Glen.*—Gneissose coarse-grained granite, apparently in beds in the granite No. III., and containing—
(*a*). Whitish felspar; anorthic, semiopaque, and sometimes in macles, probably oligoclase (crystals $\frac{1}{2}$ in. by $\frac{1}{4}$ in.).
(*b*). Jet-black mica; in great abundance, probably equal to the felspar, which occurs in rounded masses imbedded in the black mica, which itself occurs in streaks as in gneiss.

V. *Glenveagh.*—Beautiful, coarse-grained, porphyritic granite:—
(*a*). Felspar; conspicuous, pink (crystals $\frac{1}{2}$ in. to $\frac{3}{4}$ in.), orthoclase.
(*b*). Quartz; inconspicuous, grey, transparent, with rounded angles.
(*c*). Mica; jet-black, abundant in minute grains; the black mica and pink felspar give character to the rock.

VI. *Glenveagh.*—Fine-grained gneissose granite:—
- (*a*). Quartz; scarcely visible, grey.
- (*b*). Felspar; white, sugary, facets rare, and when they do occur, semitransparent—probably oligoclase.
- (*c*). Mica; perfectly black, high lustre.

VII. *Poison Glen.*—Medium-grained granite:—
- (*a*). Quartz; grey, not prominent.
- (*b*). Felspar; pink, in large crystals ($\frac{1}{2}$ in. by $\frac{1}{8}$ in.), semitransparent, predominant; orthoclase.
- (*c*). Mica; jet-black, bright lustre.

VIII. *Poison Glen.*—Coarse-grained granite.
- (*a*). Quartz; conspicuous, grey.
- (*b*). Felspar; pink, in large crystals ($\frac{1}{2}$ in. by $\frac{1}{4}$ in.), transparent, bright calcspar lustre, set in a paste of quartz and pinkish felspar.
- (*c*). Mica; an occasional speck of green mica, probably not $\frac{1}{2}$ *per cent.*

IX. *Doocharry Bridge.*—Medium-grained granite, tending to become porphyritic.
- (*a*). Quartz.
- (*b*). Felspar; orthoclase, pink, in $\frac{1}{2}$ in. crystals.
- (*c*). Felspar; oligoclase, grey, in $\frac{1}{8}$ in. crystals.
- (*d*). Mica; black, in small grains or specks, and in small quantity.

X. *Barnesmore Gap.*—Coarse-grained, reddish granite, of platy structure, one-inch slabs.
- (*a*). Quartz; very prominent, grey, occupying a surface *only* inferior to the red felspar.
- (*b*). Felspar; pale red, uniform in texture, with some well-developed cleavages, not very brilliant.
- (*c*). Mica; green, very compact, with few leaves, passing into chlorite-earth: this chloritic earth covers the joint-surfaces ($\frac{1}{20}$ in. to $\frac{1}{10}$ in.), and is visible in all such partings. It is very difficult to distinguish the green mica from hornblende.

XI. *Arranmore Island.*—Porphyritic granite; felspar predominating.
- (*a*). Quartz; easily visible, abundant, grey.
- (*b*). Felspar; reddish, in distinct crystals ($\frac{1}{2}$ in. to $\frac{1}{4}$ in.), cleavage-planes distinct, with bright lustre, semitransparent.
- (*c*). Mica; black; when seen on the edge, it resembles hornblende, of which, however, there is not a particle in the rock: facets of mica difficult to see, but having a very brilliant reflexion; subordinate to both the quartz and felspar.

XII. *Tory Island.*—Coarse granite, almost entirely composed of quartz and felspar, platy structure, one-inch slabs.
- (*a*). Quartz; conspicuous, crystals ($\frac{1}{2}$ in.), grey.
- (*b*). Felspar; uniform red, with cleavage-planes of dull lustre, orthoclase.
- (*c*). Mica; greenish, sometimes white, in occasional very small plates.

XIII. *Ardara.*—Coarse-grained gneissose granite:—
- (*a*). Quartz; small grains.
- (*b*). Felspar; pink orthoclase } in lumpy masses.
- (*c*). Felspar; grey oligoclase } in lumpy masses.
- (*d*). Mica; black, in large quantity, giving a gneissose appearance to the rock.

Sphene occurs disseminated in small crystals.

XIV. *Dunlewy.*—Consists of quartz and felspar, intimately blended together, and very similar in colour, whitish grey. In this paste are numerous crystals of felspar (orthoclase), with definite ($\frac{1}{5}$ in.), lustrous, smooth faces. Also occasional stains of greenish mica, looking like chlorite, and small crystals of garnet. This granite occurs immediately beside the limestone marble of Dunlewy quarry.

XV. *Anagarry.*—A felspathic paste, with large crystals of orthoclase and fragments of quartz: contains also crystals of sphene, locally abundant (and occasional hornblende (?) in ¼ in. crystals). It is found beside the limestone, whenever the latter comes in contact with the granite, as at Anagarry, Glenlehen, and Barnesbeg.

The portion analysed was carefully freed from hornblende and sphene. From the preceding Table, it is evident that the granites of Donegal differ from each other much more in chemical composition than the granites of Leinster already described by me*. This difference was to be expected from the more decidedly eruptive character of the Leinster granites, which nowhere simulate the stratified character so remarkable in those of Donegal.

The granites Nos. IV. and XIII., for example, are rather to be considered as gneiss than granite; and their exceptional composition may be accounted for by this circumstance; but, as I have already observed, it is almost impossible to tell where the gneiss ends and the granite begins.

V. *Minerals of the Granite of Donegal.*

The minerals of the granite of Donegal may be divided into Constituent and Accidental Minerals.

The Constituent Minerals (A) are—

1. Quartz.
2. Orthoclase.
3. Oligoclase.
4. Black Mica.
5. White Mica (sometimes).
6. Hornblende (sometimes).

Of these, the first four are always present, and easily distinguishable from each other; the fifth mineral, white mica, is found locally abundant, particularly in veins, associated with special accidental minerals; and the sixth mineral, hornblende, is found intimately mixed with black mica [as in lepidomelane, *Soltmann*] in the more basic varieties of the granite.

The Accidental Minerals (B) are—

1. Sphene.
2. Schorl.
3. Beryl.
4. Garnet.
5. Molybdenite.
6. Copper-pyrites.

A. *Constituent Minerals.*

1. *Quartz.*—The quartz entering into the composition of the granite is of the usual grey variety; when found in veins, it sometimes forms fine black crystals, as at Barnesmore Gap, and sometimes smaller crystals of a rose-colour, as at Barnesmore and Sheskina-roan.

2. *Orthoclase.*—The orthoclase of the Donegal granite is generally red, but sometimes white: the following analyses show its composition:—

* Quart. Journ. Geol. Soc. Lond. Aug. 1856, vol. xii. p. 177.

TABLE V.—*Orthoclase of the Donegal Granite.*

	1.	2.	3.	Mean.
Silica	63·20	62·80	63·60	63·20
Alumina	19·72	16·84	19·32	18·64
Iron (peroxide)	0·28	0·96	0·80	0·68
Lime	2·59	4·95	0·72	2·75
Magnesia	0·09	0·11	0·14	0·11
Soda	0·06	0·46	1·84	0·78
Potash	16·30	14·91	13·55	14·92
Total	102·24	101·03	99·97	101·08

No. 1. *Glenveagh.*—White, opaque, milky, forming crystals in the granite.

No. 2. *Near Lough Mourne, above Barnesmore Gap.*—Found in great bunches, isolated, in the middle of a very close-grained mica-schist, or gneiss of very fine grain. The felspar is bright-red, and associated with milky quartz, containing specular micaceous iron-oxide. The diameters of some of the bunches are 5 ft. They are probably the terminations of veins 2 ft. wide, ending in *carbonas* in the gneiss, and have all the appearance of having been filled by aqueous action at a high temperature.

No. 3. *Castlecaldwell.*—Found associated with white mica, quartz, black mica, and occasionally schorl and iron-pyrites, in veins penetrating the fine-grained gneiss of the district. The felspar of these veins is worked for the manufacture of china, and burns white, although pink and red in the vein.

Taking the atoms of the mean composition of the orthoclase, I find—

Silica		1373	35
Alumina	358	366	9
Iron (peroxide)	8		
Lime	98	445	11
Magnesia	5		
Soda	25		
Potash	317		

The protoxide bases are here somewhat too large for orthoclase; and it is probable that this is caused by the lime of No. 2, which is unusually large in amount. There can be no doubt, however, on crystallographic grounds, that the felspar is true orthoclase.

For the purpose of comparison, I here give the mean of seven analyses of different orthoclases of the Leinster granite, and their atomic composition:—

Leinster Orthoclase (mean of seven analyses).

	Per-centage.	Atoms.		
Silica	64·59		1435	36
Alumina	18·31		352	9
Lime	0·25	9	387	10
Magnesia	0·58	29		
Soda	2·75	89		
Potash	12·23	260		
Loss by ignition	0·58			
	99·29			

The chief difference between the orthoclase of Donegal and that of Leinster consists in the fact, that lime seems in the Donegal mineral to take the place of the soda in the Leinster felspar, and that it is somewat more basic.

3. *Oligoclase.*—The oligoclase of Donegal is of a honey-waxy-greenish grey, and is easily distinguished from the orthoclase which accompanies it by its colour and by the fine striated lines that mark certain of its surfaces of crystallization, and prove it to be an anorthic felspar. The following analyses give its composition :—

TABLE VI.—*Donegal Oligoclase.*

	No. 1.	No. 2.	Mean.	Atoms.		
Silica	60·56	59·28	59·92		1303	3
Alumina	24·40	22·96	23·68	455	469	1
Iron (peroxide)	0·40	1·94	1·17	14		
Lime	5·96	4·65	5·30	189	454	1
Magnesia	0·04	0·21	0·13	6		
Soda	6·46	6·48	6·47	209		
Potash	1·76	2·38	2·07	44		
Iron (protoxide)	......	0·10	0·05	6		
Manganese (protoxide)	......	0·32	0·16			
Totals	99·58	98·32	98·95			

No. 1. *Garvary Wood, near Castlecaldwell, Co. Fermanagh.*—Pearl-grey, translucent; in veins in gneiss; associated with black mica, some orthoclase (pink), copper-pyrites, and molybdenite.

No. 2. *Precise locality unknown.*—The specimen from which it was taken belongs to that variety of granitic syenite into which the granite of Donegal sometimes passes, as at the Black Gap, Pettigo, and at Kilraine, near Ardara.

The formula to which the preceding analyses lead is the well-known formula of oligoclase—

$$\dot{R}O, SiO_3 + Al_2O_3, 2SiO_3.$$

For the purpose of comparing the oligoclase of the granite of Donegal with that of Sweden, I made a careful analysis of the oligoclase of Ytterby in Sweden, which was kindly placed at my disposal by Mr. J. B. Jukes, Local-Director of the Geological Survey of Ireland.

The following is the mean of two closely agreeing analyses :—

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		

* 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.

4. *Black Mica.*—Black mica forms in Donegal, as in the Mourne Mountains, a constant and important constituent of the granite; it is always present, and becomes green when decomposition sets in.

The following analyses show its chemical composition:—

TABLE VII.—*Black Mica of Donegal.*

	No. 1.	No. 2.	No. 3.	No. 4.
Silica	36·16	36·20	44·40	31·60
Alumina	19·40	15·95	21·52	19·68
Iron (peroxide)	26·31	27·19	10·72	23·35
Lime	0·58	0·50	2·70	0·45
Magnesia	4·29	5·00	6·14	7·03
Soda	0·48	0·16	0·74	0·74
Potash	9·00	8·65	6·18	3·90
Iron (protoxide)	0·62	0·64	3·96	4·04
Manganese (protoxide)	0·40	1·50	1·28	1·20
Loss by ignition	2·40	3·90	1·20	8·68
Totals	99·64	99·69	98·84	100·67

No. 1. *Glenveagh.*—Occurs in coarse gneiss, containing also orthoclase and oligoclase.
No. 2. *Ballygihen.*—Occurs in granite, in ½-inch plates, ¼ inch in thickness.
No. 3. *Garvary Wood.*—Associated with oligoclase, orthoclase, and molybdenite, in veins in gneiss.
No. 4. *Castlecaldwell.*—Associated with orthoclase and schorl in veins in gneiss. This mica is green, and is obviously the black mica much decomposed.

Of these micas, No. 4 is evidently decomposing, and not to be considered in forming an opinion on the average composition of the black mica of Donegal. But the differences between No. 3 and Nos. 1 and 2 are too numerous to permit us to take the average of all. To enable us to form an opinion as to the probable composition of this remarkable mineral, I here add four analyses, of which three were made by myself:—

TABLE VIII.—*Black Mica from other localities.*

	No. 1.	No. 2.	No. 3.	No. 4.
Silica	35·55	35·50	39·70	37·40
Alumina	17·08	20·80	12·25	11·60
Iron (peroxide)	23·70	21·40	23·55	27·66
Iron (protoxide)	3·55	7·74	0·96	12·43
Manganese (protoxide)	1·95	....	1·00	
Lime	0·61	0·56	4·48	} 0·26
Magnesia	3·07	4·46	7·25	
Soda	0·35	0·10	0·47	
Potash	9·45	9·00	7·30	9·20
Loss by ignition	4·30	1·25	1·00	0·60
Totals	99·61	100·81	97·96	99·15

No. 1. *Ballyellin, co. Carlow.*—(Haughton) Quart. Journ. Geol. Soc. vol. xii. p. 175.
No. 2. *Canton.*—(Haughton) Phil. Mag., April 1859, p. 259.
No. 3. *Jonesed, Sweden.*—(Haughton) unpublished.
No. 4. *Petersberg, Wermland.*—(Soltmann).

Rammelsberg ('Handbuch der Mineralchemie,' 1860, p. 668) gives, in his list of magnesia-micas, three only that can be compared with the eight analyses just recorded—viz. Nos. 23, 24, and 25, although he does not hesitate to include in his list micas whose composition with respect to magnesia ranges from 3 to 30 *per cent.* Physically, it is evident that the eight micas, whose composition is given in the preceding Tables, are identical, notwithstanding the variation in their chemical composition.

5. *White Mica.*—This mineral, although not a constituent mineral of the granite of Donegal, occurs frequently in veins, and is always associated with orthoclase, sometimes with schorl and beryl. It is biaxial, and resembles the margarodite of Leinster already described in Part I. of these Researches.

The following analyses show its composition:—

TABLE IX.—*White Mica of Donegal.*

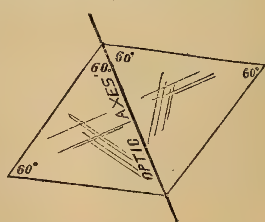
	No. 1.	No. 2.	Mean.
Silica	44·80	45·24	45·02
Alumina	29·76	35·64	} 38·22
Iron (peroxide)	8·80	2·24	
Lime	0·45	0·51	0·48
Magnesia	0·71	0·71	0·71
Soda	0·32	0·54	0·43
Potash	12·44	10·44	11·44
Iron (protoxide)	....	0·70	} 0·71
Manganese (protoxide)	0·48	0·24	
Loss by ignition	2·00	4·00	3·00
Totals	99·76	100·26	100·01

No. 1. *Castlecaldwell.*—Found in veins of quartz and pink orthoclase, containing schorl and decomposing plates of black mica. Biaxial (72° 20′). The accompanying woodcut (fig. 1) shows the position of the plane of optical axes. Angle of plate = 125°.

No. 2. *Near Ballygihen, in Dooish Mountain.*—In veins in the granite, not associated with black mica; in plates $\frac{3}{4}$ inch wide, $\frac{1}{4}$ inch thick. Biaxial (62° 10′ to 65° 10′). Angle of plate = 120°.

Fig. 1.—*White Mica from Castlecaldwell, Donegal.*

Fig. 2.—*White Mica from Breezy Mountain, near Beleek.*



In a specimen of speckled white mica from Breezy Mountain, near Beleek, I found the optical axes to form an angle of 63° 6′; and also observed their plane to coincide with the shorter diagonal of the primary rhomb, whose angles were 120° and 60°. This is shown in the accompanying figure (fig. 2), in which also the internal lines of structure of the crystal are shown; from which it seems possible that the optical plane may really bisect the acute angles of some of the component crystals, which would, in this case, have been rotated through 90°. In the specimens from Dooish, the plane of the optical axes is perpendicular to the side of the hexagonal plate of the mica, and therefore joins the acute angles of the primary rhomb.

This optical peculiarity of the Breezy margarodite distinguishes it from the margarodite of the Leinster granite, in which the plane of the optical axes coincides with the long diagonal of the primary rhomb, joining its acute angles.

From the preceding analyses the following atomic quotients may be calculated:—

	No. 1.	No. 2.	Mean.	
Silica	0·995	1·005	1·000	3
Alumina; Iron (peroxide)	0·682	0·644	0·664	2
Lime; Magnesia; Soda; Potash; Iron (protoxide); Manganese (protoxide)	0·345	0·311	0·328	1
Water	0·222	0·444	0·333	1

This result gives very accurately the well-known formula of margarodite—

$$RO, SiO_3 + 2(Al_2O_3, SiO_3) + [HO]?$$

The mean of four analyses of margarodite, from four distinct localities of the Leinster granite, gave me—

Leinster Margarodite.

Silica	44·58
Alumina; Iron (peroxide)	36·62
Lime	0·78
Magnesia	0·76
Soda	0·95
Potash	10·67
Iron (protoxide)	0·07
Loss by ignition	5·34
	99·77

The two minerals are plainly identical, and form a well-marked feature of the granite of Leinster and of the granite-veins of Donegal. Margarodite is sometimes, as at Sheskina-roan and Dooish, found in the granite itself.

6. *Hornblende.*—The granite of Donegal varies much in texture and appearance, as might be expected from its gneissose character. It occasionally passes into a granitic syenite, composed of hornblende, oligoclase, and a little quartz and sphene. The composition of the

felspar of this rock has been already given; that of its hornblende is as follows:—

Hornblende of Donegal Syenitic Granite.

	Per-centage.		Atoms.	
Silica	47·25		1050	
Alumina	5·65		108	
Iron (peroxide)	19·11	protoxides of iron and manganese	551	1587
Lime	11·76		420	
Magnesia	11·26		563	
Soda	0·98		31	
Potash	1·04		22	
Iron (protoxide)	0·94			
Manganese (protoxide)	1·70			
	99·69			

The rock, of which this hornblende is a constituent, has the following composition:—

Syenitic Granite of Donegal.

Silica	58·04
Alumina	16·08
Iron (peroxide)	8·27
Lime	6·52
Magnesia	2·94
Soda	4·65
Potash	2·21
Iron (protoxide)	0·45
Manganese (protoxide)	1·12
	100·28

B. *Accidental Minerals.*

1. *Sphene.*—This mineral is very like the clove-brown sphene of Norway: it is found in the granite, when the latter becomes basic, containing much black mica and oligoclase; but it is principally found in a rock formed of a paste of quartz and felspar, that often lies between the granite and limestone of the metamorphic rocks of Donegal. This is especially observable at Anagarry and Barnesbeg, where this rock is so abundant as to become entitled to the name of sphene-rock; and it cannot be distinguished from similar rocks from Norway.

2. *Schorl.*—This mineral accompanies orthoclase in veins, and is often curved and cracked, showing the wider openings of the fissures next the convex side, and filled with quartz, as if the curvature of the schorl, and the filling of its fissures with quartz, were the result of an action that took place after the deposition of the mineral.

3. *Beryl.*—The only known locality for beryl in Donegal is She-

skina-roan, near Dunglow. It is green, with occasionally a shade of blue, and occurs both in reefs of quartz traversing the granite along its leading joints, and also in the granite itself, which, in this case, becomes very quartzose, and its black mica disappears, giving place to fine rhombs of margarodite.

The beryl of Donegal has never, so far as I know, been analysed—a circumstance which may give some additional value to the following analysis:—

Beryl, from Sheskina-roan, Co. Donegal. Sp. gr. = 2·686.

	Per-centage.	Oxygen.			
Silica	65·52		34·02	....	4
Alumina	17·22	8·05	8·50	....	1
Iron (peroxide)	1·53	0·45			
Lime	0·43				
Magnesia	0·13				
Glucina	13·74		8·69	....	1
Water	0·90				
	99·47				

This analysis gives very accurately the well-known formula of beryl—

$$Be_2O_3,\ 2SiO_3 + Al_2O_3,\ 2SiO_3.$$

Mallet's analysis of the beryl of Killiney, in the Leinster granite, is as follows:—

Beryl of Leinster Granite.

Silica	66·13
Alumina	17·87
Iron (peroxide)	1·62
Glucina	13·09
	98·71

This mineral bears the closest resemblance to the beryl of Sheskina-roan in its chemical composition.

4. *Garnet.*—This mineral, in bright ruby-coloured crystals, is found in the granite of Glenties, Anagarry, and other localities. Form dodecahedral.

5. *Molybdenite and Copper-pyrites.*—These minerals are found in veins of granite, at Garvary Wood, near Castlecaldwell, associated with oligoclase and black mica.

VI. *Mineralogical Composition of the Granite of Donegal.*—The granite of Donegal, as I have shown, is composed of four minerals, quartz, orthoclase, oligoclase, and black mica, with perhaps an unknown paste besides. It is now necessary to determine numerically its mineral composition, and to investigate the constitution of its paste. In order to do so, we must first fix the composition of each constituent.

1. *Quartz.*—This is assumed to be pure silica.

2. *Orthoclase, Oligoclase, Black Mica.*—I take the average composition of the orthoclase and oligoclase already given; and for that

of the black mica, I assume the mean of Nos. 1 and 2 of Table VII., which were procured from the granite of Glenveagh and Ballygihen, and resemble each other closely.

Table X.—*Mean Composition of the Constituent Minerals of the Granite of Donegal.*

	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

From the preceding Table we may readily calculate the following, which gives the proportion of oxygen belonging to the silica, peroxides, and protoxides of each constituent mineral, and which is necessary for the determination of the per-centage of the constituent minerals.

Table XI.—*Oxygen-proportions of the Constituent Minerals of the Granite of Donegal.*

	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

Let us take as an example of the mineralogical calculation the granite of Doocharry Bridge, No. IX., which is nearly in the centre of the granite axis, and represents well the average granite of Donegal. Its analysis and oxygen-proportions are as follows:—

Granite of Doocharry Bridge.

	Per-centage.	Oxygen.
Silica	72·24	37·51
Alumina	14·92	7·46 (Alumina and Iron (peroxide))
Iron (peroxide)	1·63	
Iron (protoxide)	0·23	2·50 (Iron (protoxide) to Potash)
Manganese (protoxide)	0·32	
Lime	1·68	
Magnesia	0·36	
Soda	3·51	
Potash	5·10	
	99·99	47·47

If, now, $Q.$, $Or.$, $Ol.$, and $M.$ denote the per-centages of quartz, orthoclase, oligoclase, and mica in this granite, we have the following equations from the preceding oxygen-ratios:—

$$375100 = 5192\ Q. + 3281\ Or. + 3111\ Ol. + 1878\ M. \quad \ldots\ldots (1)$$
$$74600 = 891\ Or. + 1141\ Ol. + 1628\ M. \quad \ldots\ldots (2)$$
$$25000 = 355\ Or. + 361\ Ol. + 394\ M. \quad \ldots\ldots (3)$$

To which we may add the following:—

$$100 = Q. + Or. + Ol. + M. \quad \ldots\ldots\ldots\ldots (4)$$

the reason of which is evident.

From these four equations, the four unknown per-centages are to be determined.

Eliminating $M.$ from (2) and (3), we find

$$1130800 = 22689\ Or. + 13817\ Ol. \quad \ldots\ldots\ldots (a.)$$

Also, eliminating $Q.$ from (1) and (4), we obtain

$$144100 = 1911\ Or. + 2081\ Ol. + 3314\ M. \quad \ldots\ldots (b.)$$

Again, eliminating $M.$ between (b) and (3), we obtain the following equation in $Or.$ and $Ol.$:—

$$2607600 = 42357\ Or. + 37650\ Ol. \quad \ldots\ldots\ldots (c.)$$

Solving equations (a) and (c) for $Or.$ and $Ol.$, we obtain

$$Or. = \frac{6545}{269} = 24 \cdot 33,$$
$$Ol. = 41 \cdot 88.$$

Introducing these values of $Or.$ and $Ol.$ into equation (2), we find

$$M = 3 \cdot 16.$$

And, finally, from (4) we obtain

$$Q = 30 \cdot 63.$$

The mineralogical composition, therefore, of the granite of Doocharry Bridge is—

Doocharry Bridge Granite.

Quartz	30·63
Orthoclase	24·33
Oligoclase	41·88
Black mica	3·16
	100·00

The preceding calculation leaves little to be desired in point of accuracy, although it is open to the objection that it is somewhat laborious. I believe it to be superior in accuracy to the method of measurement used by Delesse. This distinguished geologist has obtained the following proportions for three granites, one from Egypt, and the other two from the Vosges:—

Granite.	Quartz.	Orthoclase.	Oligoclase.	Black Mica.
Red Granite of Egypt	44	43	9	4
Vosges, Tholy	52	45	2	1
Vosges	60	28	7	5

The per-centage of quartz in these granites appears very great, and to vary much in quantity. The granite of Leinster contains—

Leinster Granite.

Quartz	27·66
Mixed felspar (tersilicated) ..	52·94
White mica	14·18
Black mica................	5·27
	100·05

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3. *On a* Stalk-eyed Crustacean *from the* Carboniferous Strata *near* Paisley. By Thomas H. Huxley, Esq., F.R.S., Sec. G.S., &c.

In a paper published in the Geological Society's 'Journal' (vol. xiii. p. 363, 1857), I described several specimens of a Stalk-eyed Crustacean, from rocks of Carboniferous age, to which I applied the generic name of *Pygocephalus*, referring the genus to either the Decapodous or Stomapodous group of the Class.

My friend and colleague, Mr. Geikie, F.G.S., has been so good as to draw my attention to what I believe to be another specimen of the same Crustacean, obtained by the Rev. Mr. Fraser, M.A., from one of the coal and ironstone mines in the Strath of the Clyde, about two miles from Paisley, in dark shale*, and, by the obliging permission of its owner, has placed it in my hands for examination and description. I say, I *believe* the new fossil to be another specimen of *Pygocephalus*, because, in consequence of the different position in which the present specimen is imbedded in the matrix, a strict comparison with the others is almost impossible; and my determination is based rather on general analogy of the forms than on a complete identification.

While the other specimens presented a view of the ventral surface, this shows the lateral aspect of the animal, exhibiting a side-view of the carapace, of the thoracic and some of the cephalic appendages, and of the large and curved abdomen. The carapace, the lateral surface of which is convex from above downwards, is narrow

* "This dark shale," says Mr. Fraser, in a letter to me, "is about 19 fathoms below the surface. The ironstone-clay-band lies about 7 fathoms above it; and 36 fathoms beneath it, occurs what is known here as the Hurlet or Nitshill Coal."

and apparently truncated in front, but deep behind, its postero-inferior angle being somewhat produced, but rounded off. It measures 0·65 in. in extreme length, 0·3 in. in extreme depth. The dorsal

Sketch of Pygocephalus (?) *from the Coal-shale near Paisley.*

walls of the abdominal *somites,* of which only the anterior three or four are clearly distinguishable from one another, are large in proportion to the carapace, having a depth of 0·3 in., and an antero-posterior length of 0·13 in. The free inferior edges are not clearly defined, but their margins seem to have had much the same curvature as those of *Astacus* or *Homarus.* The first obvious abdominal segment is separated from the carapace by an interval, in which I think I can trace the remains of the small, true, first abdominal segment, not much more than half the size of the others. If this be the case, then the dorsal parts of the fifth and sixth *somites* are broken away; and all that remains of the telson and the appendages of the sixth *somite* is a broad flat plate, which lies in front of the third and fourth abdominal *somites.*

I explained in my previous paper the difficulties which I met with in endeavouring to understand this part of the body of *Pygocephalus*; and I am sorry to say that the new specimen casts but little light upon the subject. The appendages are fairly displayed. At the anterior part of the carapace I believe I can discern the eye-stalk, which is about 0·1 in. long, broader at its free than at its attached end, and exhibits a depression, which is broad in front, but narrows behind to a point on the outer side of its distal half. This depression appears to result from the more yielding character of the integument, that investing the rest of the eye-stalk being dense and shining; and the surface of this softer integument is distinctly facetted. The character of the appendage, in short, closely agrees with that of the dried eye-stalk of a Podophthalmous Crustacean. Behind and below the eye-stalk the remains of the antennule are traceable; and this is succeeded by the antenna, its great basal scale being very largely developed. Behind these follow about seven slender, filiform, jointed limbs, diminishing in length from before backwards; indistinct traces of a second division, or *exopodite,* are discernible in these limbs.

Notwithstanding the imperfect condition of this new specimen, and the very little that it enables me to add to what was already known of *Pygocephalus,* it is so desirable to call the attention of collectors to the various aspects under which the higher *Crustacea* make their appearance in the oldest rocks at present known to contain them, that I venture to communicate the present notice to the Geological Society.

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4. *On the* Premolar Teeth *of* Diprotodon, *and on a* New Species *of that* Genus. By Thomas H. Huxley, Esq., F.R.S., Sec. G. S., &c.

[Plate XXI.]

A short time since, I was requested by Dr. Cotton, F.G.S., to examine a series of Australian fossils in his collection, which were procured by Mr. Isaacs from Gowrie, in the district of the Darling Downs in Queensland, the same locality from which other specimens in the Hunterian and British Museums were obtained. These fossils consisted of numerous teeth and fragments of jaws of *Macropus Atlas* and *M. Titan*; part of the upper jaw of a new species of Kangaroo, as large as these, but allied to *Lagorchestes* and *Hypsiprymnus*; with three lumbar vertebræ, a sacrum, portions of two innominate bones, three ossa calcis, and a right metatarsal of the great toe, belonging to these Marsupials. The metatarsal is remarkable for its short and stout proportions. But the most interesting among these remains were fragments of *Diprotodon*, comprising sundry molar teeth, a small portion of the right ramus of a lower jaw, and parts of the right and left upper jaws of two distinct individuals. Of these upper jaws, the former, which I shall call No. 1 (Pl. XXI. fig. 1), contained the premolar in place and the socket of the succeeding molar, with one fang in place. Fortunately, among the detached teeth, I found the crown and principal fang of this molar, and the premolar of the other side of the same skull. The other or left upper jaw, No. 2 (fig. 4), has a very different colour and texture, from the nature of the ferruginous matrix in which it has been imbedded. It retains a part of the palatine plate, and holds three teeth—the premolar and first and second molars. What (from its aspect and mineral condition) I do not doubt to be the fourth, or hindermost, molar of the same series was found loose among the other teeth.

The genus *Diprotodon* was founded by Professor Owen* upon part of a lower jaw, collected by Sir Thomas Mitchell, from a cave in the Wellington Valley. In 1845 further details were given by the same author†, who described two fragments of lower jaws, and all the lower series of teeth but the premolar. Of this tooth all that is said is, "its socket shows that it was implanted, like the other molars, by two fangs" (*l. c.* p. 214). A dorsal vertebra and a calcaneum, from the same deposits, are provisionally ascribed to the same genus.

* Mitchell's 'Three Expeditions into the Interior of Eastern Australia,' vol. ii. p. 368, pl. 9. fig. 1. 1838.

† Report of the Meeting of the British Association for 1844, p. 223; 'Report on the Extinct Mammals of Australia, &c.,' by Prof. Owen, F.R.S.

In the "Catalogue of the Fossil Organic Remains of *Mammalia* and *Aves* in the Museum of the Royal College of Surgeons" (1855), Professor Owen has given a fuller description, accompanied by figures, of the previously known remains of *Diprotodon australis*, and has added an account of some fragments of ribs, scapulæ, and limb-bones. No portions of the upper jaw, or of its teeth, are described in these successive communications; but in the paper "On some outline drawings and photographs of the skull of the *Zygomaturus trilobus*" (Quart. Journ. Geol. Soc. 1859, p. 168), it is stated of "*Zygomaturus*,"—"By the dentition of the upper jaw this fossil agrees in that essential character with the genus *Diprotodon*" (p. 173); and further, at p. 175, "The bony palate appears to have been entire or without any unusually large palatal vacuity, in this respect resembling the same part in *Macropus major* and *Diprotodon*;" and again at p. 175,—"In the cranium of *Diprotodon* in the Sydney Museum, of which photographs have been transmitted to me by Mr. George Bennett, the number of molar teeth is reduced to eight, four on each side; but it is by the loss of the first small molar; and from the appearance of that molar in *Zygomaturus*, I conjecture that it would also be shed in an older individual. But there are specimens in both the British Museum and the Hunterian Museum which demonstrate that the *Diprotodon* has five molar teeth developed on each side of both upper and lower jaws, as stated in my 'Report on the extinct Mammals of Australia.'"

I may remark, incidentally, that I am unable to find any reference to the upper jaw in the 'Report' here cited. In the passage which immediately precedes that just quoted, Professor Owen says,—"I have to state that the British Museum has now received ample evidence that the generic distinction which Mr. MacLeay believes to exist between that fossil (*Zygomaturus*) and *Diprotodon* is not present."

My valued friend Mr. MacLeay, however, by no means made the mistake here attributed to him, of establishing a new genus unnecessarily. "*Zygomaturus*" is, without doubt, generically distinct from *Diprotodon*: indeed, Mr. MacLeay's conclusion is implicitly admitted by Professor Owen in the paper which follows that cited above, and which is chiefly devoted to an attempt to prove the identity of *Zygomaturus* (MacLeay) with *Nototherium* (Owen); for the latter genus is regarded by Professor Owen as perfectly distinct from *Diprotodon*.

In the plate (Plate IX.) which accompanied that communication, the left penultimate upper molar of *Diprotodon* is figured (fig. 6); and the transverse direction of the principal ridges, as contrasted with their oblique direction in *Nototherium*, is noted.

I have now, I believe, adverted to all that has been written regarding the dentition of *Diprotodon*; and it will be observed that much remains to be learned respecting the premolar teeth and the dentition of the upper jaw generally. I shall proceed, therefore, to describe, at some length, the fossils noted above as Nos. 1 and 2.

No. 1 (Pl. XXI. figs. 1, 2, 3). This consists of so much of the right maxilla of a *Diprotodon* as would lie between an anterior boundary-line, drawn through the anterior end of the infraorbital canal and the alveolar margin, half an inch in front of the premolar, and a posterior boundary-line, drawn at right angles to the alveolar margin, between the fangs of the first molar tooth. The superior limit of the fragment is the commencement of the lacrymal or antorbital prominence. The distance between the alveolar margin and the latter is 3 inches. The outer surface of the maxilla is strongly inclined inwards below the suborbital foramen, flattened or slightly convex from the alveoli of the premolar and molar to the level of that foramen, and slopes backwards and inwards, so as to be markedly concave, above that point. Although not more than an inch and a half of the infraorbital canal is preserved, its anterior end is fully half an inch below its posterior extremity, so strongly is it inclined downwards and forwards.

In all these characters the fossil agrees with *Diprotodon*, and differs from *Zygomaturus* * ; in which latter animal the surface of the maxilla slopes directly outwards and backwards from the infraorbital foramen to form the prominent anterior margin of the orbit. In *Zygomaturus* the zygomatic process of the maxilla is given off at a point where the surface of that bone is quite smooth in the fossil before us.

Of No. 2 (Pl. XXI. figs. 4, 5, 6), a left maxilla, less of the upper and anterior, and more of the posterior and inner part, remain. The floor of the infraorbital foramen remains, and exhibits the same rapid slope as that of the other specimen. A strong horizontal palatine process is given off from the inner side of this fragment of the left maxilla. Its greatest breadth is one inch and three-eighths; and its inner boundary, rough and broken, presents no indication of a suture, so that the palate had more than double this width at this point. Opposite the interval between the first and second molars a small canal opens forwards, upon the under and anterior surface of the palate opposite the premolar. The palatine plate is three-eighths of an inch thick, and presents a flat external division, separated by a ridge from an inner part which slopes somewhat upwards; but behind the opening of the canal just mentioned, the under or oral surface rises both inwards and backwards ; and, the upper or nasal surface falling in the same proportion, the palatine plate ends posteriorly and internally, opposite the interval between the second and third molars, in a thin edge, which, in this specimen, is nowhere completely entire. In a specimen of the right maxilla of *Diprotodon*, containing all the teeth save the premolar, in the collection of the British Museum (marked 32858), to which I shall have occasion to make frequent reference, the palatine plate is seen to end in a free, thin, rounded edge, and to become

* I employ Mr. MacLeay's generic name *Zygomaturus* for the fossil skull which he originally described, because, until a lower jaw has been discovered in connexion with such a skull, and that lower jaw turns out to be generically identical with the mandible upon which Professor Owen founded his genus *Nototherium*, the identity of *Nototherium* and *Zygomaturus* cannot be considered to be proved.

narrower from the level of the commencement of the third molar; so that, no doubt, a great palatine vacuity existed at this spot. This is the more remarkable, as, judging from a cast in the same collection, the palate of *Nototherium* was entire, and extended, as in the Kangaroos, behind the last molar tooth.

The molar teeth have the general characters of those of the lower jaw of *Diprotodon* already described by Professor Owen. Each exhibits two principal transverse ridges, with a posterior, almost obsolete, and an anterior, much more prominent and thick, but still low, basal ridge. The principal ridges are directed transversely to the axis of the palate and the alveolar margin, or have, at most, but a very slight inclination backwards and inwards. They are slightly concave backwards; and they wear down at first into two oval or elongate-reniform facets, separated by a deep valley, whose outer ends are, as usual, higher than the inner. The tooth becomes abraded faster in front than behind,—the anterior basal ridge contributing a single or double strip-like facet, which becomes connected in the middle with the worn face of the anterior of the two principal ridges. The latter also eventually unite in the middle of the tooth; so that, in much-worn teeth, the broad, four-sided field of dentine is surrounded only by a narrow band of enamel, the lateral portions of which present two sharply re-entering angles. There is no cingulum continued upon either the outer or the inner sides of the base of these teeth. The surface of the enamel has that sort of "reticulo-punctate or worm-eaten" look which is mentioned by Professor Owen as characteristic of the teeth in this genus.

The first molar is rather smaller than the second: the third is wanting: the fourth is considerably longer than the second, as the measurements given below will show, and has not the square outline of the first and second; but it diminishes posteriorly by the incurvation of its outer contour. Hence the posterior transverse ridge of the fourth molar is much smaller than the anterior. The tooth is not at all worn, and seems to have been but just cut. The principal crests are excavated from side to side posteriorly, and are correspondingly convex anteriorly. Superiorly they rise to a minutely ridged and forwardly curved edge, which is slightly concave upwards. The anterior basal ridge is sharply defined, but is not so thick as in the second molar.

Each molar tooth has a single posterior fang and two anterior fangs.

The premolar tooth (not more than half the size of the molar which succeeds it, and very much less worn) differs somewhat in its characters in the two fossils. I will first describe it as it appears in No. 1, where the premolar teeth of both sides are preserved. The tooth is implanted by two fangs, an anterior, smaller, and a posterior, larger; and its crown has somewhat the form of a tetrahedron with a truncated apex. The posterior side is flat, and slopes obliquely forwards to the roof-like summit of the tooth. The outer convex surface (fig. 1) is divided into three minor vertical convexities by two shallow grooves, which cease about halfway towards the base of the crown. The inner surface (fig. 3), less extensive than the outer, is convex and triangular, being narrower towards the summit of the crown. It passes gradually into the anterior side, which is also triangular, but still narrower. From the vertical depressions on the outer surface two grooves extend inwards on to the crown, which is thus divided by two transverse valleys separated by elevations. Of these, the two posterior, broad and ridge-like, join internally to form the inner surface of the tooth; while the anterior, which has more the form of a cone than that of a crest, is not more than half as broad as the others, and terminates, internally, in a smoothly rounded convex pillar, which remains distinct to the base of the crown. From its anterior surface a ridge springs, which, gradually decreasing in height, skirts its base and then ascends, upon the inner part of the middle ridge, to form the anterior boundary of the inner face of the tooth. The posterior basal ridge is well marked and concave upwards; its inner and outer ends, as it were, ascending upon the postero-external and postero-internal angles of the tooth. The anterior, or mammillary, elevation is not at all worn in either tooth. The middle and posterior ridges are slightly worn, so as to give rise to two elongated facets, each not more than one-sixth of an inch wide, and passing into one another internally, being separated only by the posterior groove, which dilates somewhat suddenly at its inner end (fig. 2).

The premolar of No. 2 is constructed upon precisely the same general plan as that of No. 1, but differs in several details. Thus, it is slightly smaller, and the antero-internal ridge which skirts the base of the mammilla has a somewhat different form. But the most marked difference is offered by the outer surface of the tooth (fig. 4), which presents not merely three smoothly convex surfaces, as in the other specimen, but exhibits three well-defined vertical ridges, connected by prominent, curved, basal elevations. The premolar of this specimen is altogether somewhat smaller than that of the other.

That both these specimens are specifically distinct from the only species of *Diprotodon* known at present, viz. *D. australis*, appears likely, at first sight, from a comparison of the dimensions of the corresponding teeth.

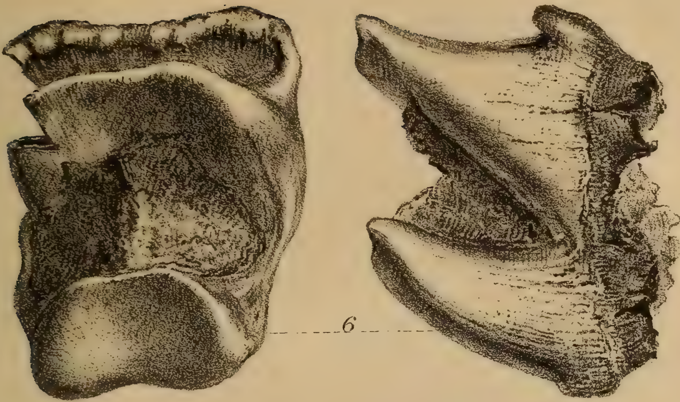
In the maxilla of *Diprotodon australis* (British Museum, No. 32848), to which I have already referred, the socket of the premolar and the first and second molars occupy a space of 4½ inches in the alveolar margin of the maxilla: in No. 2 the same teeth occupy only about 3½ inches. The measurements of the individual teeth, given in eighths of an inch in the following table, present a nearly similar ratio.

	No. 2.		No. 1.		*D. australis* (B.M.).	
	Breadth.	Length.	Breadth.	Length.	Breadth.	Length.
Premolar	6½	7½	7	8	5	8*
First molar	9½	10	12	10	13	12
Second molar	11½	12			16	15
Fourth molar	13	16			17	20

* These are measurements of the alveolus and its contained fang. The crown of the tooth was doubtless much larger in each dimension.

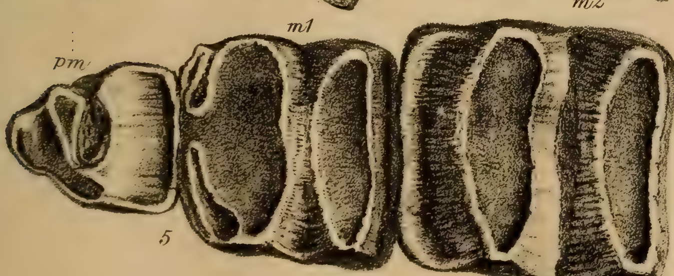
G. De Wilde lith. ad nat.

TEETH OF DIPRO



6

4



5

W. West imp.

G De Wilde lith ad nat.

TEETH OF DIPROTODON, QUEENSLAND.

W West imp

From these measurements it would appear that No. 2 was about one-fourth smaller than *Diprotodon australis*, and that No. 1 took a place between No. 2 and the latter, but nearer No. 2. The question of the systematic value of the differences between No. 1 and No. 2, on the one hand, and between both of these and *Diprotodon australis*, now arises.

In No. 2, the outer surface of the premolar is ridged, and the crown of the first molar is not so broad as it is long.

In No. 1, the outer surface of the premolar presents simple convexities, without ridges, and the first molar is distinctly broader than long.

In *Diprotodon australis* the form of the premolar is not known; the first molar is somewhat broader than it is long.

I entertain no doubt that Nos. 1 and 2 are specifically distinct; and I propose for No. 2 the name *Diprotodon minor*. Whether No. 1 is specifically distinct from *Diprotodon australis*, or whether its difference in size is merely sexual, I cannot pretend to say, in the absence of any premolar teeth of undoubted *D. australis*.

From the very slight extent to which the premolar is worn while the first molar is so much abraded, I suspect that the former tooth must have persisted for a long while, instead of being pushed out at an early period as in many *Macropodidæ*. In form and pattern the premolar does not depart more widely than the molars themselves from the type found in some Kangaroos, such as *Halmaturus*; and the cast of *Zygomaturus* in the British Museum shows that the upper premolar in that animal had an essentially similar structure, though it seems to have been somewhat larger in proportion to the molars.

DESCRIPTION OF PLATE XXI.

Fig. 1. Part of the right upper maxilla of *Diprotodon* (*australis*?); viewed laterally.
2. The under or oral face of the same fragment.
3. A premolar tooth, apparently from the opposite maxilla of the same animal; viewed from the inner side.
4. Part of the left upper maxilla of *Diprotodon minor*; viewed laterally.
5. The under or oral face of the same specimen.
6. Fourth molar, probably of the same specimen of *Diprotodon minor*.

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5. *On the* Old Red Sandstones *of* Fifeshire.

By James Powrie, Esq., F.G.S.

Introduction.—In a paper which I communicated to the Geological Society last year*, I stated my belief in the conformability of all the Old Red Sandstones as exhibited in Forfarshire. In that paper as originally framed, I had even questioned the correctness of Sir C. Lyell's section of the Forfarshire rocks ('Manual of Geology'), in so far as this shows an overlying unconformable conglomerate at

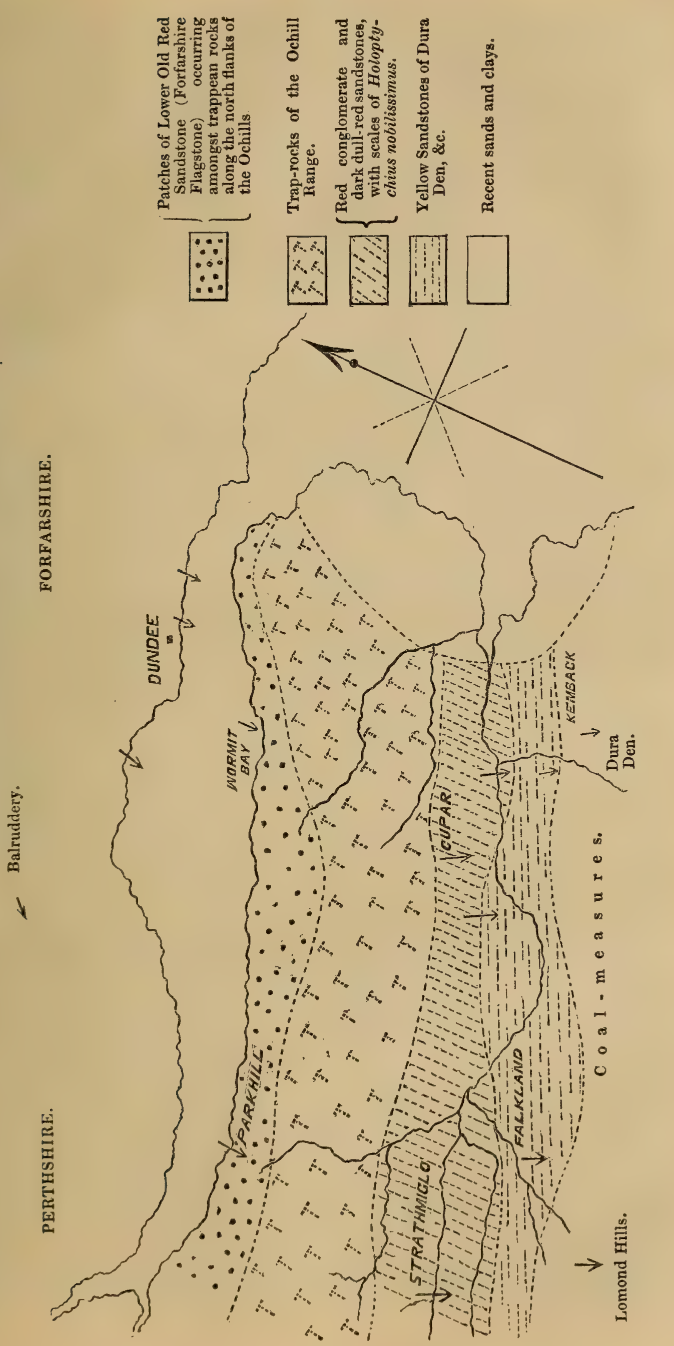
* Quart. Journ. Geol. Soc. vol. xvii. p. 534.

the White Ness, near Arbroath. Somewhat more careful investigation convinced me that in this at least I was mistaken; and this fortunately in time to have the copy of my paper so far altered before it appeared in the Society's Journal for November 1861. From subsequent investigation, I have seen no cause for supposing that in any other locality in Forfarshire has this want of conformity been exhibited; and in order to be able to fix the horizon of the overlying and unconformable conglomerate at White Ness, I have been induced to extend my investigations into such parts of Fifeshire and Perthshire as I thought might throw light on this subject. I was the more induced to this, as it was shown in Mr. Geikie's paper*, of January 1860, that a break existed in the Old Red Sandstone of the South of Scotland; and hence I suspected that, in all probability, the unconformable conglomerate at White Ness might belong to the upper members of the Old Red. In no instance have I yet found a section sufficiently continuous, and showing the upper and lower portions of our Old Red in connexion, to afford decisive proof that in this supposition I was correct. There are still several localities which I have not as yet visited, where a distinct section showing the succession of these beds may be looked for; but these are all situated in the neighbouring county of Perth, and I hope to be able more fully to describe the Old Red Sandstones of that county in a future paper; my present purpose being to confine myself to a short notice of these formations as seen in Fifeshire, appending a notice of the organic remains found in them.

The Strata.—The Old Red Sandstones of Fifeshire are cut into two very distinct portions by the trap-rocks of the continuation of the Ochill Range, which, stretching in a direction from nearly south-west to north-east, skirt the Fifeshire banks of the Tay, and may even be traced into Forfarshire, where they appear to have occasioned the great anticline of that county. The sandstones found along the south-east flanks of this range seem to me to belong entirely to the upper members of the Old Red Sandstone; they form a band, of very considerable breadth, extending all through Fifeshire, separating the Coal-formation of the south from the trap-rocks of the Ochills, and may be described as consisting of three divisions: *first*, a light-yellow, rather solid-bedded sandstone, immediately underlying the Coal-formations; *second*, a deep-red solid sandstone underlying the first-mentioned; and *third*, a pebbly conglomerate. See Map.

The upper yellow sandstones may be well studied in Dura Den, where they are exposed in considerable mass. This Den is interesting not only for its picturesque beauty, but also on account of the well-known fossil fishes found in its sandstones. These sandstones are of a medium grain, soft and easily wrought when first lifted, but hardening much on exposure to weather; they rise in unequal and rough flags, and are in very considerable quantity, extending to a depth of several hundred feet. Occasional scales and other remains of Fishes are found all through; in only one layer, however, have entire fishes yet been found; but, when this is reached, they are

* Quart. Journ. Geol. Soc. vol. xvi. p. 312.



Geological Sketch-map of a part of Fifeshire.

found in marvellous profusion—so much so, that on one flag of some three feet in length and two feet in breadth I have counted as many as thirty entire fishes, and these, being of a deep-bright black, afford a most striking contrast to the clear light-yellow ground on which they are laid down. The rocks here dip in a direction a little south of south-east, at an angle of about 8° or 10°: although but small space is interposed between them and the overlying Coal-measures, they are not found exposed in absolute contact; but, by taking the common dip and inclination of these formations, and their general relations, it is quite evident that the Carboniferous formations overlie the Dura Den sandstones conformably. In the quarries of whitish Carboniferous sandstone at Kemback Hill, and also in the overlying limestone of Lediddo, the dip is found to correspond very closely with that of the Dura Den sandstones. To the north, at the opening of the Den, the second member of this series is found in a quarry now long unwrought—a deep-red sandstone, solid-bedded, a good deal fractured, and pretty full of *Holoptychius*-scales. The junction of these red beds with the overlying yellow sandstones is not seen, the rock, where this should take place, being deeply buried under the alluvium of the Eden. The dip here is also a little south of south-east, at an angle of about 12°, corresponding so nearly with that of the yellow sandstones as to preclude any idea of want of conformity. Still northward, at the turnpike-road, the *third* member, the conglomerate, is found; but, as it is here but little exposed, I could not positively ascertain its inclination: about three miles to the west, however, a similar conglomerate is exposed in the Lady Burn, at Cupar, and here the dip is clearly towards the south-east, at an angle of about 15°. We have thus, although with no continuous section, the rocks exposed at small distances, and consisting, as already stated, from below, first, of a reddish pebbly conglomerate, second, a red sandstone with *Holoptychius*-scales, and third, the yellow sandstones of Dura Den, with their included fish-bed; and these again are overlaid by the Carboniferous whitish sandstone of Kemback Hill, full of *Lepidodendra*, *Sphenopteris*, &c., all dipping a little south of south-east, and at nearly equal angles of inclination.

Again, some twelve miles to the south-west, we find, at the village of Falkland, the yellow sandstones similar to those of Dura Den, dipping towards the south-east at angles of from 12° to 14°. To the south, in the Lomonds, the Mountain-limestone is largely developed, having a similar dip and inclination. At Strathmiglo, lying to the north-west of Falkland, the red sandstones are largely wrought, and are full of *Holoptychius*-scales, and here also dip toward the south-east with an inclination of from 13° to 15°. Indeed, the junction of the red and yellow sandstones was exposed in a drain quite near to the public road when, in company with Mr. Page, I visited this locality last summer. The conglomerate is found not far from Auchtermuchty; its inclination here, however, I am not at present able to give correctly. Thus, a similar series to that at Dura Den is found here also, and seemingly conformable.

Besides these, in many localities all the way from where the conglomerate is first found at the village of Ferry Port on Craig (now Tay Port), on to Kinross, where the red sandstones are displayed (a distance of over thirty miles), similar formations are found, such as the yellow sandstones of Cupar Muir, the red and yellow sandstones in the Edinburgh Railway-cuttings, &c., and in every instance, unless when evidently distorted by the trap-rocks so common all over Fife, having similar dips and lying at similar angles. It thus seems very evident that the upper members of the Old Red Sandstone series are, in Fifeshire, found conformably reposing the one upon the other, and are also conformably overlaid by the Coal-formations.

The connexion of these Upper Old Red Sandstone rocks with the Lower, the equivalents of the Forfarshire flagstones, is much more obscure. Not only is no continuous section of these exhibited in Fife, but, as is the case to the south of the trap-rocks of the Ochills, in that county, it is only the upper members of the series that are found. In like manner it seems to me, that the detached patches of sandstones found along the north flanks of these hills, and in the Fife banks of the Tay, belong altogether to the lower division, although it must be confessed that only one locality (Park-hill) affords undeniable evidence of the age of any of these patches.

In Dr. Anderson's 'Monograph of Dura Den,' it is stated that "they (the upper rocks) are always unconformable to the grey sandstones, when seen in conjunction, as in Rossie Den, Balruddery, Park-hill, and Wormit Bay." I much regret that I cannot confirm the Doctor's observations, as, had they been correct, they would have set the matter at rest. Rossie Den and Balruddery are both in Perthshire. I may, however, remark that nowhere in Balruddery Den are the Upper Old Red Sandstones found. Rossie Den I have never carefully examined. Park-hill is the only locality in Fifeshire where I have yet found positive proof of the existence of the lower beds. That they are there developed is clearly shown by the remains of *Pterygotus*, and that very characteristic although obscure organism, the *Parka decipiens*, so named from this locality. The dip here is a little to the east of south, and at an angle of about 12°. A concretionary limestone having a similar dip and inclination, and agreeing in character with the concretionary limestones of Forfarshire, is also here found. I believe that in this same locality, but to the north-east, a red-sandstone quarry formerly existed, in which *Holoptychius*-scales are said to have been found; it is now quite obliterated, its site being converted into arable land. I could never ascertain the inclination of these sandstones; they must, however, have formed a continuation of the red Holoptychian sandstones of the Carse of Gowrie, as, were they in connexion with the Park-hill flagstones, they must have underlain them, being considerably to the north-east of the Park-hill quarry, while the beds there dip towards the south and east. Along the Fifeshire banks of the Tay, the character of the rocks is for the most part plutonic; several patches of sandstones, however, are found, but, so far as I am aware, in only one place (Wormit Bay) in sufficient quantity to afford satisfactory evidence of their character and dip. In Wormit Bay they are of a greyish-brown colour, rather micaceous, and somewhat indurated: the lithological character so closely resembles that of some portions of the Forfarshire sandstones, and so little that of the upper red sandstones of Fife, that, although unable to detect any organic remains, I have no hesitation in regarding them as a portion of the lower formations, *i.e.* the Forfarshire series: their dip is towards the south and a little east, at an angle of about 25°, which more nearly coincides with that of the Park-hill flagstones than with that of the upper portions of the series; but in no place in this Bay are the upper and lower beds found in contact. A conglomerate, having an indurated matrix, is found near Balmerino Harbour; but it shows no features sufficiently marked to indicate its alliance to either the great lower conglomerate of Forfar or the upper of the Lady Burn at Cupar. Some indurated shales are also thrown up here amongst the trap and this conglomerate; and, a little to the west, patches of conglomerate and red sandstone are found in the Birkhill plantations, but nowhere affording satisfactory evidence of position.

In the great conglomerate so largely developed in Forfarshire, the pebbles, although consisting of many varieties of porphyry, quartz, jasper, and such like, are all much water-worn and well rounded, while the matrix, sometimes soft and friable, sometimes indurated, and sometimes trappean, is almost always highly siliceous or argillaceous, seldom or never calcareous. In the overlying unconformable conglomerate at White Ness, composed mostly of disintegrated portions of the lower rocks, the general character of the pebbles is similar to that of those in the older formation. With these, however, are included subangular fragments of the older red sandstones and conglomerates, while some portions of the matrix are highly calcareous; indeed, occasionally the cementing material is altogether composed of calcspar. In its lithological character and structure, the Fife conglomerate, as exposed in the Lady Burn and elsewhere, much more nearly resembles the latter than the former; there subangular fragments of red sandstones are mixed up with the pebbles, and in some strata they are imbedded in a matrix almost entirely composed of coarse calcareous matter.

No direct evidence is thus afforded in the Old Red Sandstones of Fifeshire as to the relative position of the upper and lower members of these formations. No doubt can exist as to the sequence and conformability of the upper series and the overlying Coal-formation; but they are so completely cut off from the lower formations, that, although the direction and angle of their dip seem slightly different from that of the lower series, yet these latter occur in patches so isolated and so much broken up by the trap-rocks, that little reliance can be placed upon their observed inclination and relative position. The unconformability of the White Ness conglomerate to the underlying sandstones and conglomerates of Forfarshire cannot for a moment be doubted; and the many characters in common between it and that in the Lady Burn at Cupar are so marked, that I have little hesitation in stating my conviction that they both belong to the same formation,—that hence the Whiteness conglomerate forms part of the Upper Old Red Sandstone, and that thus the same break and want of conformity exists in the Old Red Sandstones of Forfarshire and Fifeshire which has been so well shown by Mr. Geikie to take place in those of the South of Scotland. Yet it must be confessed that the lithological character of our rocks changes so frequently that this can only be looked upon as presumptive evidence, and by no means as sure proof. In order that this notice of these sandstones may be more readily understood, I herewith give a sketch-map of that part of Fifeshire referred to in this paper, in which I have laid down the approximate boundaries of these upper and lower formations. These boundaries, however, can only be looked upon as mere approximations, as the junctions in, I may say, every case are deeply buried under the alluvium of the valley of the Eden; and this, as well as most of the other streams running along the strike of the rocks, affords no section of them.

The Fossils.—Regarding the Palæontology of the Old Red Sandstones of Fifeshire, in the lower series the only fossiliferous beds I have yet observed are those of Park-hill, and here the *Parka decipiens* was first noticed, and so named, by the late Dr. Fleming; and during a visit I paid to that locality last summer, Dr. Anderson, who kindly accompanied me, and pointed out the various localities in the neighbourhood of Newburgh, picked up a piece of shale having a small portion of a plate of *Pterygotus Anglicus* beautifully impressed upon its surface. Besides these, I am not aware of any organisms belonging to these lower formations having been as yet found in the county of Fife. As to the upper series, no fossils have been found in the conglomerate; and, in the red sandstones, only scales and other portions of *Holoptychius* have yet been discovered. These organisms extend upwards into the overlying yellow sandstones. The only locality which has as yet proved richly fossiliferous is Dura Den, so justly celebrated for its various genera of fossil fishes; these have already been so frequently and, especially of late, so ably described by Professor Huxley in the Tenth Decade of Plates published in the Memoirs of the Geological Survey, that it would not only be presumptuous but superfluous in me to give any lengthened description of them; but having had, since the diggings for the British Association were commenced in 1860, opportunities of examining several hundreds of those fishes (I may especially refer to a collection lately made* for, and now in the Museum of, the Philosophical and Literary Society of St. Andrews), I intend to notice some points which seem to me either to differ from previous descriptions of, or to add to our information regarding, these divisions of the Old Red Sandstone.

Holoptychius.—Such very considerable alterations will yet require to be made in the classification of the fishes hitherto described as belonging to this genus, that I intend this to form the subject of a future communication; in the meantime I would merely remark that only two species of *Holoptychius*, *H. Andersoni* and *H. Nobilissimus*, and of the latter only detached scales and other fragments, are, in my opinion, found in the sandstones of Dura Den.

* By permission of Mrs. Dalgleish, on whose estate this deposit is situated.

Glyptolæmus.—The specimens of this genus that I have examined differ in no respect from the description given by Professor Huxley. Some small specimens seem to indicate the possibility of the existence of more than one species; but of this the proofs are as yet indistinct.

Phaneropleuron.—The genus *Phaneropleuron* is very readily recognized by the ribs being so distinctly exhibited in all specimens that I have yet seen. This seems to have been occasioned both from the ribs being ossified, and also from the scales being very slenderly attached to the integument, and hence being seldom found on the body at all, and thus the neural and hæmal spines, being only covered by a very thin skin, are distinctly seen, while in fishes covered with firmly attached and strong, thick scales, such as *Holoptychius* and the like, even had these been ossified as in *Phaneropleuron,* they would have been completely hidden from view. One or two scales only in any of the specimens have been found occupying their proper position, many others being scattered over the surface of the slab. These scales had been very thin, compared with those of *Holoptychius* or *Glyptolepis,* ornamented on half the scale with rather well-marked, radiating, curved ridges, the other half having delicate radiating striæ. This sculpturing seems, as in many other of these fishes, to vary in different parts of the body. They were of a circular or, rather, elliptical form, and in a fish about fifteen inches in length were about half an inch in diameter. None of the specimens that I have yet examined show the under part of the head; and, in all, the cranial bones are very indistinctly preserved. The opercular bone seems to have been large and particularly strong, as it is well preserved in most specimens, even in those where every other portion of the head is quite obliterated. What appears to have been a coracoid is indistinctly preserved in some. The anal, caudal, and dorsal fins seem to have been united, the dorsal having been certainly extended along the posterior half of the body. On one or two specimens there are indications showing the probability that this fin was continued along the half of the remaining portion of the body, if not all the way to the occiput, as described in the 'Decade.' This fin increases in height posteriorly, but, instead of being truncated, appears to have been rounded off posteriorly, the body of the fish gradually lessening in circumference, and extending all through. The caudal fin appears to me to have been almost diphycercal in character, the upper and lower lobes being nearly equal in size. The ventral fin is better preserved in the specimen figured in the 'Decade' than in any other that I have yet seen; it is, however, distinctly marked in one or two. The pectoral fin also is preserved, although less distinctly shown. These fins were very similar in character: the pectoral was rather larger than the ventral; both were acutely lobed, and had, as stated in the 'Decade,' the edges fringed with delicate fin-rays. In all other respects, in so far as my observation goes, they coincide with the description given in the 'Decade.' Nor are there the slightest grounds for the supposition that more than one species of this genus exists in the Dura Den sandstones.

Pterichthys.—Several specimens of this genus have been disinterred of late, one of which, in the St. Andrews Museum, exhibits a rather complete view of the form and arrangement of the dorsal plates; while another has the ventral plates so distinct, that, although imperfect on one side, their form and arrangement can be very satisfactorily ascertained. Sir Philip Egerton's most interesting paper in vol. iv. of the Quart. Journ. Geol. Soc. has so fully exhausted this genus, that I have little, if anything, to add to it. All the specimens which I have yet seen of this fish from Dura Den fully corroborate the correctness of the views advanced in that paper; the principal peculiarity of the Dura Den species (*Pt. hydrophilus*) being the great length and the slender form of its pectoral appendages, these much exceeding in this respect any of the older-known species, although in turn outdone by the lately discovered *Pt. macrocephalus* of the yellow sandstones of Farlow*. In *Pt. hydrophilus* these appendages are about equal in length to the body. No other species of this fish is found in Dura Den.

Platygnathus and Diplopterus.—No vestige of these genera has yet occurred to me in the many fish-bearing slabs from Dura Den I have examined. Judging from the drawings given in Dr. Anderson's 'Monograph,' I have little doubt that what is there figured as *Platygnathus* was a fully developed tail of *Holoptychius* or *Glyptolepis*; and what is given as *Diplopterus* was merely an imperfect and distorted head of *Glyptolæmus*.

Glyptopomus.—I have only seen one very imperfect specimen of this genus, and thus can add nothing towards completing its restoration.

Glyptolepis.—Perhaps the most interesting result of the late explorations in Dura Den has been the discovery of the remains of a fish seemingly belonging to this genus, as pointed out by Mr. Page. The creature in this specimen appears to have been so doubled up and twisted, that the head and shoulders lie very nearly at right angles to the body. Its length appears to have been not much under 2 feet, with a depth, at its greatest diameter, of about 4 inches; but, from the twisted condition of the body, these can only be tolerably near approximations. The body was of about equal thickness from the pectoral region to nearly that of the anal and posterior dorsal fins, and from thence it gradually tapered off to the caudal extremity. The posterior dorsal and anal fins are opposite, and placed at less than their length from the tail-fin. In this specimen, these and the caudal fin are well preserved. The caudal fin has much of the diphycercal character, the under lobe only slightly exceeding the upper in size. The posterior dorsal fin seems to have been obtusely lobate. The exact position of the anterior dorsal is not well shown, from the twisted condition of the fish; sufficient, however, is preserved to show that it was placed far back on the body, less than its own length in advance of the posterior. The remains of what might have been a ventral, or more probably a pectoral fin, are also distinctly marked. None of these are sufficiently entire to show the lobation, if, as seems

* Quart. Journ. Geol. Soc. vol. xviii. p. 103.

highly probable, they possessed lobes. The fins are rayed, and the rays appear to have subdivided as they approached their extremities: they are very large. The head is rather small in proportion to the size of the fish, short and depressed. The cranial bones appear to have been sculptured, but are very imperfectly preserved; two large parietals, placed in close juxtaposition, but distinct, are the only tolerably entire portions of the skull. There are also the remains of what look like three occipital plates, and also of what I suppose to have been a supratemporal bone, of considerable size. The under side of the head is not shown. The scales are cycloid in form, and in this specimen nearly half an inch in diameter; they were thick and strong, although less so than those of *Holoptychius*. The general character of the markings on the scales shows very minute, granular, radiating striæ,—the granular markings being so arranged as to have the appearance of concentric circles. This marking, however, appears to have been occasioned by the internal structure of the scales. In a few the external sculpturing is partially preserved; these seem to have all the characteristic sculpturing of the scales of *Glyptolepis*, their surface being divided into two nearly equal portions, the one covered with small tubercles in lines radiating towards, but not reaching, the centre, the other having distinctly marked ridges, becoming rather fainter towards the edge of the scale. Extending beyond, and in the same line as that in which the posterior portion of the body of this fish lies, are a great number of scales, of the same character as those covering its body, as if, when first laid down, the creature had been extended at full length, but before being finally entombed it had been folded over, leaving a large number of detached scales on the sand where it first lay, and these had been afterwards covered up and preserved.

On the same slab the impression of another fish, about 9 inches in length, is also preserved. This, although very imperfect, seems, from the character of its scales, &c., to have belonged to the same genus; while, on carefully examining other slabs, many scales, sometimes singly, sometimes in masses, and having the same characteristic markings well preserved, are by no means uncommon.

The general features of this fossil seem to ally it so closely to *Glyptolepis*, that I have little doubt that it will be found to belong to that genus; but in several features it diverges considerably from any of the species I have yet seen: the scales, although similarly ornamented, have the sculpturing larger and more prominent, the fins are more fully developed, and while the caudal fin in the others is described as heterocercal, in this the upper and lower lobes are very nearly equal.

Conclusion.—The Dura Den sandstones have thus, up to the present time, yielded six well-marked genera, viz. *Holoptychius*, *Glyptolæmus*, *Phaneropleuron*, *Pterichthys*, *Glyptopomus*, and *Glyptolepis*. Each of these genera seems there to be represented only by one species, with the exception of *Holoptychius*, and even in this genus the existence of more than one species is doubtful. Nowhere else, all through the upper red and yellow sandstones, has anything beyond mere fragments of bones and scales of fishes as yet been found, these generally belonging to *Holoptychius nobilissimus*. Whether these upper yellow sandstones shall hereafter be classed as Upper Old Red, the lower beds of the Coal-measures, or as passage-beds, it appears to me that, although they are conformably overlain by, and very much resemble in lithological character, the white Carboniferous sandstones, yet a very great change of conditions must have occurred between their times of deposit. The character of the organic remains in these is so marked, and so different in the two, that even want of conformity could scarcely more exactly define the boundary between them. Although, all through the upper red and yellow sandstones, scales and other fragmentary remains of fishes are abundant, yet in no instance have I ever been able to detect any organism showing decidedly vegetable structure; and in the overlying Carboniferous sandstones, while vegetable remains are in great abundance (very perfect specimens of *Sphenopteris*, *Lepidodendron*, and other Coal-plants being found in almost every layer), no fragments of any Fish, so far as I know, have yet been found. Another almost anomalous peculiarity may be noticed, namely, that while Coprolites are common in these Carboniferous sandstones, I have never yet detected any in the fish-beds of Dura Den. I may add, that whereever Fishes are found in the Forfarshire flagstones, there Coprolites are in abundance.

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6. *On some* Upper Coal-measures, *containing a bed of* Limestone, *at* Catrine *in* Ayrshire. By E. W. Binney, Esq., F.R.S., F.G.S.

Some years since the writer described, in a short communication read before the Society and printed in the Quarterly Journal*, the breccia at Ballochmoyle and the red and purple strata found near Catrine in Ayrshire. As to the latter, he expressed no opinion whether or not they were Permian or Carboniferous, evidence being then wanted to decide that question; but his impression was that they were Carboniferous strata much higher in the series than any which had yet been described in Scotland. A visit to the locality a few days since enabled him to establish beyond doubt that the strata at Ballochmoyle Braes, Catrine, and Sorn represent a coal-field as high as any in the English series,—in fact, one similar to those at Ardwick, near Manchester; Uffington and Leebotwood, near Shrewsbury; Buxterby, near Nuneaton; and Lane-End, Potteries. Mr. Ralph Moore, in his valuable sections of the Scottish coal-fields, gives the Ayrshire strata as follows:—

	fathoms.
Upper Coal-series	313
Limestone series	52
Lower Coal-series	200†

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* Quart. Journ. Geol. Soc. vol. xii. p. 138.

† "Papers on the Blackband Ironstone of the Edinburgh and East Lothian Coal-field, and the advantages to be derived from their development, read before

In the remarks accompanying the 'First Sketch of a New Geological Map of Scotland,' published in 1861, Sir R. I. Murchison and Mr. Geikie say, at p. 13,—

"Another chief feature of the present map, as distinguished from all other maps of the country, consists in the subdivision of the Carboniferous formation.

"This group of Rocks consists in Scotland of the following members:—

Scotch Series.	English Equivalents.
Upper or Flat Coals	Coal-measures.
Moor-rock, or Roslyn Sandstones	Millstone-grit and Upper Limestone-shales.
Lower or Edge Coals Carboniferous Limestone	Carboniferous Limestone.
Lower Carboniferous	Lower Limestone-shales.

"The Upper Coals represent, wholly or in part, the true English Coal-measures, which lie above the Millstone-grit. They occur, in Scotland, in four basins,—one in Mid-Lothian, a second in Fife, the third and largest along the Clyde, south-east of Glasgow, while the fourth occupies a small area in Ayrshire. The position of the Millstone-grit has not yet been satisfactorily traced, and is therefore not shown on the present map. The Lower Coals are understratified in their higher and lower portions with seams of marine limestone, the fossils of which identify the series as the equivalent, partly terrestrial, partly marine, of the Carboniferous Limestone of England."

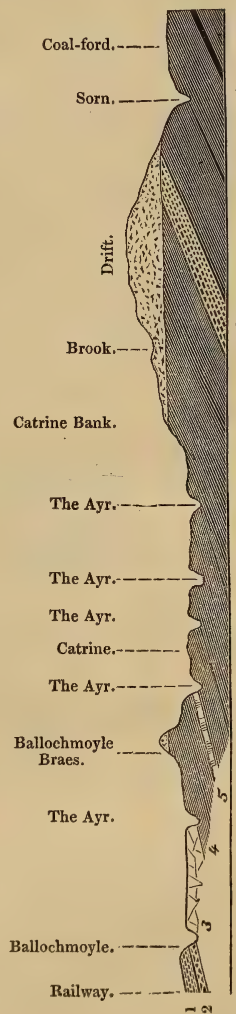
The above authors are quoted to show what information has lately been published on the divisions of the Scottish coal-fields; but, so far as my knowledge extends, no evidence, either in England or Scotland, has come before me which decidedly establishes the terrestrial character of a single fossil, either vegetable or animal. With Mr. Moore, also, I consider that the Upper Coals occupy a somewhat larger area in Ayrshire than the authors of the map have afforded them. But, on the other hand, Mr. Moore appears to have taken in all the Permian sandstones, as belonging to this division; so that the correct area will probably lie between the two views. It is quite clear that both the divisions of the authors are convenient and natural, and will greatly assist in investigating the country.

After an examination of the English and Scotch coal-fields, my opinion is that the Muir-stone Rock occupies nearly the position of the Millstone-grit; but the lower portion of the Middle Coal-measures of Lancashire and Yorkshire is represented by the Ayrshire beds at Common, worked by Mr. Lancaster, of the Portland Iron Company. Beds of *Anthracosia*, so far as my experience goes, are not of great value, when taken alone, in identifying particular strata in the Coal-measures; but if one fossil has more value than another, it is the large *Anthracosia* (*A. robusta*) found about 65 yards above the "Arley Mine" of Wigan. Now in the black-

the Royal Scottish Society of Arts, by Ralph Moore, Mining Engineer, Glasgow, with coloured plans and sections of the coal-fields in the Counties of Ayr, Renfrew, Dumbarton, Stirling, Linlithgow, Edinburgh, and East Lothian." Glasgow, 1861, p. 9.

band ironstone at Common this fossil occurs; and, from its occurrence there, coupled with other circumstances, my belief is that the Common strata represent the lower portion of the middle division of the Lancashire Coal-measures. At Sorn the upper portion of the middle division is met with; whilst the Catrine and Ballochmoyle strata represent the higher part of the middle and the upper series of Lancashire.

The section (fig. 1) which it is my intention to describe is seen in the Valley of the Ayr, and extends over three miles. It commences with the Glasgow and South-western Railway Viaduct over the Ayr at Ballochmoyle, and continues through Ballochmoyle Braes, Catrine, and Sorn to the Coal-ford at the latter place.



W. Fig. 1.—*Section in the Valley of the Ayr, from the Glasgow and South-western Railway to Sorn Coal-ford.*—Distance 3 miles. E.

Since my observations made on the Permian sandstone and breccia six years since*, little information has been published, with the exception of a paper by Professor Harkness, F.R.S., on the Permian rocks of Scotland†, who, at p. 262 of his paper, states:—"In going up the stream [the Ayr], from the higher to the lower beds of breccia, we come upon a trap-dyke, which cuts off the beds, and from which the fragments entering into the composition of the breccias have been obtained; and on the eastern side of the dyke we have Carboniferous grits similar to those which surround the sandstones of the Thornhill area."

After a second examination of the dip of these strata, it appeared, by an observation near the small iron gate by the river-side opposite the old quarry, to be at an angle of

* "On the Permian Character of some of the Red Sandstones and Breccias of the South of Scotland," vol. xii. of the Society's Journal, p. 138.

† "On the Sandstones and Breccias of South Scotland, of an age subsequent to the Carboniferous Period," vol. xii. of the Society's Journal, p. 254.

15° to the west. At this place the plane of the rock appeared to be a true one; but it must be borne in mind that there is a great deal of false bedding in the strata, so that my old observation, which made the angle of dip only 8°, is not to be altogether discarded. The sandstone was observed running into the underlying breccia in tongue-shaped masses. The last-named deposit was also carefully examined for other stones than trappean rocks, but none were met with. There was perhaps one exception, in which pieces of rounded quartz, of a white colour, were seen. This specimen was not, however, observed *in situ*, but occurred in the river-course, and might have come from a distance. The fragments of the trap in the breccia were, for the most part, angular; but some few of them had lost their edges. A considerable time was spent in attempting to find the breccia in absolute contact with the trap-rock on the east side of the former, in order to determine whether or not the former passed into the latter and was interstratified with it, or if the trap was intrusive. The appearance of the amygdaloidal rock in contact with the hardened wall of red sandstone, on the Catrine side (fig. 2), would nearly lead to the belief that the trap was intrusive, as some portions of the red sandstone are mingled with it; but still such hardened sides are not dissimilar to what are sometimes seen on the sides of a great fault.

Fig. 2.—*Sketch of the Red Sandstone in the Trap-rock; looking Westward.*

a, a. Trap-rock.
b, b. Red Sandstone.

The range of the trap here was N.W. and S.E.; and it did not present any apparent dip; but on the Ballochmoyle side, near Howford Bridge, the beds appear to bend, and then dip to the N.E. At this place also beds are seen in them having the appearance of crumbling ashes. At the point of contact between the trap and the red sandstone, on the eastern side at Catrine-Holm, the latter rock contains small portions of the blue and green carbonates and the sulphuret of copper, as well as metallic copper. My specimens were small, and obtained at the surface, but it is probable that better specimens might be discovered in cutting down by the side of the trap. Native copper is not very common in Scotland, this being, in fact, the first instance of its occurrence in Permian or Carboniferous strata there which has come to my knowledge.

The high bank above Catrine-Holm, known by the name of Ballochmoyle Braes, dips due west at an angle of 15°, which exactly agrees with the dip of the Permian strata on the western side of the trap before mentioned, and would appear to sanction the conclusion that the latter was stratified and not intrusive. However, although the trap is placed in the section as interstratified and not intrusive, my opinion on the matter is not very decided either one way or the other, until further and more decisive evidence can be obtained.

The following is a rough section of the strata in the cliff at Ballochmoyle Braes:—

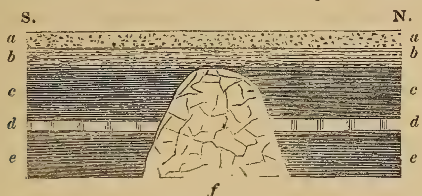
		feet.	in.
Drift.	Brownish clay	9	
	Angular gravel, with scarcely any sand in it*	3	
Upper Coal-measures.	Purple sandy clays	12	
	Purple and variegated sandstones and clays	36	
	Limestone	0	8 to 10
	Purple grits and clays	30	

On my first visit to Catrine, owing to my not having had access to the grounds at Ballochmoyle, the limestone was not noticed. This bed is very interesting, as it contains specimens of *Spirorbis carbonarius* and a *Cypris* (?), probably *C. inflata*. Its fracture is conchoidal, it has a porcelain-like appearance, and it resembles the upper limestone found in the higher Coal-measures at Ardwick, near Manchester, so completely that no person could distinguish the one from the other. Like that bed, it presents a mottled appearance, and lies imbedded in variegated shales and clays, and, in all probability, will prove as valuable a hydraulic lime.

On looking westward at the cliff, as it faces you, the dip of the strata being into the hill, a singular mass of rotten whinstone in compressed spheroidal masses appears. At its base it was about 20 yards broad, and appeared to taper towards its top.

The accompanying woodcut will show how it occurs.

Fig. 3.—*Section at Ballochmoyle Braes.*



a, a. Drift; 12 feet. *b, b.* Red and variegated grits and shales; 12 feet. *c, c.* Red shales and grits; 36 feet. *d, d.* Limestone; 10 feet. *e, e.* Red shale and grit; 30 feet seen. *f.* Trap-rock.

The sides of the strata on the south side of the whin looked a little hardened, and presented the appearance of having been heated for a short distance; but those on the north side could not be observed, owing to a mass of fallen soil and rock. The whin did not appear to have disturbed the overlying strata, or to have displaced them at its sides.

Red and purple-coloured Coal-measures, consisting of beds of gritstone and shale, are seen in the bed and on the banks of the River Ayr all the way to Catrine Bridge, their dip being to the west at angles varying from 15° to 18°. About 80 yards above the bridge, in some bright-red clays, fossil plants, of the genera *Pecopteris*, *Neuropteris*, and *Lycopodites*, and a small bivalve shell, were met with, but in such a bad state of preservation that their specific characters

* This bed of gravel is very interesting, and deserves a separate notice. From its position it was difficult to examine carefully; but it is evidently the lower bed of a deposit of valley gravel, and shows that the waters of the River Ayr once flowed at a much higher level than at present.

are difficult to make out. The plants reminded me of the flora at Ardwick; but better specimens are required than the flooded state of the river allowed me to collect before they can be identified with those fossils.

A little above the bleach-works bridge at Catrine is seen a bed of red clays containing spheroidal bodies, having concentric laminæ of a greenish-blue colour, and containing a black speck in the centre. For the whole distance between the old bridge and the bleach-works bridge, the Coal-measures, especially the fire-clays, have a bright-red appearance, and look as if they had been burnt. There appears to be something like Stigmaria-rootlets in them, but not very distinct.

Beyond the red clays is a small bed of red gritstone, having fossils bearing a resemblance to bifurcating stems, of about an inch in diameter, on its surface. Next comes a coarse-grained sandstone of a purple colour, which is fractured by a fault running from north-west to south-east, the extent of which cannot be seen. Proceeding up the river, the strata soon again recover their original dip to the west, and are seen in its bed up to Nimmo's Braes, where they disappear and are covered up with soil. Opposite to the Burial-ground at Sorn Castle a coarse-grained sandstone, of a red colour, makes its appearance. It is of considerable thickness, and dips to the west at an angle of 15°. It looks more like a Millstone-grit than an Upper Coal sandstone, and contains white quartz-pebbles of the size of a common bean. This rock reminded me much of a pebbly bed of gritstone found in the upper part of the North Staffordshire Coal-field, near Burslem. The strata, consisting of fine-grained and laminated gritstones, continue past Sorn Suspension-Bridge, where they dip to the west at an angle of 18°, to the Cleugh Bridge. Coal-measures now and then make their appearance in the bed of the river through Sorn up to the Coal-ford, near which the strata appear much dislocated. Near this place a small seam of coal, probably one of the upper beds of the Common series, had been formerly wrought.

It would be interesting to ascertain the exact position of this seam with relation to the blackband-ironstone at Common worked by the Portland Company; for, if that could be done, all the Carboniferous strata from the Coal-ford at Sorn to the trap at Catrine-Holm could be added to the Upper Coal-measures of Ayrshire, as given by Mr. Ralph Moore in his valuable section. In a correspondence which I have had with that gentleman, he states that the seam of coal occupying the position of the Lanarkshire main coal should be about 130 fathoms above the blackband-ironstone worked by Mr. Lancaster, of the Portland Ironworks, at Common, near Auchinleck; and he places the Common blackband in the positions of the slatyband-ironstone and the celebrated Boghead cannel-coal. Mr. Lancaster, in a letter to me, states that he does not know much about the Coal-ford seam; but he thinks it has been worked for one of the thin coals lying above the Common measures. This is very likely to be the case, as the limestone-series of coals is seen on their outcrop in the River Ayr above Glenlogan House. From the old limestone quarry there to Sorn, the distance on the rise and dip of the strata is 2040 yards, a space large enough for the outcrop of the whole of the Common coals; therefore, if we assume the Coal-ford seam to be identical in position with the uppermost Ayrshire coal in Mr. Moore's section, we have 12,940 feet as the distance between the Sorn Coal-ford and the trap at Catrine-Holm, near where the bed of limestone is found. This, on being divided by 4, assuming the inclination to be one in four, which is about a fair average, would give 3235 feet, or 539 fathoms, of strata. Probably the angle of dip may, on the whole, scarcely average so much as one in four, and faults may intervene so as to lessen the thickness; but, making ample allowance for these causes, there appears to be a thickness of between 250 and 300 fathoms of Carboniferous strata in this distance which has to be added to the top of Mr. Moore's section,—a goodly addition of Coal-measures to the Scotch Coal-field, although up to this time no seams of coal have been met with in it.

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7. *On the* Geological Structure *of the* Southern Grampians. By Professor James Nicol, F.R.S.E., F.G.S.

(Abstract.)

[The publication of this Paper is deferred.]

The author stated that in 1844, and in subsequent years, he indicated that the Silurian strata of the South of Scotland are represented in the North by the metamorphosed or so-called primary strata; and he proceeded to point out that the object of the present communication is to examine the relation which the three great formations, Clay-slate, Mica-slate, and Gneiss, bear one to the other as regular constituents of the crust of the earth, and especially in certain parts of the Scottish Highlands, as illustrated by sections observed by himself. These he correlated with what is seen in other parts of the Highlands.

He also stated that, both in former papers and in his published map, he has always regarded the gneiss of the west coast and certain mica- or chlorite-slates of the interior as identical only so far as both belong to the great series of metamorphic formations inferior to the red sandstone and quartzite, but still as distinct formations with peculiar features, and, it may be, of widely different age.

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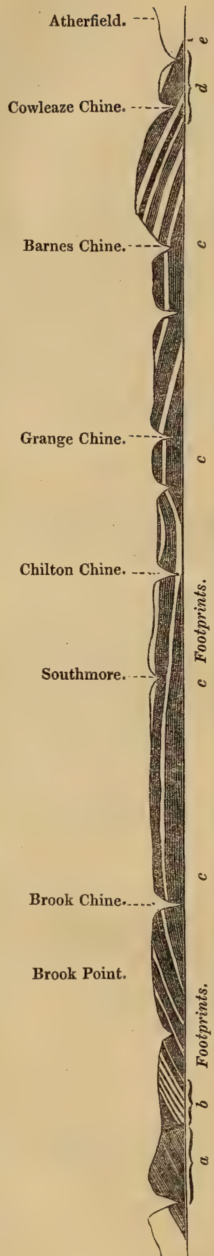
8. *On some* Natural Casts *of* Reptilian Footprints *in the* Wealden Beds *of the* Isle of Wight *and of* Swanage. By S. H. Beckles, Esq., F.R.S., F.G.S.

Since my last communication to the Society, in 1854, on the subject of Wealden Footprints (Quart. Journ. Geol. Soc. vol. x. p. 456, &c.),

*Fig. 1.—Section of the Wealden Beds, from Compton Bay to Atherfield, Isle of Wight**. (Length 6 miles.)



a. Wealden shales, overlain by Lower Greensand.
b. Wealden shales, with some Lower Greensand at top.
c, c. Red and variegated clays, with bands of sandstone.
d. Wealden shales.
e. The Perna-bed of Lower Greensand.

* This Section has been drawn for me by Mr. H. M. Jenkins, from data supplied by Mr. T. R. Jones.

I have met with several other specimens, some of them of very considerable size, in the Wealden beds near Compton Bay, Isle of Wight. Of these I have secured seven specimens. They are large trifid casts, each having the posterior portion more or less elongated, like the specimen indicated by the diagram, fig. 1, p. 396, Quart. Journ. Geol. Soc. vol. viii. One of them (fig. 2) I had raised from its natural position, as a mass attached to a thin bed of hard sand-rock, in reddish clay, on the shore at low water, between Brook Point and the Chine to the west of it (see section, fig. 1). The other specimens were found loose on the clay of the shore at low water, and were more or less worn by wave-action.

These all have the usual three divergent, toe-like projections, varying in proportional size in the several specimens, and radiating from a palmar mass; but, in addition, the hinder portion forms a long tapering projection. In the largest (figs. 2 & 3), the whole length of the block is 3 feet 4 inches, but 3 feet 7½ inches if measured along the curvature of the base; the breadth across the toes is 27 inches; across the "heel," just behind the central mass, 14 inches. The thickness, where the imprint of the toe (A) is represented by the natural cast, is 12 inches; where the palmar protuberance (C) has sunk into the pressed clay, 15 inches; and where the hinder part of the foot, or the metapodial portion, has impressed the mud, the cast diminishes gradually in width and in thickness (B), as if this portion of the extremity of the animal had been oblique to the foot, at an angle of about 25°. It would thus appear that the foot of a large and heavy animal, walking on muddy ground, sank so deep as to bring the metapodium into contact with the ground; and the inclination of this part of the foot indicates an enormous Reptilian animal, walking with its legs bent and body near the ground.

Figs. 2 & 3.—*The Natural Cast of a Footprint from the Wealden Beds of the Isle of Wight.* (About one-twelfth of the natural size.)

Fig. 2. *Lower surface.*

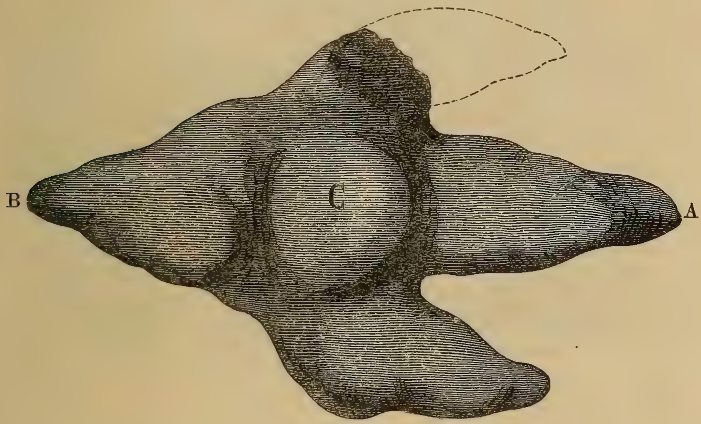
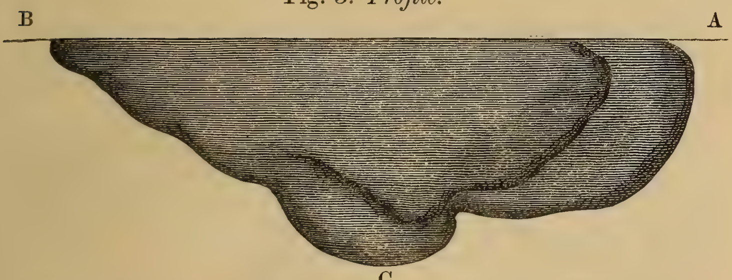


Fig. 3. *Profile.*



The central prominence (C) in the trifid casts has nearly always a somewhat lateral position towards the largest of the outside toes, and it occupies about two-thirds or three-fourths of the entire breadth of the "palm." The foot of *Iguanodon* appears to explain this. It has the distal extremity of the inner metatarsal, or that which supports the shortest toe, posterior to the extremities of the middle and outer metatarsals, so that in this case (and possibly in other Dinosaurs) the integument and flesh would here produce a pad corresponding to what I may term the heel of the palm. I believe that my largest specimen from the Isle of Wight exhibits traces of the impression of the skin in this region of the foot.

The metapodial bones of the animal making the tracks here indicated must (if the posterior impression was due solely to those bones, and not partly also to the end of the tibia) have been about the size of the largest metatarsal (?) that I have seen from the Wealden beds (Isle of Wight). This was nearly twice the size of the corresponding element of the foot of the half-grown *Iguanodon* figured by Owen; and, judging from the vertebræ with which the bone referred to was associated, I am inclined to believe it to have belonged to a *Cetiosaurus*, or possibly to *Pœcilopleuron*. Further, I possess phalangeal bones, recognized as belonging to *Iguanodon*, that indicate an individual large enough to have produced such footprints as those under notice. With regard to the three-toed character of the imprints, it is certain that other Dinosaurians besides the *Iguanodon* had the same modification of structure*; and we must not refer these pachydactylous trifids to that animal exclusively. Further, if these rough natural casts of footprints indicate with any exactitude the phalangeal proportions of the feet, we might seek to allocate the variously proportioned foot-bones of the different Dinosaurs to the differently shaped casts; but this would be too hazardous a procedure, since the real shape of the foot could have been rarely preserved aright by the clammy mud from which the great brutes dragged their flopping feet. On the firmer ground alone, such as the sandstone on which Mr. Ross has lately found the imprints at Hastings†, could the exact outline of the foot be well preserved.

Other natural casts of footprints I have found in the Wealden beds of Swanage Bay, at about 200 yards from the western end of the Wealden cliff there. They occur in two bands of sand-rock, usually about 1 foot thick, separated by about 20 feet of clay, and coming down to the sea-shore with the other beds. These casts are of the usual thick-toed trifidal shape, and of the usual size—about 15 inches long.

One specimen of footprint (not a cast), remarkable for its small size (fig. 4), being only about 3 inches long and 3 inches broad, but distinctly trifid like most of the others known, I met with on the shore of the Isle of Wight, about halfway between Brook and Brixton (see section, fig. 1). It was one of several, about 15 inches apart, on a sandstone band, at very low water.

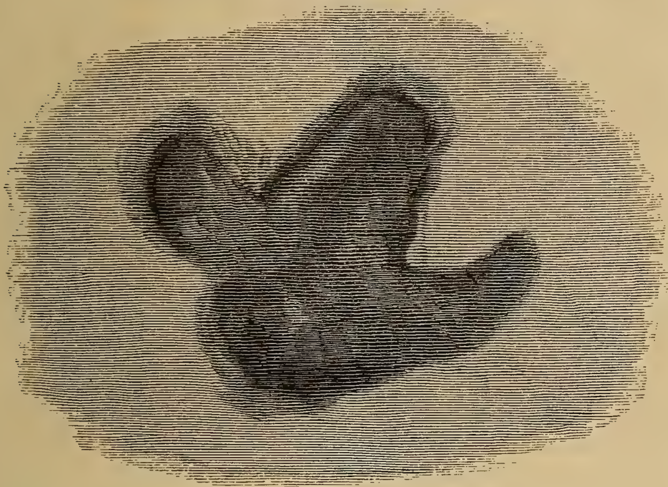
In the abstracts of my former papers, an ornithic relationship was arrived at as the general conclusion as to my views respecting the uniserial trifid footprints found in the Wealden, and my descriptions and remarks certainly gave it foundation; but in my manuscript, still in the possession of the Society, I also intimated that these bodies were probably connected with the Reptilian phalanges with which they are associated in the clay and sandstones of the

* For instance, see the metapodium of *Hylæosaurus*, figured and described by Prof. Owen, Pal. Soc. Monograph, 1857, p. 18, pl. 11.

† See the August Number of the Society's Journal (No. 71, p. 248).

Weald, and I wished to accept the trifids as representatives of the as yet unknown feet of the Dinosaurs. I find that Prof. Owen has referred to this view of the subject, both in his paper in the Society's Journal, vol. xiv. p. 175, and in his 'Palæontology,' 2nd edit. p. 293.

Fig. 4.—*Sketch of a Footprint from the Wealden Beds of the Isle of Wight.* (Two-thirds of the natural size.)



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9. *On the* Geology *of* Zanzibar. By Richard Thornton, Esq.

[From a Letter* to Sir R. I. Murchison, F.R.S., F.G.S., &c.]

Our route lay from Mombas to the S.W., over the Shimba, thence N.W. to the Kadiaro, then S.W. to the Pare, then north to the Lake Yīpe, thence through Dafeta to Kilema, where we made one attempt to ascend the Kilimandjaro, but had to turn back at an elevation of about 8000 feet. We then went round by the foot of the mountain to Madjami, thence we returned by Dafeta, Lake Yīpe, Pare, and the north foot of Usambara, to Wanga on the coast, which we reached on the 101st day from Mombas.

We did not succeed in reaching the top of the Kilimandjaro; but I have its altitude from six different stations, connected by tolerable triangles at distances varying from 15 to 50 miles. From these I believe the height of the Kilimandjaro to be about 20,000 feet.

Its shape varies much as seen from different points of view; but, from all places we have seen it, its base rises very gradually from a great plain: the outline of the top, as seen from Madjami, is a great dome (but this face is nearly flat); as seen from the east it is

* Dated Zanzibar, November 16, 1861.

conical, with the apex cut off, forming a little plain sloping somewhat to the north. The southern slope of this cone is much steeper than the northern. Several miles to the N.E. of the top, a great conical peak rises to about 17,000 feet; and about fifty miles to the west of Kilimandjaro, a great conical mountain, named Méru, rises from the great plain of the Massai to an elevation of perhaps 18,000 feet.

As seen from the east, the snow forms only a thick cap to the Kilimandjaro, with a broad tongue creeping down the south slope; and, when the sun is high, several long streaks of snow are seen lying in small ravines descending from the cap. As seen from Madjami, the snow partially covers the S.W. face of the dome (about one-fourth the height of the mountain), but several large bare patches of rock show out above the snow: the snow here seems to lie at its steepest possible angle; so that fresh snow, falling on this side, must at once slip down to the foot of the face of the dome. On one evening, at Madjami, we saw three such slips of snow in about an hour's time. On the eastern peak a few patches of snow are seen when the sun is high.

All parts of the mountain we saw are composed of lava of subaërial origin. From not reaching the top, and having seen only the S.E., S., and S.W. parts of the mountain, I cannot speak with certainty of its structure; but I think that the Kilimandjaro is the north-eastern part of an old subaërial volcano, the south-western and larger part having sunk down several thousand feet, and been partially broken up by faults. The great fault separating these two parts lies about N.W. and S.E., and forms a very steep, long, flat, south-western face to the mountain; and a high, very rugged mountain-mass lying a few miles to the north of Madjami may be the relics of the top of the original mountain.

The commonest rocks to the south and south-west of the mountain are a vesicular porphyry, with crystals of glassy felspar, and a fine, hard, stony, slate-coloured lava, slightly vesicular, and sometimes containing small black crystals. In the south-east of the mountain there is much of a similar stony lava, only generally more vesicular, and containing more of the small black crystals. Near the foot of the mountain is much highly vesicular brown lava; and at the outer edge of the south-east slope several uniclinal ridges of metamorphosed sandstone project through the lavas, which here appear to have their original slope; the strike of these ridges is about N. and S., and the dip E. at about 20°.

The geological structure of the rest of the country through which we passed seemed to be very simple. The strike of the whole is about N. and S., and the dip easterly at various angles. Our route lay through a great plain (comparatively a plain, but in reality it rises and falls a little), which stretches far into the interior. It is bounded on the south by the northern ends of the ranges of Usambara, Pare, Ugono, Anusha, &c., and to the north by the southern ends of the Endara and Bura, &c., and contains the mountains of Kadiaro, Kilimandjaro, Méru, &c. Between the Kilimandjaro and

Ugono this plain is narrowed to a neck; but it again spreads out to the west as the Great Plain of the Massai.

Commencing at the coast, we have first a band, from 3 to 5 miles wide, of coral-limestones and sandstone, &c., which is, I think, of an early tertiary age. This formation is, in common with the greater part of the country through which we passed, covered with red earth, in which I have not seen any fossils. Then comes rather higher ground, composed chiefly of yellow clay-shale; then the coast-range, which varies from 600 to 1300 feet high, consisting of flagstones and sandstones. In the former are many traces of fossils, and thin layers of carbonaceous matter; in these at Rabbai I found a few recognizable indications of a kind of Calamite (?), similar to those found in the coal-formation of the Zambesi. (The salt-water creeks of Mombas run with deep water at high tide into the foot of this coast-range.)

The general dip of this sandstone-formation is slightly seawards; but at Rabbai it is thrown by faults in various directions. The Shimba is about the highest part of this range, and presents a fine escarpment, about 800 feet high, towards the interior. On the face of this escarpment I found many blocks of silicified wood; but apparently the wood had been much decayed before being silicified. From hence, until halfway to the Kadiaro, we passed over low ridges of flagstones and shales, perfectly similar to those of the Zambesi coal-formation. The dip was to the east at about 5°. These end in a low escarpment, about 200 feet high, at the foot of which the great plain commences (but is not very level). As far as Kadiaro, where rock is seen on the surface, it is generally white sandstone, frequently containing deep circular cavities, in which we often found water. Beyond Kadiaro, metamorphism commences, ending to the south-west in many detached uniclinal ranges and hills of the metamorphosed sandstone-formation, fronting and dipping from the north-east ends of the Pare and Ugono ranges.

The high ranges bounding this plain to the north and south all appear to be uniclinal, dipping to the east. The Pare range is, I think, of old crystalline metamorphic rock, dipping to the east at a high angle. The Usambara range has, I think, a base of the same rock, capped by thick beds of the metamorphosed sandstone, dipping slightly to the east; and the Bura range, judging from its outline as seen from a distance, may have a similar structure. The eastern part of the Ugono range is of stratified rock; but the western is, I think, composed of syenite. The Anusha range appears to be of stratified rock, dipping to the east at a high angle. The Kadiaro is a high, narrow, precipitous mountain, composed of old crystalline metamorphic rock, in thick beds, dipping to the east at about 5°.

We have not reached the axis of structure of Eastern Africa; but very far to the south-west from Kiléma are seen, on a clear day, three very high rugged mountains (as high as the Meru Mountain) with conical tops, which, if not volcanic (and I think their sides are too steep, and shapes too irregular, for ordinary volcanos), may be composed of the axial granite.

10. *On a* Section *at* Junction-Road, Leith.

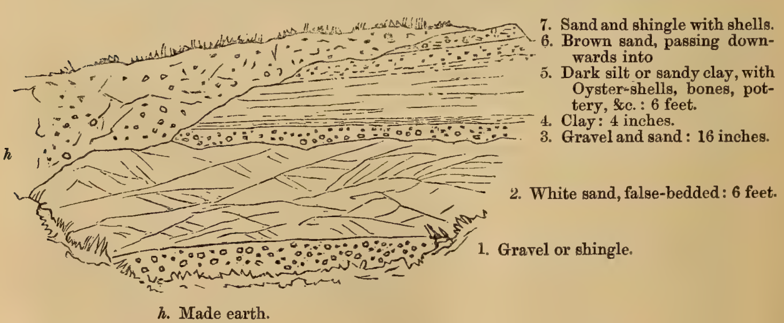
By William Carruthers, Esq., F.L.S.

(Communicated by S. P. Woodward, Esq., F.G.S.)

The investigation of changes in the earth's surface which have been effected since its occupation by man, or within the historic period, deservedly receives a large amount of attention in the present day. Any facts which will enable us to form an estimate of the time in which geological changes are produced are of the utmost value to science. Hence the importance of Mr. Leonard Horner's investigations in the Delta of the Nile, Mr. Geikie's observations on the coast of the Forth, and similar recent contributions, if based on certain and incontrovertible data, can scarcely be over-estimated. But while the multiplication of such observations is desirable, the elimination of erroneous data forming the bases of important deductions is no less so. And if the pottery raised from such a depth in the Nile sediment as to convince Mr. Horner that it was deposited there 14,000 years ago be Roman pottery, or if the Roman pottery of Mr. Geikie's Forth section be of modern manufacture, it is of as much, if not of more value to science, that such received errors be corrected, than that new truths be added.

In August last year I read Mr. Geikie's paper, "On a Rise of the Coast of the Frith of Forth*." Being in Edinburgh at the time, I visited the section which formed the basis of his hypothesis. With his sketch in my hand, I had no difficulty in recognizing the various beds he describes in his paper. But the story that the section presented to me was very different from Mr. Geikie's reading of it. The republication of his views during the past year, in popular Journals as well as before this Society †, has induced me to submit to you the grounds upon which I differ from him. I shall use Mr. Geikie's section, copied in fig. 1, and alongside of it a copy of the section

Fig. 1.—*Section at Junction-Road, Leith.* After Geikie.



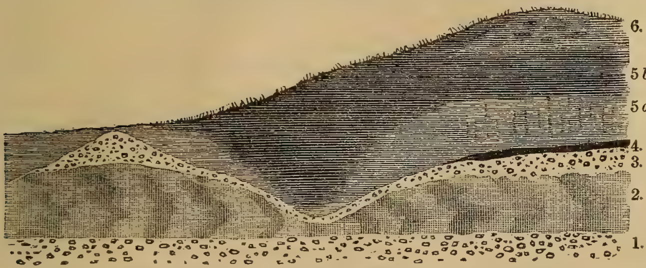
from my note-book, made on the spot, together with a section (fig. 2) of the same beds made carefully by a friend somewhat later,

* Edinb. New Phil. Journ., New Series, vol. xiv. p. 107.

† See the Memoir printed in the August number of this Journal, p. 218, &c.

when the operations of the workmen had exposed a greater extent of the beds.

Fig. 2.—*Section at Junction-Road, Leith.*



. Very recent overshot earth and sand.
5 b. Cultivated soil with cinders, coal, shells, &c.
5 a. Clay passing upwards into cultivated soil.
4. Clay bed.
3. Gravel and sand.
2. Drift sand, false-bedded; containing a medieval jar.
1. Gravel (resting on the Boulder-clay).

The basement-bed (No. 1) is a very coarse gravel, evidently washed out of the Boulder-clay, on which I observed it rested. Bed No. 2 is a considerable thickness of fine, light-coloured, blown sand. It strikingly exhibits the false stratification characteristic of materials arranged by wind. The whole of the flat on which Leith is built is covered with this sand. It comes out on the surface in the Links, where it is prevented from being blown about by a thin covering of turf. Dr. Paterson, of Leith, obtained, some months ago, from this sand a perfect jar, determined by Mr. Birch, of the British Museum, to be of medieval manufacture. It was found, 12 feet deep, in undisturbed position in the bed, when digging the foundations of a house. Dr. Paterson read a paper on this interesting discovery to the Society of Scottish Antiquaries last winter. The place at which it was found is at a little distance from Mr. Geikie's section; but the continuity of the bed between the two places has been determined during drainage-operations which have been lately carried on in the district. This medieval jar, then, which is believed by Dr. Paterson to have been deposited in its place when the layer of sand was finally arranged, occurs in a bed much older than that containing the supposed Roman pottery, and which, according to Mr. Geikie, was deposited when the Romans were in Britain.

Beds 3 and 4 are, as described, strata of gravel and clay. Bed 5 is that in which the pottery was found. It is described by Mr. Geikie as "a dark silt, or sandy clay, well stratified, having thin lenticular interlaminations of sand, with occasional oyster-valves, a few stones, and fragments of bones and pottery." It was formed as a littoral deposit like "the dark sandy mud which covers such extensive flats between tide-marks at Leith." "Whatever," he adds, "may be the contents of this bed of silt, they are undoubtedly of contemporaneous deposition." Among the contents were fragments of pottery of two kinds, glazed and unglazed, and which Mr. M'Culloch, the Curator of the Scottish Antiquarian Museum, "stated he would have no hesitation in pronouncing to be Roman, if found near a Roman station." Mr. Geikie accordingly concludes that "the existence of Roman pottery in the silt shows us that the deposition of these upraised beds was going on during the Roman occupation of Britain, and therefore that this rise (of 25 feet) has taken place since the time of the Romans."

The whole value of the section, as giving a key to the age of the deposit and a period within which an important change in the relative level of land and water in the valley of the Forth took place, depends on this bed No. 5. I therefore carefully examined it, and satisfied myself that this was not an unaltered silt deposit, but that it had been a cultivated surface, and that its contents had been placed in it by the husbandman in the process of cultivation. I could discover no evidence of internal lamination; indeed, having carefully examined it with this in view, I am satisfied that it does not exist. Moreover, the contents of the bed, viz. pottery, oyster-shells, and bones, small fragments of coal and coal-cinders, are scattered *irregularly* through the bed without the slightest approach to laminar arrangement. The occurrence of immense quantities of coal-cinders in the bed made me first doubt the antiquity Mr. Geikie gave to it; for, if the Romans, when in Britain, used mineral fuel, it certainly was not in the quantity needed to supply such a store of cinders as this supposed bed of littoral silt contains. The cinders also gave me the key to, as I believe, the true nature of the stratum. The section is at the foot of Bowling Green House *garden*, and this bed evidently at no far distant date formed part of the cultivated surface of the garden, its contents being obtained from the manure that was year after year dug into it. The base of the bed is clay of a lightish colour; this gradually darkens upwards as it has been influenced by tilling and by the organic matter thus introduced, until it becomes a rich dark soil within two feet of its surface. The two upper beds in Mr. Geikie's section are recent deposits of materials obtained from digging the foundations of houses, as is evidenced by their character, as well as by the large board exhibited at the road-side, permitting "Rubbish to be laid down here free." The different localities of the houses supplied the different kinds of overshot,—some cartloads of sand having been deposited here, of earth there, or of gravel and sand in another place; but none covering more than a few yards.

I have recently obtained a considerable number of objects carefully collected from bed No. 5. Among them are a number of specimens of both the kinds of pottery obtained by Mr. Geikie. These I submitted to Mr. Birch, of the British Museum, who, after a minute examination of every specimen, declared that they were certainly *not* Roman, but might be the work of any period since the 14th century. I subsequently submitted them to Mr. Franks, also of the Museum, and, without being aware of Mr. Birch's opinion, he confirmed it, asserting that no portion of them was older than medieval, and that all of them might be comparatively recent. In addition to this testimony it will be remarked that the edges of the fragments are invariably sharp, never rubbed as if they had been acted upon by moving water. This is also strikingly characteristic of the fragments of bones, which all apparently belong to an animal that still supplies a large proportion of the animal food of the country. But, besides these, I have obtained from the same bed more unequivocal testimony to the recent period at which it received its contents, by the discovery in it of fragments of tobacco-pipes. I neither showed these fragments nor mentioned their occurrence to Messrs. Birch and Franks, so that their judgment was not in the least influenced by them. If additional evidence were needed to show the true nature of bed No. 5, these portions of tobacco-pipes surely finally settle the matter. Mr. Geikie asserts that, "whatever may be the contents of this bed of silt, they are undoubtedly of contemporaneous deposition; in other words," he adds, to make it more plain, "all the materials imbedded in the stratum were laid down at the same time with the stratum itself." That is, according to his theory of the nature of the bed, either these tobacco-pipes on the Society's table were the work of the Romans, or the valley of the Forth has been raised 25 feet since the latter part of the 16th century, when it is generally believed Sir W. Raleigh introduced tobacco into this country.

It cannot be doubted, it seems to me, that Mr. Geikie's important inferences were based on a too hasty examination of the section, and were adopted the more readily because perhaps they fell in with opinions already held.

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11. *On the* Death *of* Fishes *during the* Monsoon *off the* Coast *of* India. By Sir W. Denison, Governor of Madras.

[In a letter to Sir R. I. Murchison, F.R.S., F.G.S., &c., dated Potucamund, November 1st, 1861.]

On steaming between Mangalore and Cananore, on the west coast of the Peninsula, I was sensible of a very offensive smell, which at last I found to proceed from the sea itself. When I landed at Cananore, I found that the sea-breeze brought in a similar smell—a little modified in intensity, of course; and, on inquiry, I found that for some time after the S.W. monsoon the sea was always very offensive,—that thousands of fish were thrown up on the shore dead. The cause of this was attributed to the mass of fresh water poured into the sea during the monsoon. In three months, 120 inches of rain, on an average, fall upon an area of, say, 60 miles in width, for the whole length of the coast-line, from each running mile of this coast; therefore there will be about 800,000,000 of gallons poured into the sea daily; but, as most of this will come out of the rivers, of course, at certain points, the quantity will be multiplied twofold. The natural consequence will be the destruction of all animal and vegetable life, which, being adapted for salt water, must die after a time in fresh water. There will, therefore, be layers of Shells covered by strata of sand and mud, Sea-weeds in various stages of decomposition, and Fish, small and great, deposited at the bottom of these seas. I saw thousands of dead fish floating, and there were, no doubt, thousands lying dead at the bottom.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the Names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Newly formed Volcanic Island *in the* Caspian Sea.

[Extract from a Report published in the 'Russian Naval Review,' translated by Lieut. Lütke, and communicated by Sir R. I. Murchison, V.P.G.S.]

On the 8th of August last, the steamer 'Turky,' in going to Asterabad, stopped (in the middle of the Caspian) at a distance of several fathoms from a newly formed island. We went to it in a boat and landed. The length of it is 23 fathoms, the breadth 12 fathoms, the height above the water 6 feet; the average depth of the sea at the distance of 5 to 6 fathoms off the island is also 6 feet. The ground is so loose yet, that the swell of the sea sweeps it away. It is very difficult to walk on the island, as the feet sink into the ground. The action of fire is to be observed all over the island. One may conclude that a short time ago it was yet in a liquid state; for the strong smell of petroleum indicates plainly a volcanic origin, and petroleum is to be seen on the stones mixed up with the earth, the whole having cooled and being now comparatively hard. In passing on the lee side of the island we also perceived the smell of petroleum.

It appears that this newly formed islet lies upon a continuation of the volcanic emanations which trend from the mud-eruptions near Kertch to the fires of Bakou, and in a line towards Asterabad.

On the Old Red Sandstone *of* Bohemia. By M. Jokely.

[Proceed. Imp. Geol. Instit. Vienna, February 26 and March 12, 1861.]

Three subdivisions may be distinguished in the Old Red Sandstone deposited along the southern or Bohemian margin of the Sudetian Mountains*. They are, in ascending order,—A. Conglomerates, with a few intercalated layers of shale and sandstones, passing upwards into a deposit of shale 180 feet in thickness. This upper portion includes beds of bituminous shale, filled with remains of Fishes and Plants, together with local occurrences of black coal, argillaceous ironstone and sphærosiderite, and (in a few cases) of traces of copper-ores. The vegetable-remains, as determined by Prof. Unger, stand

* See also Quart. Journ. Geol. Soc. vol. xvi. Part ii. Miscell. p. 38.

nearer to those from the Carboniferous beds of Waldenburg (Saxony) and of Radnitz (Bohemia) than to those hitherto known to occur in the Old Red Sandstone.—B. Arkose-sandstones and a series of thinly stratified ribboned sandstones, with micaceous shales and beds of marly limestone. This subdivision, the most extended, and overlying unconformably the strata of subdivision A, is but poor in organic remains, with the exception of silicified stems of *Araucarites* in the arkose-sandstones. A stem of *Araucarites Schrollianus*, Goepp., 24 feet in length and 3⅙ feet in diameter, has been obtained for the Museum of the Imperial Geological Institute of Vienna. A remarkable occurrence in these strata, stated by Prof. Goeppert of Breslau, is that of *Araucarites cupreus*, a species also known from the Permian strata of Russia.—C. Brownish and brick-red arenaceous shales, with subordinate layers of sandstone, marls, and bituminous slates (holding from 25 to 45 per cent. of bitumen), with associated iron-ores, sphærosiderites, and insignificant veinlets and lenticular aggregations of anthracitic black coal. These slates, constantly lying unconformably over the sandstones of subdivision B, are only met with in isolated patches, partly intercalated with the lower subdivisions. Vegetable-remains are very scarce in them; their chief characteristics are abundance of fossil Fishes and the occurrence of copper-ores, malachite, the blue and green carbonates of copper, sulphurates, silicate and black oxide of copper, and allophane, with ½ to 30 per cent. of copper, and $\frac{3}{32}$ to $\frac{4}{32}$ per cent. of silver. These ores are irregularly spread through the whole of the Old Red Sandstone; so that mining enterprises here have been generally attended with a very slight success. Probably the copper and the substances united to it in its ores have been infiltrated into the rock by mineral waters, connected with numerous operations of melaphyre. Five protrusions of this igneous rock may be traced within the Old Red Sandstone territory in question, three belonging to subdivision C, and two to A and B. The older melaphyres are characterized by the presence of amygdaloids, jasper, &c., and in some localities are cut through by melaphyric protrusions of more recent date. Porphyries between the subdivisions B and C, and effusions and protrusions of basalt are but of local and rather scarce occurrence.

[COUNT M.]

On the OLD RED SANDSTONE *of* CENTRAL BOHEMIA.

By M. LIPOLD.

[Proceed. Imp. Geol. Instit. Vienna, March 12, 1861.]

IN the circle of Prague (Central Bohemia) the Old Red Sandstone fills up the small bay of Böhmisch-Brod, about half an Austrian mile in breadth, between groups of granitic and gneissic rocks, and seems to represent (as far as its very narrow extent allows us to judge) the subdivisions B and C of the Sudetian Old Red Sandstone (see above). Melaphyres and eruptive rocks in general are wanting. Copper-ores, in the lower arkose-sandstones and marly slates (bituminous slates with seams of black coal and remains of Fishes and Plants—among them fragments of *Araucarites*), have been found in several localities. All the strata have an eastward dip, very steep along the limit of the granite, then flattening as they advance to the centre of the basin, where they become partly horizontal. [COUNT M.]

The FOSSILS *of* RUSSIA. By M. E. d'EICHWALD.

[Lethæa Rossica, ou Paléontologie de la Russie, décrite et figurée par Edouard d'Eichwald, Conseiller d'Etat actuel et Chevalier, etc. etc. Premier volume, pp. 1657, 8°; avec un Atlas de 59 Planches Lithographiées, 4to et fol. 1855–61. Troisième volume, 8°, pp. 534; avec un Atlas de 14 Planches Lithographiées, 4to et fol. 1852–55].

THE first volume of this work is devoted to the fossils of the palæozoic rocks (l'ancienne période), and is divided into two parts. Part I. (IV. Livraison, 1855) contains, 1st, an introductory description of the several groups of strata, and their geographical distribution as regards Russia, and 2ndly, a systematic account of all the known palæozoic plants of Russia, comprising 161 species in 71 genera: 128 of these species are illustrated in the Atlas. The plants are arranged in the families :—1. Confervaceæ (1 species). 2. Phyceæ (8 species). 3. Florideæ (8 species). 4. Neuropterideæ (13 species). 5. Sphenopterideæ (8 species). 6. Pecopterideæ (10 species). 7. Gleicheniaceæ (2 species). 8. Protopterideæ (8 species). 9. Marattiaceæ (1 species). 10. Selagineæ (3 species). 11. Lepidodendreæ (28 species). 12. Diplostegiaceæ (1 species). 13. Calamiteæ (17 species). 14. Equisetaceæ (4 species). 15. Annularieæ (8 species). 16. Sigillarieæ (14 species). 17. Cycadeaceæ (9 species). 18. Cupressineæ (2 species). 19. Abietineæ (9 species). 20. Noeggerathieæ (9 species). The *Terrain de la grauwacké* (1st), comprises the Cambrian and Silurian strata; 2ndly, the *Terrain carbonifère ou houiller*, comprises the Devonian and the Carboniferous; and the 3rd is the *Terrain cuivreux* or the Permian. According to M. d'Eichwald the Grauwacke formation has for its lower members.—1. Soft blue clay (with *Laminarites*, &c.), along the Gulf of Finland. 2. Quartzose sand (with *Obolus*, &c.) of Poodolowo, &c. 3. Argillaceous schists (with *Fenestella*) of Esthonia, &c. 4. Green sand (with Conodonts, &c.) of St. Petersburg and Baltischport. 5. Sphæronite-limestone of Slawänka, &c., associated with, 6. Bituminous schist. 7. Hemicosmite-limestone of Wassalem and Padis. 8. Cyclocrinite-limestone of Munalas near Wassalem, Esthonia. 9. Dolomite (*Spirifer Lynx*, &c.) of Kirna, Baltic Provinces; and 10. Dolomite (unfossiliferous) of Linden near Hapsal. The upper members are:—11. Pentamerus-limestone of Wenden, Esthonia, &c. 12. Dolomitic sandstone (unfossiliferous) of Noistfer, Esthonia, &c. 13. Compact Dolomite (without fossils) of Kuigang (Oesel). 14. Compact encrimite-limestone of Oesel. 15. Compact Eurypterus-limestone of Esthonia. The Old Red Sandstone, the Carboniferous Limestone, and the Coal-measures compose M. d'Eichwald's *Terrain carbonifère*; the characteristic fossils are mentioned at pp. 20–28. The Cupriferous Formation of M. d'Eichwald, or Permian of Murchison, is divisible into an upper and lower portion. The latter is chiefly arenaceous, not always cupriferous, but locally saliferous and gypsiferous, and often rich with fossil plants, especially in the Government of Orenburg, where also the well-known Reptilian remains occur—*Rhopalodon* (2 spp.), *Deuterosaurus*, and *Zygosaurus*. The upper portion contains calcareous beds always cupriferous (pp. 28–31).

The 5th Livraison (1859), pp. 271–748, commences the *Orycto-zoologie*, or description of the animals of the *Période ancienne*. Pages 271–323 contain some general remarks on the palæozoic fauna, and special introductions to the fossil animals of the three great divisions of the palæozoic age. Pages 325–748, the 6th Livr. (1859), pp. 749–1004, the 7th Livr. (1860), pp. 1005–1532, and pp. 1533–1635 of Livr. viii. (1861) are occupied by systematic descriptions of the *Amorphozoa*, *Rhizopoda*, *Bryozoa*, *Corallia*, *Crinoidea*, *Cystidea*, *Echinidea*, *Asteriadea*, *Ophiuridea*, *Annelida*, *Brachiopoda*, *Acephala*, *Pteropoda*, *Protopoda*, *Heteropoda*, *Gasteropoda*, *Cephalopoda*, *Ostracopoda*, *Pœcilopoda*, *Copepoda*, *Xiphosura*, *Isopoda*, *Trilobita*, *Pisces* (*Placodermata*, *Cephalaspidea*, *Ctenodipterina*, *Saurodipterina*, *Dendrodonta*, *Glyptolepida*, *Holoptychida*, *Cheirolepida*, *Sauroïdina*, *Lepidoïdina*, *Pycnodonta*, *Squalidina*, *Raiidina*), and *Reptilia*.

The 8th Livraison contains moreover a general Index to the volume, a list of Errata, Title-pages, Table of Contents, and a Preface, in which the author states that most of his palæontological researches, of which the results are given in the 'Lethæa Rossica,' were made before the great geological explorations undertaken at the cost of the Imperial Government by A. von Humboldt, G. Rose, and Ehrenberg, in 1829, and by Murchison, de Verneuil, and von Keyserling, assisted by A. von Meyendorff, Blasius, and Kokscharoff, in 1840 and 1841; and he especially refers the reader to the literature of the subject.

Volume III., forming a livraison dated 1853 (1855 on the cover), treats of the Russian fossils of the *Dernière Période ou la Période nouvelle*, comprising the Tertiary and Diluvian strata, a general notice of which, and of their fauna and flora, is given in the Introduction (pp. VII–XIX). Referring to the fossil Bison, the author gives a short account of the still existing Bisons of Lithuania (pp. XVI–XIX). A *résumé* follows the descriptions of each great group of the fossil animals; and a synoptical table (pp. 413–422) of the fossil *Invertebrata* indicates their geographical distribution. The fossil plants of the Tertiary and Diluvian periods are treated of in pp. 423–442; they belong to the *Abietineæ* (8 species), *Cupressineæ* (3 species), *Salicineæ* (1 species), *Betulaceæ* (1 species), *Juglandeæ* (2 species), and *Cupuliferæ* (4 species).

A general *résumé* of the Tertiary, Diluvian, and Alluvian deposits of the Russian Empire follows at pp. 443–518; and among other interesting subjects, the author treats of the Amber and its fauna and flora (pp. 464–472), of the Glacial and Erratic phenomena (pp. 472–487), and of the Black Soil or Tschernozem (pp. 488–509.)

[T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Geology *and* Surface-features *of* Transylvania. By Dr. Stache.

[Proceed. Imp. Geol. Instit. Vienna, March 12, 1861.]

Four great geological groups of strata, each with characteristic orographical and physiognomical features, may be distinguished within the province, striking even the superficial observer. The central portion, once the bottom of a marine basin, now filled up with the marly and arenaceous deposits of the late Tertiary period, and in many places impregnated with salt, presents fertile valleys and slopes, together with barren ranges of hills and high precipices, intersected in every direction by considerable rivers and a number of rivulets. Around this central basin runs a zone of Eocene hills (marly and calcareous strata with abundance of limestone and gypsum), conspicuous by their sharper outlines and by their groves of oaks and beeches. This zone is, as it were, the precursor of the third zone, marking the natural and political frontiers of the province by a wall of crystalline rocks with extensive, and partly as yet untouched, forests of pine and beech. The fourth or trachytic group, important on account of its metalliferous deposits, occurs in the eastern part of the province, in the shape of hilly massifs, and in dispersed and isolated patches in the western portion.

The crystalline massif on the western frontier, between Transylvania and Hungary, has the general form of a square, protruding far into the interior. The main range, running S. to N., between the water-courses of Szamos and Aranryos on one, and the Köräs on the other side, has an average altitude of 4500 feet. Three lateral ranges, of from 3000 to 5000 feet elevation, are detached from the main range, advancing eastward into the Eocene territory. The valleys and gullies in them, steep and deep (1000 to 1500 feet in the Bakato Valley), more resemble crevices than valleys.

The basis of the main S.–N. range is crystalline rocks, overlain with the red slates, grey and reddish quartz-sandstones, and white or spotted quartz-breccia ("Verrucano") of the Lower Trias. The tops and longitudinal crests consist of well-stratified blackish or grey limestones of the Upper Trias, assuming on the surface a resemblance to the Istrian "Karst Limestone" wherever they are not covered with pine-forests. The surface of the sandstone is characterized by extensive slightly convex meadows, with short grass and uniform vegetation. The limit between the Triassic limestones and these sandstones supplies the sources of most of the waters running through this wilderness. Forests on the sandstones and conglomerates are subject to devastation by storms, easily uprooting the trees, which get only an insecure hold in such soils.

Mica-schist and gneiss prevail in the three lateral ranges; this last in the centre is overlain by a broader west and narrower east zone of mica-schist. A gigantic vein of granulite, remarkably analogous to that of the Iser-Gebirg (Bohemia), runs through the central gneissic mass in a N. and S. direction. The limit between the crystalline and Eocene rocks is marked by a zone of argillaceous and amphibolic slates, including brown-iron-ores, containing 50 to 55 *per cent.* of iron. Large and numerous granite-veins and extensive masses of very pure quartz (perhaps fit for glass-manufacturing in this country so very abundant in wood) occur also in this limitary zone. [COUNT M.]

On the AMMONITES *of* VAL TROMPIA. By FR. VON HAUER.

[Proceed. Imp. Acad. Vienna, October 31, 1861.]

THESE Ammonites are found in the limestones of Monte Domaro and Guglialmo, known under the local denomination of "Medolo." This limestone is of a grey or yellowish colour, strongly impregnated with corneous silex, and is not very thick-bedded. The *Ammonites* occurring in it are changed into iron-pyrites or hydroxidated iron. Among a collection of these fossils, formed by M. Spinelli's persevering exertions, seven species may be distinguished, of which four are as yet undescribed. The remaining three species are known to occur in the Middle and Lower Lias. The "Medolo" may be considered as a geological parallel to the red ammonite-limestone of Western Lombardy; and both of these Liassic deposits are perfectly distinct from the Jurassic strata, and from the Lower Cretaceous deposits known under the provincial denomination of "Majolica."

[COUNT M.]

On the CRETACEOUS DEPOSITS *of* SOUTH-WEST HUNGARY.

[Proceed. Imp. Acad. Vienna, November 14, 1861.]

IN the Bakony Forest, these deposits, first noticed by MM. Kováts and Roemer, and explored in the summer of 1861 by MM. Stache and Paul over a rather considerable area, may petrographically and palæontologically be brought under six distinct subdivisions, some of them strikingly different in character from the Alpine and Carpathian Cretaceous strata. The nineteen species of Cephalopods occurring in them belong to the genera *Belemnites, Turrilites, Hamites, Scaphites,* and *Ammonites*; among these four are undescribed. The rest, for the most part not yet found in the Austrian Empire, are characteristic forms of the Upper Gault. All these forms occur exclusively within the subdivisions 1 and 2, distinguished by the local denominations of the "Nana beds" and the "Penzeskut beds"; no Cephalopods having as yet been found in the subdivisions 3 to 6. [COUNT M.]

On the DACHSTEIN BIVALVE. By FR. VON HAUER.*

[Proceed. Imp. Acad. Vienna, December 5, 1861.]

ONE of the most striking features of Alpine geology is the enormous development of limestones and dolomites, forming, in the north and south, secondary zones and groups of mountains, in more than one instance rivalling in height those of the Central Alpine range. Stratigraphical and palæontological investigation of the marly and arenaceous strata (the Parttnach-, St. Cassian-, Raibl-, and Koessen-strata) have led to a subdivision of these limestone and dolomite masses into Hallstatt- and Esino-strata, Great Dolomite, Dachstein-limestone, &c.

Wherever the marly or arenaceous intercalations are wanting, the determination of the relative age of these massifs, generally but scantily provided with determinable organic remains, becomes a difficult task. The large bivalves alone, termed "Dachstein-bivalves" on account of their frequent occurrence on the elevated plateau of this mountain-group, are generally spread through the massifs in question. These bivalves, which have had successively many different systematic names, are still in want of a more accurate specific determination, and of a satisfactory statement of their geological and geographical distribution. This is a task the more difficult as complete specimens, fit for the preparation of the hinge and other characteristic parts, are not easily obtained out of the solid rock.

Five distinct species of the genus *Megalodus* have hitherto been more or less confounded under the current denomination of "Dachstein-bivalve." Among them *Megalodus triqueter* (the most frequent) and *M. gryphoides* are peculiar to the Dachstein-limestone and the Koessen-strata; *M. complanatus* is characteristic of the Great Dolomite; *M. lamellosus* of the Raibl-strata; and *M. Columbella* of the Hallstatt-beds. [COUNT M.]

On some FOSSIL BRYOZOA. By DR. STOLICZKA.

[Proceed. Imp. Acad. Vienna, December 12, 1861.]

THE Oligocene fauna of Latdorf (in the Duchy of Anhalt-Bernburg) numbers a total of 158 species: among these are 47 species of *Bryozoa*, in 18 genera. Two of these genera (*Orbitulipora* and *Stichoporina*) are new; above half (24) of the species are undescribed.

The distribution of *Bryozoa* in the Tertiary deposit of the Vienna basin offers the following facts: (1) with increasing depths the

* In a Report on a Memoir by M. H. Gümbel.

Bryozoa are found to increase, the *Foraminifera* to diminish, in specific diversity; (2) *Bryozoa* are scarce in deposits of plastic clay ("Tegel") and unmixed sand; (3) a fauna rich in *Bryozoa* may be regarded as proving that the deposits containing it were formed in a moderately deep sea. [Count M.]

On the Azote *and* Organic Matters *in the* Crust *of the* Globe. By A. Delesse, For. Mem. G. S.

[Recherches de l'Azote et des Matières Organiques dans l'Écorce Terrestre. Annales des Mines, 5me sér. vol. xviii. 4e livr. et 5e livr. de 1860, pp. 151–323; and published separately, 1861.]

This memoir is especially devoted to the consideration of the amount of azote contained in various minerals and rocks, existing in them in such a state as to be given off as ammonia, either when they are heated alone or with a mixture of caustic soda and lime. In very many cases there can be no doubt of this azote having been derived from organic bodies; but, when the author makes use of the term organic matter, it must be borne in mind that, strictly speaking, he refers to compounds containing carbon and nitrogen, such as chemists usually term *organic*, without thus being necessarily derived from animals or plants.

The memoir commences with an introduction in which are pointed out the precautions necessary to avoid errors, and how it is needful to experiment on materials which cannot have been contaminated by foreign bodies, or acted on by the atmosphere. Though, when rocks contain a very small amount of azote, they may be influenced by the organic matter introduced by the infiltration of water from the surface, yet it is shown that in many cases, instead of there being any increase due to this agency, the action of the atmosphere does in reality diminish the amount of azote naturally existing in the rock at a greater depth. After describing the nature of the products evolved by the distillation of minerals and rocks, the author points out that their alkaline character is no safe criterion of the amount of ammonia given off, since it may be entirely masked by acids also evolved during the operation. Recourse was therefore had to the process usually employed in determining the nitrogen in organic bodies, viz. heating the finely powdered substance with a mixture of caustic soda and lime, in a glass tube, receiving the products in a known quantity of sulphuric acid, and determining the amount of ammonia by ascertaining the quantity of a standard solution of saccharate of lime required to neutralize the excess of sulphuric acid. Sufficient material was used to enable the author to approximately determine the amount of azote to the $\frac{1}{100,000}$th part of the substance analysed, as shown in a series of tables, in which the quantity is expressed in thousandths or decimals of thousandths, as is also the case in those quoted in the following summary.

He next considers the amount of azote in various animal products in a recent and fossil state, and shows that, though local circumstances have so much influence that one cannot with perfect certainty judge of the age of any bone from the amount of azote it contains, yet on the whole it diminishes with the age. A similar conclusion also holds good in the case of fossil shells, which, however, often contain no more than some crystallized calcite. At p. 217 (p. 67), he points out that the large amount of azote found in some bones of Hyenas from caverns and breccias indicates that they lived in France and England at an epoch when those countries were inhabited by man; and at p. 231 (p. 80) he applies the same remark to the Rhinoceros and Reindeer.

The amount of azote in various recent and fossil vegetables, and the general diminution as we pass from recent to earlier geological periods, are next passed under review. Its occurrence in graphite is an important fact in support of the opinion of that mineral having been derived from vegetable substances. In passing to the mineral kingdom, the author remarks, at p. 232 (p. 82), "that it may appear extraordinary to look for organic matters in minerals, which are usually crystalline bodies; but it is nevertheless easy to prove that they very often contain them, and that even azote occurs in determinable amount." As illustrations he gives the quantity in various sulphurets, fluor-spar, rock-salt, various ores of iron, quartz, chalcedony, opal, and such silicates as pyronene, garnet, mica, felspar, &c., as well as in zeolites, gypsum, and carbonates of lime. One of the most striking examples is that of the quartz of granite, which contains as much as 0·20 (thousandths) of its weight of azote, which is far more than the amount met with in chalk-flints, though not so much as in some opals.

Since the occurrence of azote in various rock-masses is, perhaps, the most interesting result of the author's researches, it will be well to give a more detailed account of the part of the memoir devoted to that branch of the inquiry. He says that, since erupted rocks are generally crystalline, the examination of their organic matters should necessarily give results very similar to those obtained in the case of minerals. The experiments were made as much as possible with rocks whose locality and composition were well known, and they were in a great measure collected by the author himself. Rocks having orthoclase-felspar as base, such as granite and porphyry, all contain organic matters, as is easily proved either by distillation or by determining the amount of azote. It was indeed easy to foresee this, since, as mentioned above, they had been found in quartz, felspar, and mica. The presence of this organic matter is an important fact, and serves to confirm the ideas which the author had already put forth on the origin of these rocks *. Whilst the amount of azote in the granite of Vologne is 0·15, in the quartz-porphyry of Perseigne it is 0·17, and in the minette of Wakenback it is 0·18 (thousandths). The proportion of water is also successively greater in these three rocks; and one might think that, introduced by infiltration, the proportion of azote had been thereby augmented. The author, however, shows that in a decomposed quartz-porphyry from

* "Recherches sur l'Origine des Roches," Bull. de la Soc. Géol. de la France, 2e sér. xv. p. 718.

St. Franchy the amount is 0·12, and in two decomposed granites only 0·04 and 0·03; thus showing that where granite is decomposed into sand and clay, instead of the amount of azote being increased, it is very considerably diminished. Also where granite passes into trachyte, as at Sandy Braes, near Antrim, the amount is reduced to a mere trace. Diorite, malaphyr, euphotide, serpentine, and especially variolite, also contain a well-marked quantity of organic matters. Trachyte and phonolite contain only a small quantity; but pitchstone and obsidian sometimes a considerable amount, as in the case of the beautiful black obsidian from Iceland, which contains as much as 0·15, imparting to it its black colour. This is expelled by the application of heat, and we can thus explain why it then becomes white or grey, and passes into pumice. Therefore, although pitchstone and obsidian are looked upon as volcanic glasses, they have been produced not only in the presence of water, but also of organic matter, and thus not by mere igneous action. Azote is also found in anhydrous lavas, but in such very small quantities that it may have been introduced since the formation of the rock, by atmospheric agencies. In hydrous basalts and traps the quantity is much more considerable, and sometimes amounts to as much as 0·30. However, it is an important fact in connexion with the existence of organic matter in igneous rocks, that meteoric stones occasionally contain a very considerable amount of carbonaceous matter, and even some azote; and, with reference to this, the author says that it is easy to conceive that organic matters may be formed directly and completely by the combination of their elements. The remarkable experiments of Berthelot ('Chimie Organique fondée sur la Synthèse,' 1860) prove indeed that, for a large number of them, this synthesis is possible in the laboratory. Accordingly, the organic matters in meteoric stones do not warrant the conclusions of those who have argued that they come from regions inhabited by living beings. We must, however, at the same time bear in mind that, as shown by the author, subterranean water contains organic matter, and it may thus have been introduced into minerals and rocks formed in its presence or by its action.

The various stratified rocks are those considered in detail, and the author shows that they usually contain a well-marked amount of azote; and this is especially the case with those of an argillaceous nature, which appears to have a great affinity for organic matter, and to retain it with great persistence. Of course, in the case of most stratified rocks, one may very safely conclude that the minute animals and plants, or fragments of larger organisms, mixed up with the mud at the time of deposition have furnished the organic compounds which have been shut up and retained to the present period; and in order to illustrate this, the author, in a special division of his memoir, treats on the amount of azote in recent stratified deposits, including alluvia, soils, and water. As an important fact in connexion with the subject, he shows that, although there may have been an immense excess of organic matters present, yet only a comparatively small amount is permanently retained; that derived from animals being decomposed by atmospheric agencies far more rapidly than that derived from vegetables. The quantity of azote in such rocks as clay-slate and chiastolite-slate is very striking, and in some cases amounts to as much as 0·29; yet such metamorphic crystalline rocks as talc-, chlorite-, or mica-schist and gneiss contain mere traces, and thus it should appear that the organic matters have been partially or completely destroyed where metamorphic action has been very energetic.

On the whole, the author has done good service for geology in determining the quantity of azote in a large number of minerals and rocks, as well as of other substances interesting in connexion with them; and although the amount may appear small, yet it is quite clear that its presence or absence must henceforth be borne in mind in speculating on the origin of rocks or on the changes that have since occurred in their chemical and physical constitution.

[H. C. S.]

On the Formation *of* Granite. By R. Bunsen, of Heidelberg, For.M.G.S., &c., &c.

[Ueber die Bildung des Granites. Zeitschrift der deutschen geologischen Gesellschaft, 1861, vol. xiii. pp. 61–64; and Neues Jahrbuch für Mineralogie &c., 1861, pp. 856–858.]

A strange error has for a considerable time played a great part in the geological hypotheses of the formation of granite, the correction of which will be to a certain extent a satisfaction to those geologists who think that the inferences derived from careful and well-grounded observations are threatened by the conclusions of experimental chemists. Quartz solidifies from fusion at a higher temperature than orthoclase, and orthoclase at a higher than mica. If then, assert the opponents of the plutonic origin of that rock, granite originated from a mixture of those three minerals in a state of igneous fusion, on cooling the quartz would solidify first, then the felspar, and last of all the mica. However, since the petrographical structure of granite usually indicates a different order of solidification, they maintain, further, that it was not of igneous origin. It is indeed difficult to understand how for so many years geologists should have considered such an erroneous conclusion of any value, and it is still more difficult to comprehend how even now-a-days it is still reproduced in support of geological hypotheses. No one appears to have taken into consideration*, that the temperature at which a substance solidifies when fused alone is never that at which it solidifies when deposited from solution in another substance. The temperature at

* This remark is not strictly applicable in the case of English geologists, since Sir James Hall and Mr. Gregory Watt (Phil. Trans. 1804, p. 294) have long ago used the very same kind of arguments as those of Professor Bunsen; and more recently Mr. Sorby (Report of British Association, 1858, Trans. Sect. p. 107) likewise showed by experiment that, when deposited from solution, crystals of a very fusible substance may act as nuclei for those which are far less fusible.—H. C. S.

which a chemically pure compound solidifies depends simply on its own particular nature, and on the pressure; whereas the temperature at which a substance dissolved in some other body becomes solid depends not only on its own nature, but also, and principally, on its relation to that solvent. Certainly no chemist would think of supposing that a solution would cease to be a solution when raised to a heat of 200°, 300°, 400°, or even to one at which it begins to be self-luminous—that is to say, is in what is called a state of igneous fusion (feuerflüssig). For example, whilst we consider a mixture of ice and crystallized chloride of calcium, which has become liquid, to be a solution, it would not be accurate to affirm that a liquid mixture of quartz and felspar is not, merely because it does not become liquid until the temperature is that of a red heat. Neither can there be any more doubt that what is true for solutions at a low temperature would hold good at a higher. If, as an illustration, we consider the case of a solution of ice and crystallized chloride of calcium in relation to what takes place on becoming solid, we find that, when a certain relative amount of the salt is present, the liquid begins to solidify at a heat of $-10°$ C., and then at a somewhat lower; and until the last drop has become solid, crystals of more or less pure ice are deposited, amongst which crystals of chloride of calcium are imbedded. By successively increasing the relative amount of the salt, the temperature at which the solution becomes solid may be reduced to $-20°$, $-30°$, $-40°$, $-50°$, &c., and the result is the same as before. The temperature at which the water and chloride of calcium become solid varies therefore according to the proportions in which they are mixed. It will thus be seen that the temperature at which the water solidifies can be reduced to more than 59° below the ordinary freezing-point, and that of the chloride of calcium, which when alone in a hydrated condition fuses at $+26°$, can be reduced to nearly 100° below that. Sulphate of potash, saltpetre, &c., may solidify from their solutions at temperatures which are from 600° to 800° below their point of fusion. Moreover, every one knows that on the cooling of solutions, first the water and then the salt, or first the salt and then the water, crystallize, according to the degree of their concentration. Not however to multiply examples, if in a solution of chloride of calcium containing water of which the point of fusion is 0° C., and chloride of calcium fusing at $+26°$, the less fusible does not first become solid, it is no less inadmissible to suppose that quartz and felspar would crystallize from the state of so-called igneous fusion at their own respective melting-points. On the contrary, the results obtained with all sorts of solutions are in perfect accordance with the observed facts, that in graphic granite, containing a large proportion of felspar, the quartz has crystallized before the felspar, whereas in other varieties of granite these two minerals crystallized simultaneously, or the quartz after the felspar. If then, as Rose has shown in his very recent most interesting and important memoir*, quartz does in no case pass into the amorphous modification of silica having the specific gravity 2·2 far from its point of fusion, and

* Poggendorff's Annalen, 1859, cviii. 1; Phil. Mag. 1860, xix. 32.

if this mineral could crystallize from the melted granitic mass at temperatures varying considerably, yet always below its own point of fusion, we may conclude with very considerable confidence that the silica deposited under these conditions would not have the specific gravity 2·2, but 2·6, and possess all the properties of quartz.

[H. C. S.]

On the Discovery *of the* Skeleton *of a* Mastodon *near* Nikolajew (Nicolaieff), *in* Southern Russia. By J. F. Brandt.

[Vorläufiger Bericht über bedeutende Reste eines unweit Nikolajew entdeckten Skeletes eines Mastodon; *Bulletin de l'Acad. Impér. des Sciences de St. Pétersbourg*, vol. ii. No. 3. pp. 193–195: Erster Bericht der südrussischen zoologisch-paläontologischen Expedition; *Bullet.* vol. ii. No. 7. pp. 501–507; and Einige Worte über die nähere Beschaffenheit der im vorstehenden Berichte erwähnten Skelettheile des Mastodon und die in ihrer Nähe gefundenen braunkohlartigen Holzreste, *ibid.* pp. 507–511.]

Early in 1860 the Imperial Academy of Sciences at St. Petersburg received a notice, with drawings and photograph, of the remains of a large Elephantine animal found in the South of Russia, twelve werst from Nikolajew, to which attention was first called by the army-surgeon, M. Wassilijew. From an examination of the photograph, and from information (from Admiral Butakow) as to the shape of the lower jaw, M. Brandt suggested that the remains may have belonged to *Mastodon angustidens*. "The portions of the skeletons of Mastodons hitherto found, so far as I know," says M. Brandt, "in the Middle and Upper Tertiaries of the various countries of Europe, such as Germany, and here and there in Russia, have been only isolated parts, principally molars, and more rarely fragments of the lower jaw. The Museum of the Academy possesses the half of a lower jaw, furnished with two molars, dug up in the Chersonese Government, near the town of Ananjew. Nordmann and Eichwald have described some molars of *Mastodon* likewise found in Southern Russia." M. Brandt recommended the acquisition of the Nicolajew specimen for the Academy.

In June 1860 M. Brandt sent from Nicolajew to the Academy a report of the proceedings of the expedition to that place, intrusted by the Academy to his management. After giving an account of the collections inspected at Moscow, Charkow, and elsewhere, he describes the arrival of himself and scientific companions at Nicolajew on the 31st May, and the welcome they received from Admiral von Glasenap, and the cordial cooperation of that gentleman and others in the examination of the bones and in the search for other remains.

The skeleton of the Mastodon had been found in a ravine (formed by spring-floods) about a werst distant from the village of Waskressensk (or Gorochowo), and disappearing on the Ingul, at the place where this river (an affluent of the Bug) makes a bend. The ravine bears at first, from its head, from S. to N., then it takes a N.W. direction. In the upper part of the ravine the rocky strata are denuded, and subsequently they disappear with the change of direction, and alluvial soil only is seen at the entrance of the gully.

As early as 1854, after a very rainy season, several large bones had been found here; subsequently the nearly perfect skeleton of the Mastodon was found near the upper part of the ravine, at a depth of 3 "sajen" and 2 "arschin;" the arrangement of the strata being, in descending order, as follows:—

1. Black humus; 9 inches (English).

2. A thin calcareous layer, compact, made up of shell-fragments, 6 inches thick, passing into—

3. A soft grey and white limestone, of oolitic structure, with casts of shells; 5 inches thick.

4. Soft yellowish-grey sand, here and there brownish red, with oxide of iron, harder beneath, without fossils; 8 inches.

5. Harder sandstone, alternating with beds coloured with oxide of iron, and traversed by layers of clay of various thicknesses, passing downwards into sandy clay with siliceous concretions, but no fossils; 7 feet (English).

In this bed was found the *Mastodon*; and not far off, in the same stratum, was found a layer of a kind of brown coal, an inch thick. Under this layer a stratum of limestone was observed only a few feet thick; it contained a *Cardium*. Of all these beds the bottom clay and limestone are the only two which are constant. The bones of the Mastodon skeleton that have been saved consist chiefly of the tusks and molars of the upper and lower jaws, the lower jaw, an almost perfect shoulder-blade, nearly all the ribs, a great number of cervical and dorsal vertebræ, and the tolerably perfect bones of a fore foot.

The bones were in a very fragile condition, and their extrication from the firm, moist, loamy earth required great caution. Careful drawings were made of the relative positions of the bones on the spot; and the fragments were carefully numbered, so that it is hoped they will serve to construct, in the Museum at St. Petersburg, a tolerable skeleton, that in its completeness will be one among the best of the preserved specimens of the ancient Mastodons. The bones have already reached St. Petersburg, and have been placed in their proper collocation by the Conservator Radde.

In November 1860 a supplemental notice, illustrated by drawings, of these remains, was read before the Academy by M. Brandt. The drawings are represented by a large lithographic plate in the 'Bulletin,' and are described at pp. 507–509. All the bones appear more or less displaced, some only slightly; the skull was crushed, and its bones nearly all destroyed by the action of the weather. The back upper molars lay apart from each other. The almost straight tusks, 6 feet 8 inches long, and thickest at the base, were but slightly displaced, although their alveoli had been destroyed, and they themselves broken into many pieces. The tusks of the well-preserved lower jaw were in their natural position, in sockets in a short characteristic symphysial process. The imperfect cervical vertebræ were partly displaced, and, like the most of the anterior dorsal vertebræ, were more or less broken or decayed. Only a few of the middle and posterior dorsal vertebræ were tolerably preserved; indeed, but a small proportion of them was found in their natural position. The number of the ribs remaining nearly perfect indicated, as a general rule, that all those which lay obliquely were, for the most part, in a tolerably good state of preservation. The majority of these appeared more or less dislocated, with the exception of the posterior ribs of the left side, which were only slightly displaced. The greater part of the left shoulder-blade was preserved. The right humerus, greatly displaced from its natural position, and lying close upon the vertebral column, is more entire than the left, which is, in connexion with the bones of the fore arm, crushed outwards. The figures, however, represent only a part, although certainly the chief portion, of the original depôt of the bones of the Woskressensk skeleton,—to wit, those which M. Brandt and his colleagues had been able to observe in their natural position. Before their arrival, several detached bones or fragments were found, lying scattered close to the excavation of the principal remains, and belonging chiefly to the extremities; these fragments were separately preserved, and presented to the Commission on their arrival. Moreover, the lower end of the right scapula had been sent to Odessa, to the Governor-General Count Strogonow, from whom they subsequently received it.

The bones in question are evidently a part of the imperfect remains of the bones of the extremities, which, as stated in the preceding report, had been discovered a few years ago. They lay in a superficial stratum of earth; so that the figured part of the remains, such as the lower portion of the head and the greater part of the trunk, particularly the anterior and middle portions, lay at a lower level, and were covered by a somewhat deeper layer of soil. From this disposition of the remains, it is intelligible how the displacements of the bones and the destruction of the skull took place.

The close study of the remains places it beyond doubt that they belong to an Elephantine form; and further, from the mammillated crowns of the molars as well as the lower jaw, that they are of a *Mastodon*. From the drawings which were in the first instance sent here, says M. Brandt, I was disposed to ascribe them to *Mastodon angustidens*, Cuv., *e. p. Mast. angustidens*, Owen (Brit. Foss. Mamm. p. 271), Blainville (Ostéogr. Gravigrades) = *Mastodon arvernensis*, Croizet et Jobert (Ossem. Foss. d. Puy d. Dome) = *Mastodon longirostris*, Kaup (Ossem. Foss. d. Darmstadt, p. 65) = *Mastodon Cuvieri*, Pomel (Bullet. géolog. 1848, p. 257). A closer but in nowise satisfactory study of the involved and tangled synonymy of the Mastodons led me, however, to abandon the earlier opinion formed from the drawings, in consequence of the different form of the crowns of the molars, as also the exceedingly short, straight symphysial process of the lower jaw. *Mastodon angustidens*, Cuv. (*magna, e. p.*), Owen (= *Mastodon longirostris*, Kaup), possesses a very prolonged and deflected symphysial process, half as long as the entire length of the lower jaw, with moderately stout tusks, while the crowns of the molars are characterized by the circumstance of constantly presenting in the unworn state a small and accessory outlying tubercle interposed between each pair of the strongly compressed principal tubercles on their broader surfaces.

In contrast to the characters just indicated of *Mastodon angustidens,* which would be considered identical with *M. longirostris,* it may be said that in the Nikolajew remains the symphysial process, together with the straight tusks, does not attain ¼ the length of the lower jaw. The broad surfaces of the crown-tubercles of the molars are but slightly folded, and have no accessory tubercles between them. The upper and elongated tusks are quite straight.

With reference to their form resembling that of the Tapir, the molars of our skeleton agree best with those of the *Mastodon Tapiroides,* Cuv., figured by De Blainville (Ostéogr. Gravigrades, pl. 17). The Nikolajew skeleton may therefore be referred, on the best grounds, at any rate provisionally, to *Mastodon Tapiroides.* The remains in question thus determined, since they cannot well be referred to *Mastodon longirostris,* would appear to possess a positive scientific value, and calculated to establish on more definite grounds a species hitherto accepted only from the characteristic form of the molars. At the same time they demonstrate that, at least in Europe and Russia, another species of the genus *Mastodon* existed, besides *Mastodon longirostris.*

The significant fact referred to in the preceding report is worthy of attention—that a few steps from the site of the Mastodon remains, and in one and the same deposit, there was found a layer, about an inch thick, of a rusty, incompact wood, approaching the condition of lignite. The origin of it can only be explained thus, that the place where the remains were found bore forests during the period of existence of the Mastodon, whilst at the present time its surface presents bare tracts of steppes or prairie-land. From what we know of the habits of the existent Elephants, it may also be reasonably inferred that the wood in question constitutes a part of the remains of arboreal forms, the young twigs and leaves of which furnished at least a part of the food of the Mastodons. We may lay the greater stress on this view, as the remains of our Mastodon, which were tolerably connected with each other, or at any rate not very far separated, belonged to an individual that died at no very great distance from the place where they were found. [H. F. & T. R. J.]

Note.—The Nicolaieff *Mastodon,* as above indicated by Professor Brandt, appears to belong to *M. Tapiroides*; but, as De Blainville, to whose figures the author refers, confounded two distinct species under this name, viz. *M. Borsoni* and *M. Tapiroides,* the former a Pliocene form, and the latter from the Middle Miocene deposits of France and Switzerland, it is important to add, that the Nicolaieff skeleton belongs, so far as a determination can be rested on the figures, to the *M. Tapiroides* proper of the French Palæontologists, being the *M. Turicensis* of Schinz, from the lignite beds of Käpfnach. See Schinz, Schweitz. Denkschr. vol. vii. p. 58, pl. 1. fig. 1; De Blainville, Ostéographie, Gen. Eleph. pl. 17, sup. 5 & 6[c], infer. 1 & 6[a]; Lartet, Bulletin Soc. Géol. de France, vol. xvi. p. 486, pl. 15. fig. 3. —H. F.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Occurrence *of* Liassic Plants *in the* Caucasus, *and in the* Alborus (Elbrus) Range (Persia); *and on the* Distribution *of the* Liassic Flora *. By Prof. Dr. H. R. Goeppert, For.M.G.S., &c., &c.

[Ueber das Vorkommen, &c., 'Bulletin de l'Acad. Imp. des Sciences de St. Pétersbourg,' vol. iii. No. 4 (1861), pp. 292–299.]

Fossil plants from the Lias (two species of *Zamites*) were first figured by De la Beche (Trans. Geol. Soc. 2nd ser. vol. i. pl. 7. figs. 2 & 3). Count Münster discovered a larger number on the Theta near Bayreuth, which, preserved in the Münster Collection, were described and figured by Count Sternberg and myself. Prof. C. W. F. Braun, of Bayreuth, extended these discoveries, and has supplied the most numerous and important contributions made since that time for establishing an independent flora for the Lias-formation. This flora may be said to be characterized by the prevalence of *Cycadeæ* (probably more than half of the 120 to 130 species constituting this flora belong to the Cycads) and of Ferns with reticulate venation, approaching more closely to the Ferns of the Keuper than to those of the Middle Jura. In 1843 I recognized the Liassic flora of Gaming in Upper Austria, afterwards published by Ettingshausen, as well as that of Halberstadt and Quedlinburg, on which Germar furnished a memoir. Berger has described Liassic plants from the neighbourhood of Coburg; Brongniart and Hisinger, those of Hör in Sconia; Kurr, those of Würtemberg; Andrae, those of Steierdorf in the Banat; and Buckman, those of Strensham in Worcestershire. The plants of the Coal of Richmond, Virginia, suggest, according to Jackson and Marcou, the Lias-formation.

* See also Abhandl. Schlesisch. Gesellsch. f. Vaterl. Cultur, 1861, p. 189; Jahresbericht der Schles. Ges. 1861, p. 33; and Sitzungsbericht. k. bayer. Ak. Wiss. München, 1861, p. 210.

As early as 1847 I had recognized the Lias-formation in the Caucasus (by means of fossil plants), but I have delayed to publish anything on the subject until now that Abich's latest work reminds me of it, and gives me occasion to communicate the following remarks.

In 1845 I received from Herr H. Abich, the well-known explorer of the geology of the Caucasus, various fossils, in appearance corresponding to the plants of the Coal-formation, without, as he explicitly remarks in his latest work *, making me acquainted with their geological place. They came from Tquirbul, in the circle Okriba, north of Kutais in Imerethia. The district of Okriba possesses, according to Abich, the interesting conformation of a wide and flat caldron-shaped valley, 20 wersts in diameter, which, on the southern border of the lofty range of the limestone-zone of the Caucasus, totally breaking the continuity of the Chalk-formation, that stretches to the foot of the mountain, is enclosed by it all round; only the narrow valley-cleft of the Rion gives exit to the waters of Okriba to the Imerethian plain.

The interior of this area is, according to Abich, occupied by a very thick and varied formation of clastic rocks, especially argillaceo-arenaceous laminated marl and clayey sandstones, which contain no organic remains fit for determining the geological age, excepting some not very abundant carbonized plant-remains. To these shales succeed only a coal-formation, composed of a coal-sandstone, coarse conglomerate, and coal-beds; the coal, according to Abich's section of the Urgebi Hills, on the Tserdilitsqual, near Tquirbul, having a thickness of 47 English feet, and being, for the most part, fit for economical purposes.

I could not refer the fossils collected from these strata to the true Coal-formation. Neither *Calamites* nor *Sigillaria*, *Stigmaria* nor *Lycopodiaceæ*, nor other such characteristic plants could be recognized; only Cycadaceous remains (fronds of *Pterophyllum*) appeared in the composition of these coals, bed after bed: and this was the more interesting to me, as I had formerly proved that the old coal-beds are composed each of particular kinds of plants; and in this case also I saw an example of similar conditions in a younger formation.

Among the plants, the best-preserved remains belong to a very fine *Pterophyllum*, of the fronds of which the coal appeared to be mainly composed: it stands in systematic order between *Pt. Preslianum* (*Zamia pectinata*, Br.) and *Pt. taxinum* (both from the Oolitic formation of Stonesfield); I must regard it, however, as new, and I propose to call it, not *Pt. Caucasicum*, as Abich wished, but *Pt. Abichianum*.

Pt. fronde pinnata, pinnulis integris subpatentibus, lato-linearibus basi æqualibus, approximatis apice oblique rotundatis, 18–20-nerviis, rhachi latitudine pinnularum.

[With this evidence, Prof. Goeppert considered the coal-beds in

* Vergleichende geologische Grundzüge der Kaukasischen, Armenischen und Nordpersischen Gebirge, als Prodomus einer Geologie der Kaukasischen Länder. St. Petersb., 1858, p. 104, &c.

question, and the lowest division of the Caucasian shales, to belong to the lowest division of the "Brown Jura" of the Germans, or the Lower Oxfordian stage; especially also as Abich had referred the Imerethian coal-formation to the same geological horizon as that of another coal-formation, occurring on the north side of the same mountain-district, in Mingrelia, near Goudau, between the Terek and Kuban on the Elbrous, which he had described as of Lower Jurassic age.]

A second communication of fossil plants from Herr Abich in July 1848, in better preservation and greater variety than those before mentioned, comprised many species known as characteristic on account of their wide distribution; so that I was enabled to speak more positively about them; and I was obliged to refer the plants under notice, not to the Middle or Brown Jura, but only to the Black Jura or Lias. There were species also which I have since examined, and now proceed to notice:—

1. *Tæniopteris vittata*, Brongn., also occurring in the Lias near Fantasie, and on the Theta near Bayreuth, and Veitlahm near Culmbach in Bavaria, Halberstadt, Wienerbruck, Gaming, Hinterholz in Upper Austria, Steierdorf in the Banat (according to Andrae), in the Lias at Hör in Sconia, in the Lower Oolite at Scarborough, and also at Whitby, which locality is reckoned by Bronn (Leth. Geogn. vol. ii. 1851) sometimes for Lias, sometimes for Upper Lias.

2. A *Tæniopteris*, which I had observed among the fossils from Gaming, communicated to me in 1843 by Haidinger, and at that time recognized by me as Liassic, and, on account of the strong middle nerve and stalk, determined to be either an old frond of the former or a new species, which I provisionally named *T. crassipes*. In the mean time it has been described and figured by C. von Ettingshausen * as *T. asplenioides*, so that this latter name must have preference.

3. *Alethopteris Whitbiensis*, Goepp. Widely distributed; found in the Lias in all places mentioned under No. 1, and at Lyme Regis as well as at Whitby and Scarborough in England; and at Richmond in Virginia, according to Marcou.

4. *Equisetites*. Identical with the species which C. von Ettingshausen has since named *E. Gamingensis*, from the Lias of Gaming, Upper Austria.

5. *Nilssonia elongata*, Brongn. Fragments of a leaf. *N. elongata* occurs in the Lias at Hör, Sconia, and in the Lias near Bayreuth.

Lastly, also, the coal from this locality is very similar in external appearance to the Liassic coal of Gaming and Bayreuth, and is distinguished from that of the Coal-measures in its planes of bedding being usually without the mineral charcoal generally present in the latter, and there belonging partly to Conifers (*Araucariæ*), partly to *Calamites* or even *Stigmariæ*. Hence it appears that this Caucasian formation is of Jurassic age, and should rather be referred to the Black Jura or Lias than to the Brown or Middle Jura, although

* Beiträge zur Flora der Vorwelt. Vienna, 1851, p. 31, pl. 11. figs. 1, 2, pl. 12. fig. 1; Naturwiss. Abhandl. Haidinger, vol. iv. part 1. p. 95.

Tæniopteris vittata and *Alethopteris Whitbiensis* occur freely in the lowest bed of the Brown Jura (Lower Oxfordian) near Scarborough, —a fact which should not be lost sight of.

Another opportunity for prosecuting a research in this direction was afforded me by a very interesting communication of a number of specimens from Dr. Göbel, who accompanied, as Geologist, the Imperial Russian Expedition to Chorassan under the direction of Dr. N. von Khanikoff. These fossils he collected south of the Caspian Sea in the province of Astrabad (E. Persia), east of the village Tasch, in the Alborus Hills. They were found in a coal-shale 2 feet thick, cropping out amongst alternating beds of clay, coaly clay, coal, and sandstone.

Dr. Göbel had hoped that they would indicate true coal, although as yet, after ten years' researches, M. Abich had found none in the neighbouring Caucasus. The fossils, however, do not substantiate this hope, but certainly supply an analogy to the Jurassic coal-beds discovered by Abich in Imerethia and Daghestan.

The chief plant-remains of the darkish-grey shales before-mentioned, and containing somewhat fruit-like, roundish, and longish argillaceous nodules, of inorganic origin, belong to a *Pterophyllum* very closely allied to that from Imerethia, referred to by me as *Pterophyllum Abichianum,* and indeed can scarcely be regarded as a distinct species; on this point, however, I have not quite satisfied myself. This plant is so plentiful that it occurs in every fragment of the whole collection, and is here and there associated with fronds of *Nilssonia Sternbergii,* Goepp., which occurs also in the Lias near Bayreuth. *Alethopteris Whitbiensis* and *Tæniopteris vittata* are as plentiful as the true Lias plants; and as a true characteristic plant occurs the *Camptopteris Nilssonii,* not yet known in the Caucasus, but found at Hör in Sconia, near Halberstadt, near Coburg, at Veitlahm near Culm, at Fantasie near Bayreuth in Bavaria, and of late found by Andrae in the Lias near Steierdorf in the Banat. Some fronds of *Zamites distans* (found at all the other localities except Hör) also come from the Alborus. Dr. Göbel's collection contains also a Fern in fructification, as well as an *Asplenites* and an *Equisetites,* both of which are probably new and worthy of being figured.

From the above it appears that there is as yet no evidence of the existence of the old Coal-measures in the Caucasus or the Alborus; the coal-beds hitherto found in those regions belonging to the Jura formation, and, according to the plants, to the Lower Lias.

[T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the NEOGENE-TERTIARY STRATA *of* WESTERN SCLAVONIA. By DIONYSIUS STUR.

[Die Neogen-tertiären Ablagerungen von West-Slavoniens. Von Dionys Stur. Jahrbuch d. k.-k. geol. Reichsanstalt, 1861–62, vol. ii. pp. 285 *et seq.*]

Older rocks of the Pozegan Mountains.—Besides some crystalline rocks described by the author in a former paper, these include clay-slate (probably of Carboniferous age), and an overlying felspar-porphyry and tuff which contain melaphyr in veins and in bedded masses; and also a formation, composed chiefly of a coarse conglomerate, which forms the greater part of this range of mountains.

From Maksimov-hrast, in the Tissovacer Valley, upon the southern slope of the Pozegan Mountains, and where the author first examined these strata, proceeding towards the west, it can be seen that throughout the whole of this district there prevails a conglomerate, composed of pebbles of various kinds, and only held together by a very feeble argillaceous cement. Under this stratum, besides those already mentioned, there exist the following formations, in ascending order:—

1st, A very fine-grained, laminated, shelly limestone.

2nd, A red limestone, resembling the Triassic limestone of Markovac, E. of Daruvar.

3rd, A conglomerate formed of pebbles of a dark-grey clay-slate.

4th, and uppermost, a conglomerate composed of pebbles of a fine-grained sandstone resembling the Vienna Sandstone, or the Lias Sandstone of the Alps or the Fünfkirchen Mountains.

The appearance of this stratum was quite new to the author, and, from the absence of fossils, the determination of its age was somewhat difficult. He found the Leithakalk overlying it E. of Bacindol, and the "white marl" N. of that place. South of Pozeg he saw the Pozeg conglomerate, the felspar-porphyry and tuff, and the underlying slate. Above the Pozeg conglomerate, between Maticevic and Pavlovce, N. of Neu-Kapela, there occur, first, Leithakalk, composed chiefly of Nullipore concretions, then beds of limestone with masses of *Cerithium rubiginosum*, Eichw., and *C. pictum*, Bast., upon which follows the "white marl."

The age of this conglomerate is therefore somewhere between that of the Leithakalk, on the one hand, and that of the felsit-tuff on the other. The hope yet remained that fossil plants might be found in the coal-bed contained in it. The proprietor, Herr J. D. Popovic, reports that this bed dips S.E. Its thickness is about two fathoms*; but a thinning-out was observed at the spot where the bed was won by a new shaft, at the depth of 17 fathoms, the older ones, as well as the levels, being inaccessible, so that it appeared there to be

* The measurements are in Austrian fathoms, feet, &c.

only about 7 feet thick. It is said to have regained, in some measure, its original thickness afterwards. The coal is a very good brown-coal (Jahrb. d. k.-k. geol. Reichsanstalt, 1861–62, Verh. p. 117). The beds there are horizontal, and then dip slightly to the N.W. No trace of fossils was found either in the coal, coal-shale, or the sand and conglomerate. One very important fact was gained, however, namely, that this conglomerate strikingly resembles that of Orlowe in the Waagthal, in which *Exogyra columba* occurs abundantly. A bivalve was subsequently met with, during a further examination of the district, in a few specimens of a brownish-yellow marl in the upper part of the conglomerate, in a forest road near Lazi. As, however, they were only in the state of casts, and very much crushed, they might as easily have been taken for a *Dreissena* as for an *Exogyra*. [As all further endeavours to determine the age of this formation were fruitless, the author refers it for the present to the period of the Chalk, but does not consider this determination definite.]

General description of the Neogene Strata.—The older formations hitherto treated of, namely, the crystalline rocks, the Triassic beds, the slate of the Vuciak-Thal near Pozeg, with the overlying felspar-porphyry and tuff, and the Pozeg conglomerate, form the Orljava and Pozegan Ranges. Round about them lie the Neogene-tertiary strata, spreading out as far as the Diluvial plain of the Drave and Save.

Although the author had little previous knowledge of the Neogene-beds in Croatia and Sclavonia, yet he had seen the Belvedere-Schotter conformably displayed near Agram, under which appeared the "Congerien-Tegel," with *Congeria* and *Cardium*, and, as the lowest bed, the Leithakalk, conformable to the older rocks. Between these two, and corresponding to the similar formation in the Vienna Basin, he had completely recognized the identical succession of white and grey marls, sandstone, and shale, with the *Cystoscirites Partschii*, Sternb., as equivalent to the beds near Radoboj. The situation of the beds of Radoboj and Podsused between the above-mentioned Congerien-Tegel and Leithakalk determined their correspondence with the Cerithium-beds of the Vienna Basin, and corroborated his opinion of the railway section near Podsused. At that place a block of Leithakalk is so placed between the marl-beds that the lines of stratification of the former are vertical, while the latter are horizontal.

Still further east, in West Sclavonia, he found that, whenever the succession of the strata was clearly shown, they could be referred to one or the other of the three horizons in the Vienna Basin; and he considered, though with some doubt, those beds as belonging to the Leithakalk that had a similar appearance.

The Cerithium-beds in the Vienna Basin contain a brackish-water fauna, in the Hungarian basin a marine, whilst in Croatia and Sclavonia they constitute for the most part a freshwater series. Still in Sclavonia, at the commencement of this period, *Cerithium pictum*, Bast., and *C. rubiginosum*, Eich., existed; but in the overlying "Mergel" and "Kalk-mergel" scarcely any fossils are found, except an extremely abundant, though undescribed, species of *Planorbis*.

Districts of Benkovac and Rogolje.—North of Okucane and west of

Neu-Gradiska, there was observed, in the first place, *marine and overlying white marl.* Towards the Diluvial plain of the Save, in the Slobostina-Thal, white calc-marl and grey marl were observed near Caje. Under these the Leithakalk appears near Benkovac, and beneath it the clay [Tegel] crops out at the northern end of the district. It contains *Vaginella depressa*, Daud., very abundantly, together with the following *Foraminifera*, as determined by Herr F. Karrer :—

Glandulina lævigata, *O.* r. B. N.	Rotalina Boueana, *O.*? (badly preserved).
Dentalina inornata, *O.* r. B.	Globigerina triloba, *Rss.* c. B. N.
—— elegans, *O.* c. B. N.	—— bulloides, *O.* vc. B. N.
—— pauperata, *O.* vr. B.	Truncatulina lobatula, *O.* vr. N.
Vaginulina Badenensis, *O.* c. B.	Bulimia pupoides, *O.* r. N.
Marginulina, sp.?	—— pyrula, *O.* vr. N. B.
Cristellaria cassis, *O.* r. B.	Textularia Mayeriana, *O.* vr. N. B.
——, sp.?	—— articulata, *O.* vr. B.
Robulina Austriaca, *O.* c. B. N.	Sphæroidina Austriaca, *O.* vr. N. B.
—— cultrata, *O.* c. B. N.	Biloculina lunula, *O.* r. B.
——, sp.?	
Nonionina bulloides, *O.* vr. N.	

[N.=Nussdorf. B.=Baden. c.=common. vc.=very common. r.=rare. vr.= very rare.]

They show that this clay [Tegel] is equivalent to that of Baden in the Vienna Basin. There are no traces of Gasteropods, Bivalves, or *Bryozoa*. *Cypridæ* are rare.

Near Rogolje, the lowest member of the Neogene strata is a grey marly sand, containing no traces of *Mollusca*, but the following *Bryozoa* (determined by Herr Stoliczka) and *Foraminifera* (determined by Herr F. Karrer) :—

Bryozoa.

Crisia Edwardsi, *Rss.*	Scrupocellaria elliptica, *Rss.*
Filisparsa biloba, *Rss.*	Salicornia marginata, *Goldf.* (*S. crassa*, Busk).
Idmonea foraminosa, *Rss.*	Eschara polystomella, *Rss.*
—— tenuisulca, *Rss.*	

Foraminifera.

Vaginulina Badenensis, *O.* vr. B.	Globigerina triloba, *O.* r. N. B.
Polystomella Fichtelliana, *O.* vr. N.	Uvigerina pygmæa, *O.* vr. N. B.
—— crispa, *O.* r. N. B.	Globulina gibba, *O.* vr. N. B.
Nonionina granosa, *O.* vr. N.	—— tuberculata, *O.* (?) vr. B.
Rotalina Boueana, *O.* r. N. B.	Textularia Mayeriana, *O.* r. N. B.
—— Partschiana, *O.* vr. N. B.	—— abbreviata, *O.* r. B.
—— Akneriana, *O.* vr. N.	—— deperdita, *O.* vr. N.
—— Soldanii, *O.* vr. N.	—— lævigata, *O.* vr. N.
Globigerina bulloides, *O.* r. N. B.	

The conclusion to which Herr Karrer arrives is, that these beds are higher than those of Benkovac, somewhat lower than those of Nussdorf, and probably equivalent to those of Ehrenhausen, Porzteich, and Grinzing, in the Vienna Basin. This formation continues in a N.W. direction towards Gorni Caglic, as far as a ridge near the river, when a white sandy marl and calc-marl, containing *Amphistegina Haueri*, Orb., and *A. mammillata*, Orb., may be seen alternating with Leithakalk full of small Nullipores. At the top of the ridge the white calc-marl sets in, and forms the surface-rock of this and all the higher hilly ground.

The lower beds of the marine strata extend to the Slobostina River; they are succeeded by Leithakalk, and then by the white calc-marl. Wings of Insects and remains of Plants are found in beds of shale, which, with beds of sandstone, are intercalated in the grey marl that forms the foot of the Raic-Thal, and which is covered by the white calc-marl that forms the sides of the valley.

Western slope of the Orljava-Gebirge, near Pakra.—Both of the Neogene formations may be seen in this district. The Leithakalk crops out from under the marl behind Pakra Church; it is very porous and light, and contains hollow casts of *Cerithium rubiginosum* and *C. plicatum*, and in some places a conglomerate formed of Nullipores and fragments of *Pecten latissimus*, Brocc., and other bivalves. In the ravine of Brussovac the lowest bed lies upon the crystalline rocks, and is a greyish-white marl, equivalent to the marly sandstones of Rogolje, which is overlaid by the Leithakalk, and is similar to that of Pakra. The last-named bed contains large fragments of *Pecten latissimus*, Brocc., *Gryphœa Cochlear*, Poli, and other bivalves, also *Clypeaster grandiflorus*, Bronn. Above the Leithakalk there occurs between Brussovac and Pakra a yellowish calc-marl (Cerithium-horizon), containing *Cardium plicatum*, Eichw., *Callitrites Brongniarti*, Endl., as well as *Planorbis*, sp. East of Daruvar the marl and calc-marl first make their appearance, and then the Leithakalk.

In the River Dobrakuca, near Vrbovac, N.E. of Daruvar, there occur marl and calc-marl (Cerithium-horizon); and in the latter, just as at Raic, seams of shale and sandstone are interstratified, also a coal-shale. In the latter, remains of Plants and freshwater Molluscs, also bones of Fish, are somewhat abundant; and north of Banjani narrow seams of brown-coal are reached by shafts.

Northern slope of the Orljava-Gebirge, near Vucin.—While crossing two ridges near Vucin, the author observed that the Congeria-beds are continued beneath the first ridge, which is itself composed of white calc-marl (Cerithium-horizon). Near the Rupnica-Thal, a little south of Vucin, the Leithakalk was seen; it is here chiefly composed of small, loosely connected Nullipores, *Amphistegina Haueri*, Orb., and the following *Bryozoa*:—*Hornera hippolyta*, Defr., *Myriozoum geminiporum*, Reuss, and *Cellepora globularis*, Bronn, together with crumbling shells of *Ostrea digitalina*, Eichw., and other species. The beds dip towards the north 45° to 60°. The trachyte crops out from under the Leithakalk, and reposes, further southward, upon granitic rocks, which in some places are traversed by more or less thick veins of trachyte. No trace of trachyte-tuff is found anywhere in the neighbourhood of Vucin.

Near Drenovacz, beyond Vucin, the Leithakalk is seen covered immediately by Congeria-sand, no trace of the younger calc-marl being observed, nor of the marl further from the mountains. On the other hand, the white marl appears near Orahovica, east of the last locality; and in only one place did the author see the Leithakalk cropping out from under it, and that was on the road from Duzluk to Sumedje.

Eastern end of the Orljava-Gebirge, near Gradac.—This district lies north of Gredistje, on the road between Bektes and Nasic. The crystalline rocks are here surrounded by Congeria-beds; but the Leithakalk is seen beneath them in a deep valley on the northern or Nasic side, and also occasionally on the south side, east of Gredistje. In the road upon the Bektes side, near Gredistje, there crops out a loosely coherent Nullipore-limestone, extremely like that of Vucin, containing *Pecten latissimus*, Brocc., and *Ostrea digitalina*, also *Amphistegina Haueri*, Orb., *A. mammillata*, Orb., and *Heterostegina costata*, Orb., and the following *Bryozoa*, determined by Dr. Stoliczka:—

Hornera hippolyta, *Defr.*
Idmonea foraminosa, *Reuss.*
—— tenuisulca, *Reuss.*
—— Giebeli, *Stol.*
Myriozoum truncatum, *Lam.*
Salicornia marginata, *Goldf.* (*S. crassa*, Busk).
Retepora cellulosa, *Lam.*
Cellepora globularis, *Bronn.*
Eschara bipunctata, *Reuss.*
—— monilifera, *Milne-Edw.*

This formation disappears in a southerly direction, and therefore immediately under the highly inclined Congeria-beds.

A series of beds of particular interest was found in an almost isolated position, surrounded by crystalline rocks, partly upon the heights of Gradac, and westward from them, and partly in a small basin lying northward from Gredistje. The prevailing rocks on the south-western border of the basin were clay and sandstone, the former containing many badly preserved remains of Fish. Three seams of very good brown-coal were also found in it*, dipping very fast towards the south. They are separated only by very thin beds containing *Planorbis*, sp., and together they attain a thickness of from one and a half to two fathoms. Eastwards they are soon cut off by the crystalline rocks, and westwards they very shortly disappear under the Congeria-beds. Interstratified with the coal, and filling up the rest of the basin, are tuff and conglomerate, containing pebbles of trachyte and, more rarely, of basalt.

Further westward, near Kutjevo, the coal-bearing clay, shale, and sandstone, closely corresponding with the Radaboj beds, tower up to a considerable hill from out of the Congeria-beds, and the author was informed of an outcrop of coal there. Unfortunately only one specimen of *Melania Escheri*, Brongn., that is so abundant in the Cerithium-beds (Gaunersdorf) of the Vienna Basin, has been observed here.

Southern slope of the Orljava-Gebirge, near Velika.—The Older Neogene strata crop out in this district from under the Congeria-beds, the only beds seen being the Leithakalk and those beneath it; the younger marl and the beds of Kutjevo not being observed. Near Velika the marine Neogene strata, corresponding with the "Tegel" of Baden or the beds of Rogolje and Benkovac (see above), were observed. The lowest bed is a coarse sand, here and there of a brick-red colour; upon it lies a white, light, friable marl, like that in the ravine of Brussovac; then comes the Leithakalk.

The bed of the sea of the Older Neogene epoch must therefore have been very undulating, and here and there the Trias shale must

* Jahrbuch der k.-k. geol. Reichsanstalt, 1861 and 1862, Verhand. p. 17.

have towered up out of the white marl (Baden) in the form of islands, which must have been covered immediately by the Leithakalk. The bed of white "Mergel" and "Kalk-mergel" extends from Orljava to near Podversko, and from thence to the Pozegan Range. Finally, from Podversko towards Rogolje, whence the author started, only the youngest member of the Neogene-tertiary formation is seen. Near Ober Lipovac, and between Maticevic and Pavlovce, the Leithakalk consists of a bed of white calcareous sand containing nodules of Nullipores as large as one's fist, and larger, and of an overlying bed of porous limestone three to four feet thick, consisting of shells of the following species, cemented together:—*Cerithium pictum*, Bast., *C. rubiginosum*, Eichw., *Mactra Podolica*, Eichw., *Ervilia Podolica*, Eichw., and *Cardium Vindobonense*, Partsch.

North-eastern slope of the Pozegan Range, between Pleternica and Pozeg.—In this district only a few patches of the Older Neogene strata remain. The most important locality is a recess of the high-road near Pozeg, close to a small chapel, where the following *Bryozoa*, determined by Dr. Stoliczka, were found:—

Crisia Edwardsi, *Reuss.*
Pustulopora anomala, *Reuss.*
—— pulchella, *Reuss.*
Filisparsa biloba, *Reuss.*
Hornera hippolyta, *Defr.*
Domopora prolifera, *Reuss.*
—— stellata, *Goldf.*
Ceriopora anomalopora, *Goldf.*
Myriozoum geminiporum, *Reuss.*
Scrupocellaria elliptica, *Reuss.*
Salicornaria marginata, *Goldf.* (crassa, *Busk*).
Retepora cellulosa, *Lam.*
—— Rubeschi, *Reuss.*
Membranipora angulata, *Reuss.*
Idmonea foraminosa, *Reuss.*
—— pertusa, *Reuss.*
—— tenuisulca, *Reuss.*
Pavotubigera dimidiata, *Reuss.*
Defrancia deformis, *Reuss.*
Lepraria monoceras, *Reuss.*
—— stenostoma, *Reuss.*
Cellepora globularis, *Bronn.*
Biflustra bipunctata, *Reuss.*
Eschara polystomella, *Reuss.*
—— macrocheila, *Reuss.*
—— Reussi, *Stol.*
—— cervicornis, *Lam.*
—— undulata, *Reuss.*
—— monilifera, *Milne-Edw.*

The following *Foraminifera* from this locality were determined by Herr F. Karrer:—

Rotulina cultrata, *O.* r. B. N.
Polystomella crispa, *O.* vc. N. B.
Rotalina Boueana, *O.* c. N. B.
—— Dutemplei, *O.* c. N.
Amphistegina Haueri, *O.* c. N.
Heterostegina cristata, *O.* N.
Textularia, sp. n. similar to *T. lævigata*, O., but much larger.

Besides these, there are also found in this formation *Argiope decollata*, Eichw., and *A. pusilla*, Eichw., *Balanus*, *Terebratula*, spines of *Echinidæ*, and claws of Crabs. The "Kalkmergel" is found lying against the side of the mountain between Dervisaga and Vidovci; and south of Pozeg, near Sevce, isolated thick beds of Older Neogene strata are found upon the tops of the hills, covering superficially the older rocks.

The Brooder Gebirge.—This mountain is formed entirely of Older Neogene strata. The Leithakalk appears only on the southern slope near Grabarje, the white "Kalkmergel" (Cerithium-horizon) constituting the whole of its upper portion, as also the district of Paka and Russevo, and from thence westward to the Pleternica, and southward to the line of the Odvorze-Zdence.

The Congeria-beds form the remaining greater portion of the Tertiary hilly land. They present exactly the same sections as those so well known in the Vienna Basin; but the contained fossils are somewhat different, as will be seen hereafter,—a peculiarity which was first noticed by Herr Ludwig v. Farkas-Vukotinovic*.

The Belvedere beds are also developed in the same degree as in the Vienna Basin—the Belvedere Schotter being of very local occurrence; whilst, on the other hand, the Belvedere sand covers the whole district of the Congeria-beds with a thickness of from 4 to 10 fathoms, and appears as a sandy Loess-like loam.

The next older stratum, the "Freshwater Limestone" of the Vienna Basin, is represented just as at Moosbrunn. It may be seen close to St. Leonard's Church, near Neu-Gradiska. First there crops out from beneath the Loess-like sand a sandy greenish "Tegel," containing *Valvata piscinalis*, Lam., very abundantly; then follows a stratum of whitish freshwater limestone, in beds 3 to 4 inches thick, and containing small specimens of *Congeria*, species of *Helix*, *Planorbis*, and *Melanopsis*, in casts both solid and hollow. Beneath these occur beds of soft, almost marly freshwater limestone alternating with yellow loamy sand and dark blue shaly "Tegel," and containing fossils belonging to the following species, as determined by Herr v. Frauenfeld:—*Valvata piscinalis*, Lam., *Melanopsis Esperi*, Fér., *Paludina concinna*, Sow., *P. tentaculata*, L., *P. Sadleriana*, Partsch, *Neritina transversalis*, Mhlf., and a ribbed species of *Anodonta*.

Underneath this last bed is the "Tegel," containing a bed of Lignite: the thickness of the former under the Lignite is unknown, but it must be very considerable. The stratification, as seen along the banks of the streams, is very much disturbed.

A freshwater limestone† occurs at the spring in the forest in the Drinoosta-Thal, north-west from Kutina. It contains *Paludina Sadleriana*, Partsch, and *P. concinna*, Sow.

In the drainage-area of the Drave, the Congeria-beds crop out. In a narrow pass near Borova a bed of sand may be seen dipping slightly towards the south, and upon the tops of the hills there is one, from two to three feet thick, containing sandstone concretions; the grains of sand being cemented together by carbonate of lime, derived, probably, from the shells of *Cardium*, several of which are contained in each concretion of less than one foot in diameter. The most abundant species is *Cardium Haueri*, Hörnes; it is associated with *C. Hungaricum*, Hörnes, and another *Cardium* (undeterminable), occurring only in casts; also small specimens of *Congeria* and *Paludina tentaculata*, Lam., are found.

The Loess of the older Diluvium was only observed at some points along the course of the Save, on the boundary of the plain towards the Tertiary hilly land.

The surface-rock of the plain of the Save and Drave belongs to the terrace Diluvium. [H. M. J.]

* Das Moslaviner Gebirge, Jahrbuch d. k.-k. geol. Reichsanstalt, 1862, Heft 2, Seite 95.

† See L. v. Farkas-Vukotinovic, *op. cit.* p. 95.

The Ground *beneath* Vienna ; *its Origin, its Nature, and its Relation to the* Public Health. By E. Suess. With 21 Woodcuts and a Chromolithograph Map. Pp. 326. 8vo. 1862, Vienna.

[Der Boden der Stadt Wien, nach seiner Bildungsweise, Beschaffenheit und seiner Beziehungen zum bürgerlichen Leben. Eine geologische Studie von Eduard Suess, &c.]

The first part of this work notices the most important publications on the geology of Vienna, such as those by Stütz, Jacquin, Partsch, Czjzek, Kopetzky, Stur, and others, including also the works published by the "Friends of Natural Science," the "Geological Institute," &c. It further treats of the position of Vienna, and its relation to the Alps and Carpathians,—of the form of the ground within those lines,—and of the distribution of the water-channels on the surface. The changes of direction that the streams have undergone in historic times are likewise here noticed.

The second division shows the distribution of the several strata, Tertiary, Diluvial, and Alluvial, and contains remarks on their fossils and mode of formation.

Of the Tertiary formations, the marine group, the brackish-water group, the Inzersdorf clay, and the Belvedere beds are specially noticed. The Loess and the erratic gravels constitute the "Diluvial."

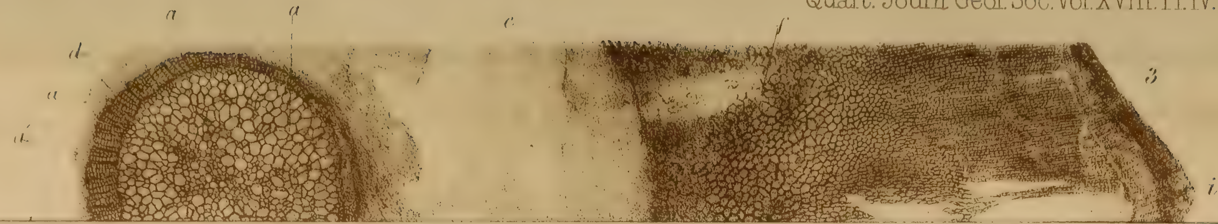
In this part also are noticed the most important changes which have been brought about in the upper strata by the agency of man, producing "made ground."

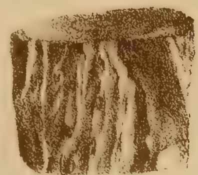
Lastly, the nature and formation of the building-materials in Vienna are treated of,—namely, sand, limestone, tile-clay, Vienna sandstone, the building-stones from the marine tertiaries (which are the best), and those from the brackish tertiaries.

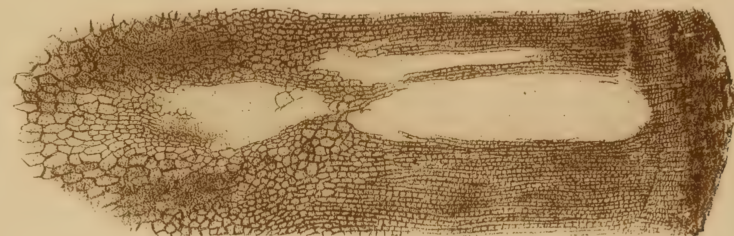
The third part contains a sketch of the geological topography of the city, describing the distribution of the several beds in Vienna: first, more especially, those of the alluvial plain of the Danube; then those of the inner town; lastly, those of the higher-lying suburbs, rom Nussdorf to Erdberg.

The fourth part is devoted to the discussion of all those phenomena which have immediate reference to the health and the vital statistics of the city, especially the practical bearings of an accurate knowledge of the distribution and nature of the subterranean water; and here the author describes the water-bearing strata, the springs of the Circle of the Danube, the waters of the High district, and the springs in the clay; and he concludes with remarks on the cholera of 1855, &c.

The map of Vienna and its suburbs is contoured with lines giving the height above the sea of the surface of the ground in Vienna fathoms (two fathoms apart), and of the height, above the sea-level, of the surface of the tile-clay or Tegel (four fathoms apart). The relative "hardness" of the water in the wells in the Rossau and the Leopoldstadt is also shown by contour-lines. The colours of the map indicate the following formations:—1. Made ground and ruins; 2. Alluvium; 3. Loess; 4. Diluvial gravel; 5. Belvedere beds; 6. Tegel with *Congeria*. The Brackish Tertiary formation (Cerithium-sand) is also indicated; and the places of the old diggings in the Belvedere gravel and in the Tegel are marked out. [T. R. J.]







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Sigillaria vascularis.

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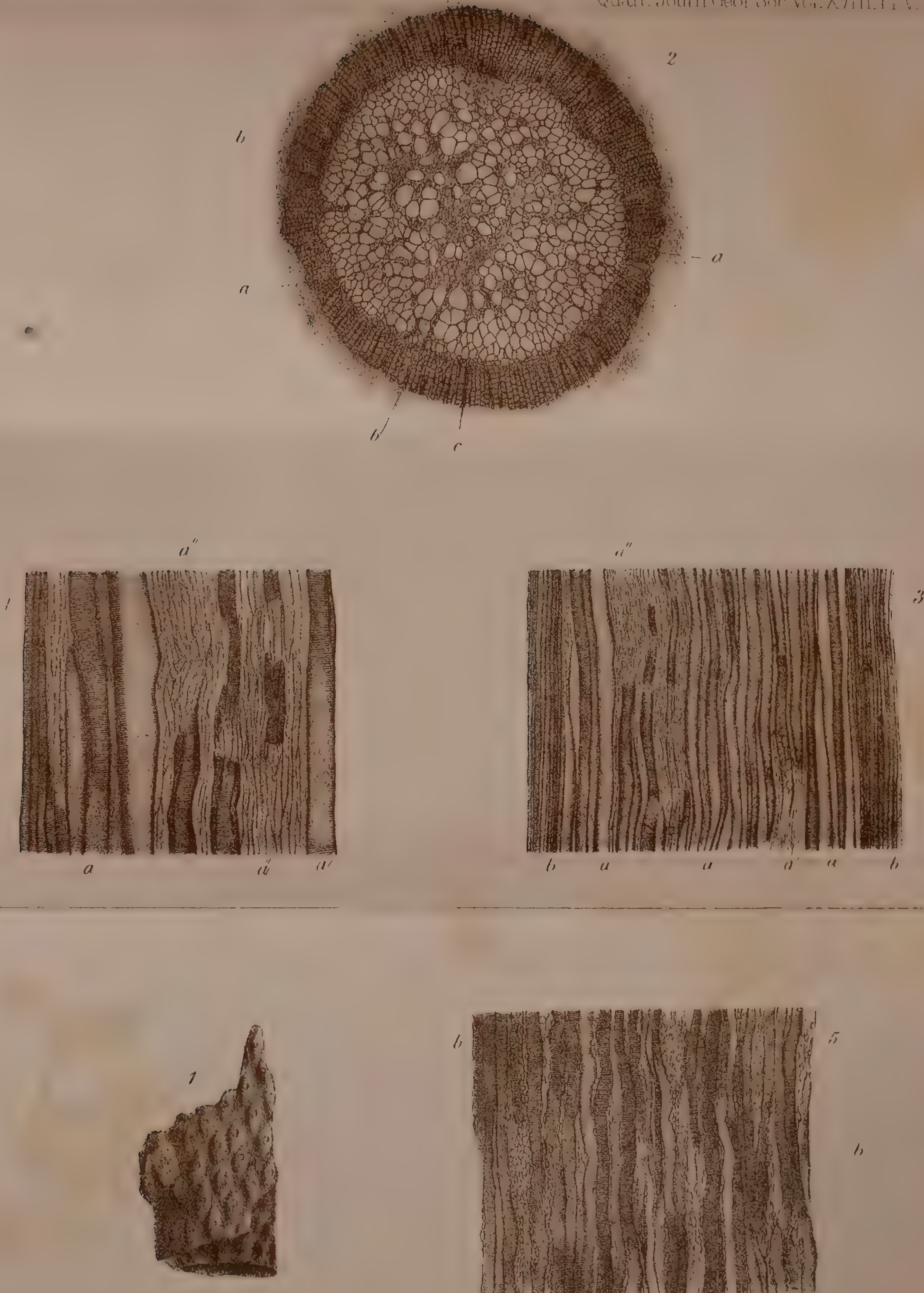
Sigillaria vascularis.



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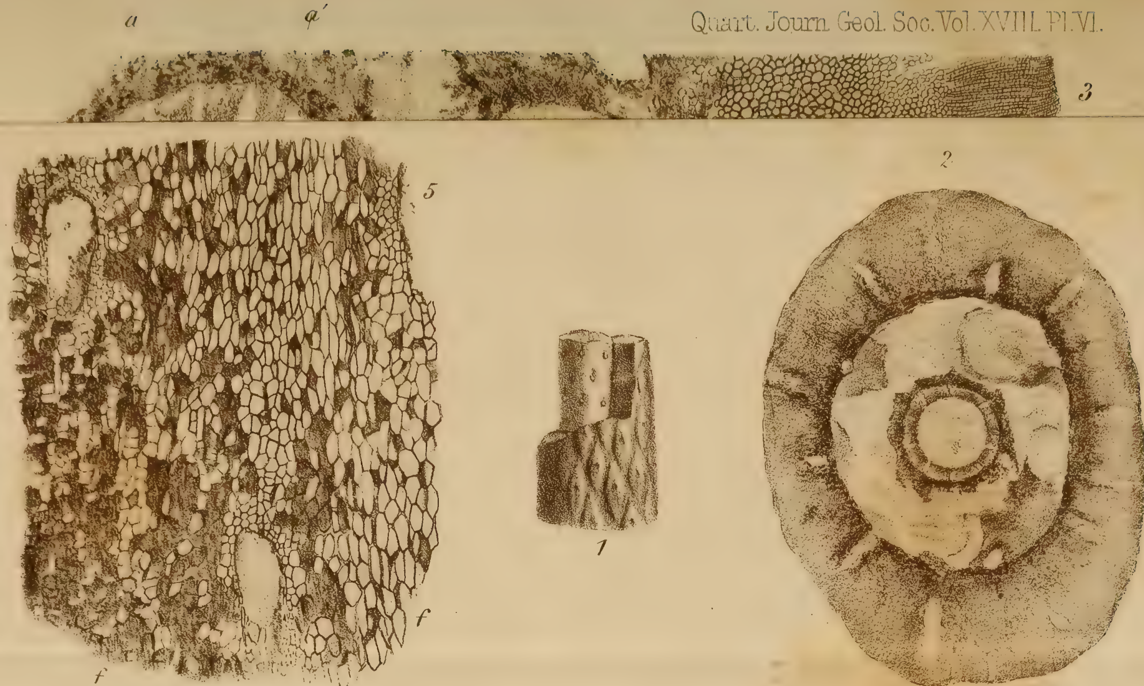

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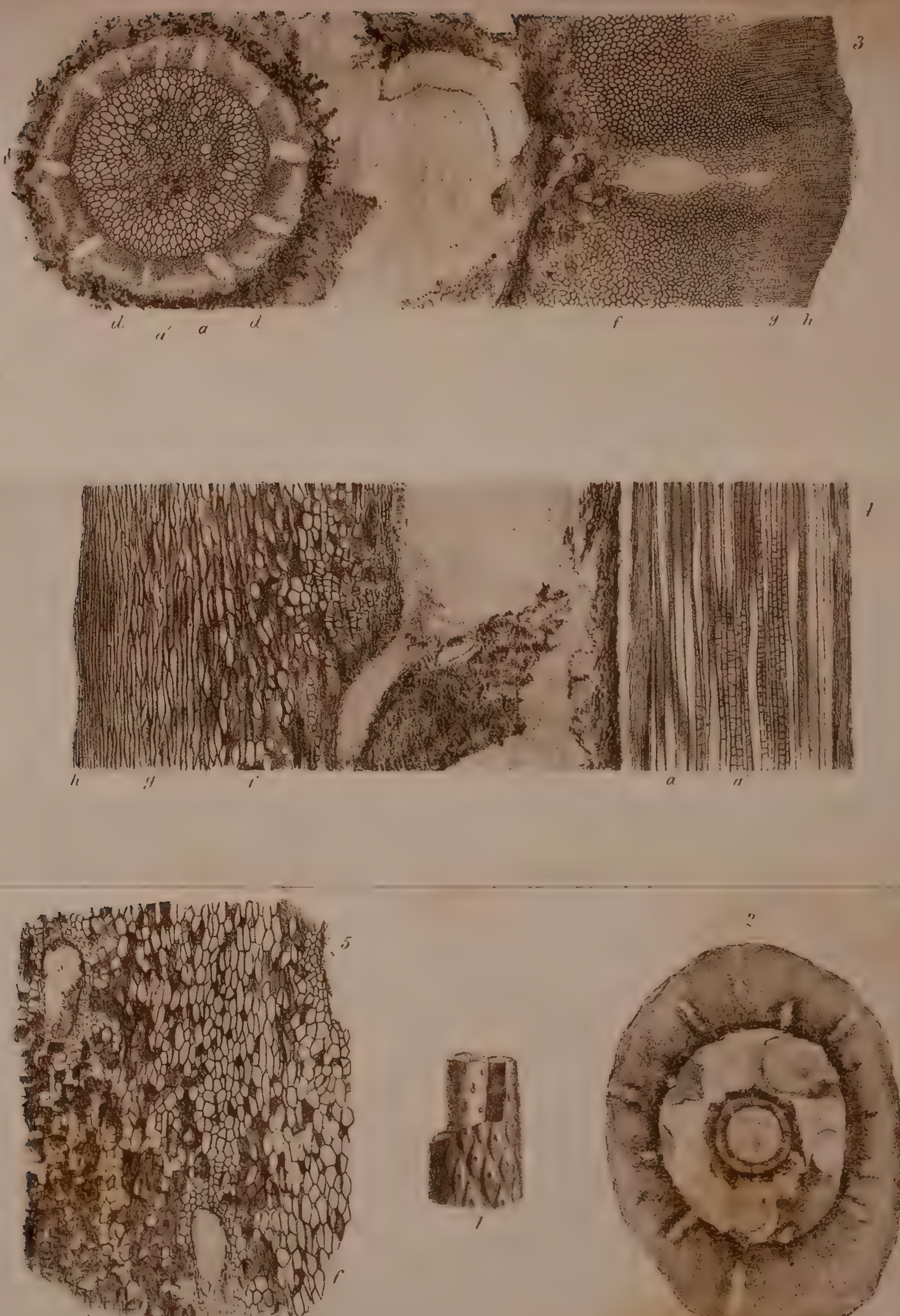
Lepidodendron vasculare.



T. West lith. ad nat.

W. West imp.

Lepidodendron vasculare.

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.

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