THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE FIFTH.

1849.

PART THE FIRST.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, BROWN, GREEN, AND LONGMANS.

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

NEW YORK:—WILEY AND PUTNAM, 161 BROADWAY.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCXLIX.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

ELECTED FEBRUARY 1849.

President.

Sir Charles Lyell, F.R.S. & L.S.

Vice-Presidents.

G. B. Greenough, Esq. F.R.S. & L.S.
Leonard Horner, Esq. F.R.S. L. & E.
G. A. Mantell, LL.D. F.R.S. & L.S.
Sir R. I. Murchison, G.C.St.S. F.R.S. & L.S.

Secretaries.

William John Hamilton, Esq. Pres. Geog. Soc.
John Carrick Moore, Esq. M.A.

Foreign Secretary.

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

Treasurer.

John Lewis Prevost, Esq.

COUNCIL.

J. S. Bowerbank, Esq. F.R.S.
W. B. Carpenter, M.D. F.R.S.
Charles Darwin, Esq. M.A. F.R.S.
Sir Henry T. De la Beche, F.R.S. & L.S.
Sir P. Grey Egerton, Bart. M.P. F.R.S.
Prof. E. Forbes, F.R.S. & L.S.
Capt. Henry James, R.E.
Lyon Playfair, M.D.
Lieut.-Col. J. E. Portlock, R.E. F.R.S.
Samuel Peace Pratt, Esq. F.R.S. & L.S.
Prof. A. C. Ramsay.
D. Sharpe, Esq. F.L.S.
The Very Rev. the Dean of Westminster, D.D. F.R.S. & L.S.
S. V. Wood, Esq.

Assistant-Secretary.

Professor Nicol, F.R.S.E.

TABLE OF CONTENTS.

LIST OF THE FOSSILS FIGURED AND DESCRIBED IN THIS VOLUME.

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

Name of Species.	Formation.	Locality.	Page.
	Plants. (1.)		
Sigillaria alternans, stump. Woodcut, f. 1.	Coal-measures.	Sydney, C. Breton.	355
—— ——, stem and bark. Woodcut, f. 2–5.	Coal-measures.	Sydney, C. Breton.	356
—— ——, conical tap roots. Woodcut, f. 7, 8.	Coal-measures.	Sydney, C. Breton.	357, 358
—— ——, dome-shaped stump. Woodcut, f. 9.	Coal-measures.	Sydney, C. Breton.	359
	Zoophyta. (12.)		
Graptolites folium. Pl. i. f. 5.......	Silurian	Loch Ryan	15
—— pristis. Pl. i. f. 6.	Silurian	Loch Ryan	16
—— ramosus. Pl. i. f. 7.	Silurian	Loch Ryan	16
—— *tænia*. Pl. i. f. 8................	Silurian	Wigtonshire	16
—— tenuis. Pl. i. f. 9 *a*............	Silurian	Wigtonshire	16
—— sextans. Pl. i. f. 10, 10 *b*, *c*....	Silurian	Wigtonshire	17
Conis contortuplicata. Pl. iv. f. 1–4.	Greensand ...	Atherfield	63
Choristopetalum impar. Pl. iv. f. 5–11.	Greensand ...	Atherfield	69
Cyathopora? elegans. Pl. iv. f. 12–15.	Greensand ...	Reigate	83
Siphodictyum gracile. Pl. v. f. 16–23.	Greensand ...	Atherfield	94
Chisma furcillatum. Pl. v. f. 24–28.	Greensand ...	Atherfield	98
Alcyonites parasiticum. Pl. viii. ...	?	?	319
	Echinodermata. (1.)		
Pentremites. Woodcuts. Part 2. p. 9.	Carboniferous limestone.	Alabama	Pt. ii. 9.
	Mollusca. (14.)		
Pleurotomaria Moorei. Pl. i. f. 1.	Silurian	Ayrshire	14
Murchisonia scalaris. Pl. i. f. 2. ...	Silurian	Ayrshire	14
Euomphalus? ——. Pl. i. f. 3. ...	Silurian	Ayrshire	14
Orthis confinis. Pl. i. f. 4.	Silurian	Ayrshire	15
—— *noctilio*. Pl. vi. f. 2 *a*, *b*, *c*. ...	Silurian	Vallongo	151
—— *Miniensis*. Pl. vi. f. 3 *a*, *b*. ...	Silurian	Vallongo	152
—— *Duriensis*. Pl. vi. f. 4 *a*, *b*. ...	Silurian	Vallongo	152
—— *Lusitanica*. Pl. vi. f. 5 *a*, *b*. ...	Silurian	Vallongo	152
Orthoceras vagans. Pl. vi. f. 6 *a*, *b*.	Silurian	Vallongo	153
Neritoma sinuosa. Woodcut, f. 1.	Portland oolite.	Swindon	334
Tylostoma Torrubiæ. Pl. ix. f. 1, 2.	Subcretaceous.	Portugal	378
—— *punctatum*. Pl. ix. f. 3, 4, 4*a*, 4*b*.	Subcretaceous.	Portugal	378
—— *globosum*. Pl. ix. f. 5, 6.	Subcretaceous.	Portugal	379
—— *ovatum*. Pl. ix. f. 7, 8.	Subcretaceous.	Portugal	379

EXPLANATION OF THE PLATES.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 16, 1849.

REPORT OF THE COUNCIL.

In presenting to the Geological Society of London their Annual Report for the past year, the Council have the satisfaction of announcing, that notwithstanding the late pecuniary embarrassment by which they regret to find that almost all the scientific bodies of London have been more or less materially affected, the numbers of this Society have only been reduced by 3 during that period.

The following statement shows the changes which have taken place during the past year: new Fellows elected, who have paid their admission-fees, 17; Fellows elected in former years, who have paid this year, 5; Foreign Member, 1; total 23. On the other hand, there have been deaths, including one Foreign Member and one Honorary Member, 17; and resignations 9, total 26. Deducting the increase 23 from the decrease 26, we have a diminution of 3, thereby reducing the numbers of the Society during the year 1848 from 897 to 894.

The excess of income over expenditure during the past year has been £238 7*s*. 5*d*. This has been mainly owing to the diminution of expense in the publication of the Journal, amounting to nearly £100; to the office of Curator having been vacant during nine months, making a difference of £97 10*s*.; and to the receipt of an unexpected sum of £46 for Transactions, in consequence of the great reduction in their price.

The number of living compounders at the close of 1847 was 130; it has been increased during the past year to 131; during this period one compounder has died, and two Fellows have compounded, whose compositions, together with one received in 1847 too late to be funded during that year, have been invested in the funds. The total amount received from these 131 compounders has been £4126 10*s*. The amount of Stock held by the Society at the close of 1848 was £3563 15*s.* 11*d.* against £3453 14*s.* 7*d.*, the amount held at the close of 1847; and its estimated value on the 31st of December 1848 (Consols being 89) was £3172.

The Council having observed that a large stock of the Transactions still remained unsold, and believing that by a greater diffusion of the information contained in them, they would materially add to the usefulness and prosperity of the Society, they have resolved that all excess over fifty copies of the volumes of the second series of the Transactions, including Vol. VII., should be reduced in price one-half below the already reduced prices, both to the Fellows and to the public; they have also resolved that all excess beyond fifty copies of the Proceedings should be reduced to one-fourth of the former price. By these means they trust that much geological information will be distributed, that the funds of the Society will be benefited, and their shelves cleared of a heavy incumbrance.

They have further to announce the completion of the fourth volume of the Journal and the publication of the first part of Vol. V. They have also resolved, considering the inconvenience attending the practice of making the publication of the Journal depend on an annual vote, and also considering that the experience of the last three years justifies the propriety of contemplating the present mode of publication as a permanent arrangement, that the publication of the Quarterly Journal be henceforth regularly continued without any annual resolution.

The attention of the Council has been especially directed to the Museum Report of last year, the principal portion of which was printed and circulated in the fifteenth number of the Journal. The recommendations and suggestions embodied in that Report have on various occasions been carefully discussed by the Council, and some of them have already been acted upon. In the Foreign Collection the Council have resolved that many of the inorganic specimens should be removed, thereby gaining space for the admission of valuable organic specimens, hitherto retained in the crypts for want of space; and they have the satisfaction of stating, that in consequence of the zeal and activity of some of their members, who have voluntarily offered their services for this purpose, the want of a Curator has in this respect not been experienced.

The important question of the arrangement of the whole Foreign Collection has not yet been taken into consideration. Some of the arguments in favour of the various systems proposed will be found in the Reports of Mr. Lonsdale and of Professor Forbes, appended to the Museum Report of last year.

Referring to their Report of last year, the Council regret that the same causes which then induced them to reduce the expenditure incurred in the care of the Museum should still continue in operation; they have consequently not considered it expedient to appoint a Curator for this year; they trust however that the state of their finances will shortly enable them to make such arrangements as will ensure the due care and superintendence of the Collections, without which they are well-aware the value and importance of the Museum must in a great measure be lost.

It will be remembered that it was stated in the Annual Report of last year that the Council had resolved that the balance of the proceeds of the Donation Fund should be appropriated to making available to science the fossils which had been received from the Cape of Good Hope in 1844 from Mr. Geddes Bain, and that a Committee was appointed to carry out this object. A portion of the sum placed at their disposal has been accordingly expended; and the Committee having reported that they did not recommend any further expenditure on the fossils in question, the Council have resolved that the remaining portion of the Award (amounting to £27 2*s.*) be granted to M. Alcide d'Orbigny, for the purpose of aiding him in the publication of his 'Paléontologie Française,' on account of the value of that work to British geologists.

In conclusion, they have to announce that they have awarded the Wollaston Palladium Medal for the present year to Mr. Joseph Prestwich, jun., for his papers communicated to the Geological Society of London, and more especially for those relating to the tertiary deposits of the London and Hampshire districts; and that they have resolved that the balance of the proceeds of the Donation Fund for the present year be granted to Mr. Lonsdale, in aid of the publication of his work on Fossil Corals.

Report of the Museum and Library Committee.

No important addition has been made to the British Collection since the last Annual Report, and the arrangement remains in the same condition as at that period, with the exception of a considerable number of specimens of the Azoic Rocks which have been removed from the drawers.

The Foreign Rock Specimens are in progress of examination and re-arrangement by a Committee appointed for that purpose, with the view of admitting of the exhibition of a greater number of the Foreign Organic Remains. As the labours of that Committee are not yet concluded, it is unnecessary to offer any further remarks on that subject.

Library Report.

In the course of the last year the Library has been increased by the donation of upwards of 150 volumes and pamphlets; among these donations may be noted, as especially valuable, more than 100 Charts and Plans and Nautical works published by the Dépôt de la Marine of France; Hermann von Meyer's work on the Saurians of the Muschelkalk; the Palæontology of New York, presented by the State of New York; Memoirs, Maps and Sections of the Geological Survey of Great Britain; Haidinger's Report on the Proceedings of the Friends of Natural Science in Vienna; the Physical Atlas by Berghaus and Johnston, presented by J. W. Johnston, Esq.; the Annales des Mines, completing our series to the present time; and

Humboldt's Essay on the Kingdom of New Spain, presented by Alfred Tylor, Esq.

Your Committee strongly recommend that the Annals and Magazine of Natural History be added to the periodicals taken in by the Society, and they would especially direct attention to the list of desiderata appended to the Annual Report of 1848.

Signed, G. A. Mantell.
J. S. Bowerbank.
13th February, 1849. Robert Austen.

Comparative Statement of the Number of the Society at the close of the years 1847 *and* 1848.

	Dec. 31, 1847.	Dec. 31, 1848.
Compounders	130	131
Residents	248	233
Non-residents	445	457
	823	821
Honorary Members	20	19
Foreign Members	50	50
Personages of Royal Blood	4—74	4—73
	897	894

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1847 *and* 1848.

Number of Compounders, Residents and Non-residents, December 31, 1847				823
Add, Fellows elected during former years, and paid in 1848	Residents	3		
	Non-residents	2		
		— 5		
Fellows elected, and paid, during 1848	Residents	8		
	Non-residents	9		
		—17		
			—	22
				845
Deduct, Compounder deceased			1	
Residents „			5	
Non-residents „			9	
Resigned			9	
			—	24
Total number of Fellows, 31st Dec. 1848, as above				821

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1847		74
Add, Foreign Member elected in 1848		1
		75
Deduct, Foreign Member deceased	1	
Honorary Member ,,	1	
	—	2
As above		73

Number of Fellows liable to Annual Contribution at the close of 1848, *with the Alterations during the year.*

Number at the close of 1847			248
Add, Elected in former years, and paid in 1848			3
Elected and paid in 1848			8
Non-residents who became Resident			3
			262
Deduct, Deceased		5	
Resigned		9	
Compounded		2	
Became Non-resident	7	13	
Ditto in former years	6		
		—	29
As above			233

DECEASED FELLOWS.

Compounder (1).

William Twining, M.D.

Residents (5).

Robert Bingley, Esq.
Mr. Justice Bosanquet.
Lieut.-Col. Brandreth.
Marquis of Bute.
G. F. Richardson, Esq.

Non-residents (9).

E. T. Artis, Esq.
G. T. Fox, Esq.
Rev. John Hailstone.
Sir T. D. Lauder, Bart.
Henry Leach, Esq.
Edmund Lomax, Esq.
Edw. Mammatt, Esq.
James Watt, Esq.
W. J. West, Esq.

Honorary Member (1).

George Cumberland, Esq.

Foreign Member (1).

J. J. Berzelius, M.D.

The following Persons were elected Fellows during the year 1848.

February 23rd.—William Talbot Aveline, Esq., of the Geological Survey of Great Britain.

March 22nd.—Nathaniel Beardmore, Esq., Great College Street, Westminster; John R. McClean, Esq., Great George Street, Westminster; Robert Hunter Semple, Esq., Torrington Square; William Wills, Esq., Birmingham; Capt. R. T. W. L. Brickenden, Cuckfield, Sussex; and H. W. Freeland, Esq., Duke Street, St. James's.

April 5th.—James MacAdam, Esq., Royal Academic Institution, Belfast; and Robert William Mylne, Esq., Carlton Chambers, Regent Street.

—— 19th.—Sir John William Lubbock, Bart., St. James's Place.

May 3rd.—John Dorrington, Esq., Linton, Cambridgeshire.

—— 17th.—J. R. Logan, Esq., Singapore; and Rev. John Thornton, Kimbolton, Huntingdonshire.

—— 31st.—H. Wedgwood, Esq., Woking, Surrey; and Thomas Brown, Esq., Cushendun House, Antrim.

November 1st.—Lieut. Douglas Galton, Royal Engineers.

—— 29th.—Charles Timins, Esq., Oxford Villas, Cheltenham.

December 13th.—Thomas Josiah Laing, Esq., Hillingdon Grange, Hillingdon; and Charles Brumell, Esq., Carlton Chambers, Regent Street.

The following Person was elected a Foreign Member.

February 2nd.—James Hall, Esq., New York, United States.

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

British Specimens.

Plagiostoma Hermanni, from the Lower Lias, Warwickshire; presented by J. W. Kirshaw, Esq., F.G.S.

Specimen of Pentacrinite; presented by E. H. Bunbury, Esq., M.P., F.G.S.

Specimens from the Mountain Limestone, Alnwick; presented by George Tate, Esq., F.G.S.

Fossils from the Lias and Oolite near Cheltenham; presented by the Rev. P. B. Brodie, F.G.S.

Cast of Humerus of Mastodon; presented by H. Ball, Esq.

Cast of Head of *Crocodilus Spenceri*, from Isle of Sheppey; presented by Prof. J. Tennant, F.G.S.

Charts and Maps.

104 Charts and Plans and 8 Nautical works in 12 volumes, published by the Dépôt de la Marine; presented by M. le Directeur Général du Dépôt de la Marine.

The Maps and Sections, forming a continuation of the Geological Survey of the United Kingdom; presented by Sir H. T. De la Beche, on the part of Her Majesty's Government.

The Physical Atlas, by Henry Berghaus, LL.D. and A. Keith Johnston, Parts 1—10; presented by the publishers, Messrs. W. and A. K. Johnston.

Palæontological Map of the British Islands, by A. K. Johnston. From the Sketches and Notes of Prof. E. Forbes, 2 sheets; presented by Prof. E. Forbes, F.G.S.

The following List contains the Names of all the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Academy of Sciences of Paris.
American Academy of Arts and Sciences.
American Philosophical Society.
Athenæum Club.
Athenæum, Editor of.
Austin, Messrs. Thomas.

Ball, H., Esq.
Berwickshire Naturalists' Club.
Binney, E. W., Esq.
Boston Society of Natural History.
Botfield, B., Esq., F.G.S.
Brayley, E. W. jun., Esq., F.G.S.
British Association for the Advancement of Science.
Brodie, Rev. P. B., F.G.S.
Bunbury, E. H., Esq., M.P., F.G.S.

Carpenter, W., M.D., F.G.S.
Chantereaux, M. Bouchard.
Chemical Society of London.
Corbaux, Miss F.
Coxe, L. S., Esq., F.G.S.
Cumming, Rev. J. G., M.A., F.G.S.

D'Archiac, M. le Vicomte, For. Mem. G.S.
Davidson, M. M. Th.
Daussy, M.
De la Beche, Sir H. T., Pres. G.S.
Dépôt Général de la Marine de France.
Dillwyn, L. W., Esq., F.G.S.
D'Orbigny, M. Alcide, For. Mem. G.S.
Dumont, Prof. A. H., For. Mem. G.S.

East India Company, Hon.
Elie de Beaumont, M. L., For. Mem. G.S.

Favre, M. Alphonse.
Fischer de Waldheim, G., M.D., For. Mem. G.S.
Fitton, W. H., M.D.
Flügel, Dr. J. G.
Forbes, Prof. E., F.G.S.
Frapolli, M. L.

Genève, Société de Physique de.
Geological Society of Dublin.
Geological Society of France.

Geological Survey of Great Britain.
Göppert, Prof.
Greenough, G.B., Esq., V.P.G.S.
Grey, Right Hon. Earl.
Guyot, M. A.

Haidinger, Herr W.
Hall, James, Esq., F.G.S.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Horticultural Society.

Imperial Society of Moscow.
Indian Archipelago Journal, Editor of.

Jobert, M. A. C. G.
Johnston, Messrs. W. and A. K.
Joly, M. M. N.

King, Capt. P., R.N.
King, William, Esq.
Kirshaw, J. W., Esq., F.G.S.
Koninck, M. L. de.

L'École des Mines.
Leeds Philosophical Society.
Leidy, Joseph, M.D.
Leymerie, M.
Liverpool, Literary and Philosophical Society of.
Lubbock, Sir J. W., Bt., F.G.S.

Mantell, G. A., LL.D., V.P.G.S.
Martins, M. Ch.
M'Coy, F., Esq.
Mitchell, Lieut.-Col. Sir T. L., F.G.S.

Nattali, M. A.
New York Lyceum of Natural History.
Northumberland, Natural History Society of.
Nyst, M. H.

Palæontographical Society.
Philadelphia Academy of Natural Sciences.
Portlock, Lieut.-Col., F.G.S.
Pratt, S. P., Esq., F.G.S.

Quetelet, M. A.

Ramsay, Prof. A. C., F.G.S.
Reeve and Co., Messrs.
Richardson, Joshua, Esq., F.G.S.
Rouquairol, M.
Royal Academy of Belgium.
Royal Academy of Munich.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Asiatic Soc., China Branch.
Royal Geographical Society.
Royal Geological Society of Cornwall.
Royal Irish Academy.

Silliman, Prof., M.D., For. Mem. G.S.
Sismonda, E., M.D.
Smith, Rev. J. Pye, D.D., F.G.S.
Smith, J. Toulmin, Esq.
Sowerby, G. B., Esq.
St. Petersburg, Imperial Academy of.
Strickland, H. E., Esq., F.G.S.
Swedenborg Association.

Tate, George, Esq., F.G.S.
Tennant, Prof. J., F.G.S.
Twining, William, M.D., F.G.S.
Tylor, A., Esq., F.G.S.
Tyneside Naturalists' Field Club.

Vaudoise Society.
Von Helmersen, Herr G.
Von Volborth, Dr. A.

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

Zoological Society.

List of PAPERS *read since the last Anniversary Meeting, February 18th*, 1848.

1848.

Feb. 23rd.—Additional Remarks on the Deposits in New Zealand containing the remains of Struthious Birds, by G. A. Mantell, LL.D., F.G.S.

———— On the Geology of Ridgway, near Weymouth, by C. H. Weston, Esq., F.G.S.

March 8th.—On the Position in the Cretaceous Series of Beds containing Phosphate of Lime, by R. A. C. Austen, Esq., F.G.S.

———— On the presence of Phosphoric Acid in the Subordinate Members of the Chalk Formation, by J. C. Nesbit, Esq., F.G.S.

———— Outline of the Geology of the Salt-field of Cheshire, by G. W. Ormerod, Esq., F.G.S.

March 22nd.—On the Internal Structure of Halonia, by J. S. Dawes, Esq., F.G.S.

———— Observations on the Cystidea and the Crinoidea generally, by Major Thomas Austin, F.G.S.

———— On Fossil Bones from the Crag, Suffolk, by John Wiggins, Esq., F.G.S.

April 5th.—Sketch of the Structure of part of North Wales, by J. B. Jukes, Esq., F.G.S., and Alfred Selwyn, Esq.

———— Sketch of the Structure of part of North and South Wales and Shropshire, by Prof. A. C. Ramsay, F.G.S., and W. T. Aveline, Esq., F.G.S.

April 19th.—Palichthyologic Notes, Supplemental to the Works of Prof. Agassiz, by Sir P. G. Egerton, Bart., M.P., F.G.S.

———— On the Transportal of Erratic Boulders from a lower to a higher level, by Charles Darwin, Esq., F.G.S.

———— and May 17th.—On Scratched Boulders, by James Smith, Esq., of Jordan Hill, F.G.S.

May 3rd.—On the Permian System of Saxony, by Prof. Naumann; communicated by Sir R. I. Murchison, F.G.S.

———— On Changes in the Earth's Axis of Rotation, by Sir John Lubbock, Bart., F.G.S.

———— On Changes of Temperature, &c. on the Earth, by W. D. Saull, Esq., F.G.S.

May 17th.—On the Silurian Rocks of Wigtonshire, by J. C. Moore, Esq., Sec. G.S.

———— On the Fossils from Wigtonshire, by J. W. Salter, Esq., F.G.S.

———— On recent Formations near Edinburgh, by James Nicol, Esq., F.G.S.

1848.

May 31st.—On the Colouring Matter of Red Sandstones, by J. W. Dawson, Esq.; communicated by the President.

———— On a Dragon Fly found in the Lias, by the Rev. P. B. Brodie, F.G.S.

———— On the Structure of the Calamite, by J. S. Dawes, Esq., F.G.S.

June 14th.—On Organic Remains recently found in the Wealden, by G. A. Mantell, LL.D., F.G.S.

———— On the Strata from Christ Church Harbour to Poole Harbour, by Joseph Prestwich, jun., Esq., F.G.S.

———— Notes on the Souffrière of St. Vincent, by Major Henry Davis; communicated by Sir Charles Lyell, V.P.G.S.

———— On the Geological Structure of Western Australia, by Dr. Sommer; communicated by the President.

———— On Ingleborough Cave, by J. W. Farrer, Esq., F.G.S.

———— Notes on Corals from the Greensand at Atherfield, by William Lonsdale, Esq., F.G.S.

Nov. 1st.—On the supposed Soft Parts of an Orthoceras, by James Hall, Esq., For. Mem. G.S.

———— On Slaty Cleavage, by Daniel Sharpe, Esq., F.G.S. (second communication).

Nov. 15th.—On the Gypsum of Nova Scotia, by Abraham Gesner, M.D., F.G.S.

———— A Comparison of the General Structural Features of the Disturbed Districts of Europe with those of America, by Prof. H. D. Rogers, For. Mem. G.S.

Nov. 29th.—On Fossil Plants from the Anthracite Formation of the Alps of Savoy, by C. J. F. Bunbury, Esq., For. Sec. G.S.

———— On the Neighbourhood of Oporto, including the Silurian Coal and Slates of Vallongo, by Daniel Sharpe, Esq., F.G.S.

Dec. 13th, and Jan. 17th, 1849.—Notes on the Alps and Apennines, more particularly on the Cretaceous and Supracretaceous Groups, by Sir R. I. Murchison, F.G.S.

1849.

Jan. 3rd.—On the Hampshire Freshwater Tertiaries, by J. C. Moore, Esq., Sec. G.S.

———— Additional Observations on the Ridgway Cutting, by C. H. Weston, Esq., F.G.S.

———— On the Silicified Soft Parts of a Zoophyte, by J. S. Bowerbank, Esq., F.G.S.

Jan. 31st.—On Saurian Remains from the Greensand of the United States, by Prof. Owen, F.G.S.

1849.
Jan. 31st.—On the Affinities of the Genus Platysomus, by Sir P. G. Egerton, Bart., M.P., F.G.S.

———— On Neritoma, a new Genus of Fossil Brachiopod, by John Morris, 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 Henry Thomas De la Beche, retiring from the office of President.

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

3. That the thanks of the Society be given to R. A. C. Austen, Esq., E. H. Bunbury, Esq., Prof. Daubeny, M.D., Robert Hutton, Esq., and John Morris, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

Sir Charles Lyell, F.R.S. and L.S.

VICE-PRESIDENTS.

G. B. Greenough, Esq., F.R.S. and L.S.
Leonard Horner, Esq., F.R.S. L. and E.
G. A. Mantell, LL.D., F.R.S. and L.S.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.

SECRETARIES.

William John Hamilton, Esq., Pres. R.G.S.
John Carrick Moore, Esq.

FOREIGN SECRETARY.

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

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

J. S. Bowerbank, Esq., F.R.S.
C. J. F. Bunbury, Esq., F.L.S.
W. B. Carpenter, M.D., F.R.S.
Charles Darwin, Esq., F.R.S.
Sir H. T. De la Beche, F.R.S. and L.S.
Sir P. Grey Egerton, Bart., M.P., F.R.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq., Pres. R.G.S.
Leonard Horner, Esq., F.R.S. L. and E.
Capt. Henry James, R.E.
Sir Charles Lyell, F.R.S. and L.S.
G. A. Mantell, LL.D., F.R.S. and L.S.
John C. Moore, Esq.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Lyon Playfair, Ph.D., F.R.S.
Lieut.-Col. J. E. Portlock, R.E., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
John Lewis Prevost, Esq.
Prof. A. C. Ramsay.
D. Sharpe, Esq., F.L.S.
The Very Rev. the Dean of Westminster, D.D., F.R.S. and L.S.
S. V. Wood, Esq.

Trust Accounts.

Receipts.	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1848, on the Wollaston Donation Fund				11	10	0
Balance at Banker's, Geological Map Fund				30	3	0
Received on account of the Geological Map (sold)	11	5	0			
Dividends on the Donation Fund of 1084*l*. 1*s*. 1*d*. Red. 3 per Cents.	31	11	6			
				42	16	6
				£84	9	6

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

R. HUTTON,
J. PRESTWICH, Jun., } *Auditors.*

Jan. 29, 1849.

Payments.	£	s.	d.	£	s.	d.
Cost of Engraving Palladium Medal awarded to the Very Rev. Dr. Buckland				0	6	0
Paid on account of Geological Map: Mr. Greenough, balance of 1847				11	10	0
Balance at Banker's, Trust Account	72	19	6			
Belonging to Ordinary Account	0	6	0			
				72	13	6
				£84	9	6

Valuation *of the Society's Property; 31st December*, 1848.

Property.	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. IV.				45	11	8
Balance in Banker's hands				483	17	6
Balance in Banker's hands (included in Trust Account)				0	6	0
Balance in Clerk's hands				27	5	7
Funded Property, 3563*l*. 15*s*. 11*d*. Consols				3172	0	0
Arrears of Admission Fees	27	6	0			
Arrears of Contributions prior to 1848, considered good	9	9	0			
Arrears of Contributions of 1848	25	4	0			
				61	19	0
				£3790	19	9

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

Jan. 26, 1849. J. L. PREVOST, *Treasurer.*

Debts.	£	s.	d.
Due to Messrs R. and J. E. Taylor, on Journal, Vol. IV.	48	14	0
Due to Messrs. Reeve, on Journal, Vol. IV.	8	10	5
Balance in favour of the Society	3733	15	4
	£3790	19	9

INCOME.

	£	s.	d.	£	s.	d.
Outstanding, 1847 :						
Quarterly Journal, Vol. III. (Messrs. Longman & Co.) paid June 6th				64	7	4
Quarterly Journal, Vol. III. (Author's Corrections) paid January 26th				10	5	0
Balance at Banker's, January 1, 1848	238	12	7			
Balance in hands of Clerk	22	19	3			
				261	11	10
Compositions received	63	0	0			
Ditto at Banker's, December 31st, 1847	31	10	0			
				94	10	0
Arrears of Admission Fees	39	18	0			
Arrears of Annual Contributions	15	15	0			
				55	13	0
Admission Fees of 1848				144	18	0
Annual Contributions of 1848				719	15	6
Dividends on 3 per cent. Consols				102	3	10
Sale of Transactions				103	8	11
Sale of Transactions in separate Memoirs				3	6	7
Sale of Proceedings				2	18	0
Journal, Vol. I., allowance on sale from the Publisher				1	0	0
Sale of Journal, Vol. II.				10	1	0
Sale of Journal, Vol. III				24	6	6
Sale of Journal, Vol. IV.				172	2	9
Sale of Library Catalogue				0	7	6
				£1770	15	9

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

R. HUTTON,
J. PRESTWICH, Jun., } *Auditors.*

Jan. 29th, 1849.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Outstanding, 1847:						
Quarterly Journal, Vol. III. (Messrs. R. and J. E. Taylor)..				59	18	6
Fuel (Patent Fuel Company)				6	15	0
House Repairs (Mr. G. Laing)				8	1	9
Compositions invested				94	10	0
General Expenditure:	£	s.	d.			
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	6	18	0			
Furniture Repairs	21	0	9			
New Furniture	15	1	11			
Fuel	39	12	0			
Light	24	13	5			
Miscellaneous House Expenses, including Postages	49	3	6			
Stationery	15	5	4			
Miscellaneous Printing	35	3	9			
Tea for Meetings	27	10	11			
				279	0	11
Salaries and Wages:						
Assistant Secretary	130	0	0			
Curator (1 Quarter)	32	10	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	31	18	6			
Occasional Attendants	13	4	6			
Collector	22	10	3			
				410	3	3
Library				19	12	10
Museum				9	13	5
Diagrams at Meetings				15	11	0
Miscellaneous Scientific Expenses				3	3	7
Contribution of 1848 repaid				3	3	0
Publications:						
Transactions	17	3	5			
Transactions, separate Memoirs	0	6	9			
Journal, Vol. II	0	10	6			
Journal, Vol. III.	4	7	1			
Journal, Nos. 13, 14, 15 and 16	325	0	8			
Journal, No. 17	1	15	0			
Proceedings	0	10	0			
				349	13	5
				1259	6	8
Balance at Banker's, Dec. 31, 1848	483	17	6			
Balance do. (included in Trust Account)	0	6	0			
Balance in Clerk's hands	27	5	7			
				511	9	1
				£1770	15	9

ESTIMATES *for the Year* 1849.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Account due by Messrs. Longman and Co. in June, on Journal, Vol. IV.				45	11	8
Arrears (See Valuation-sheet)				61	19	0
Ordinary Income for 1849 estimated:						
Annual Contributions (210 Fellows)				661	10	0
Admission Fees:						
Residents (6)	37	16	0			
Non-residents (6)	63	0	0			
				100	16	0
Dividends on 3 per Cent. Consols				102	3	10
Sale of Transactions, &c.				30	0	0
Sale of Quarterly Journal				210	0	0
				£1212	0	6

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
Bill due to Messrs. R. and J. E. Taylor, on Journal, Vol. IV.				48	14	0
Bill due to Messrs. Reeve, on Journal, Vol. IV.				8	10	5
General Expenditure:						
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	35	0	0			
Furniture Repairs	15	0	0			
New Furniture	10	0	0			
Fuel	30	0	0			
Light	26	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	20	0	0			
Miscellaneous Printing	25	0	0			
Tea for Meetings	27	0	0			
				282	11	4
Salaries and Wages:						
Assistant Secretary	130	0	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	9			
Occasional Attendants	12	0	0			
Collector	25	0	0			
				380	4	9
Library, Binding and Additions				30	0	0
Museum				27	0	0
Diagrams at Meetings				15	0	0
Miscellaneous Scientific Expenditure				5	0	0
Publications, Quarterly Journal				400	0	0
,, Transactions				15	0	0
				£1212	0	6

Jan. 26, 1849.

J. L. PREVOST, TREASURER.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

16th FEBRUARY 1849.

Award of the Wollaston Medal and Donation Fund.

After the Reports of the Council and Committees had been read, the President delivered the Wollaston Donation Medal to Mr. Prestwich, addressing him as follows:—

Mr. Prestwich,—It is with no slight feeling of satisfaction that, as President of this Society, it becomes my official duty to present you with the highest honour which our body has it in its power to award. We know that though your labours for the promotion of our science are those of one devoted to the search of truth for its own sake, the time which can be thus employed can only be snatched at intervals from the cares of commercial life. Your study of chemistry under our late lamented colleague, Turner, enabled you justly to appreciate the value of that science in its applications to geology. So also with your knowledge of physics, obtained at the same institution, the University College, London, at the same time. With these aids, and a just appreciation of the value of organic remains, you have investigated those districts, for your communications respecting which the Geological Society of London this day presents you with its Palladium Wollaston Medal. You first made known to us your researches in the coal district of Colebrook Dale, and subsequently those in the tertiary districts of London and Hampshire,—all characterized by that judicious consideration of the conditions obtaining at the time, without which just views respecting the state of the various parts of our earth's surface at different periods can scarcely be obtained. Receive this medal, Mr. Prestwich, as a mark of the high value which this Society sets upon your labours; and may you long continue to employ that time which you can devote to science in the promotion of the branch of knowledge which we are associated to cultivate.

On receiving the Medal, Mr. Prestwich replied as follows:—

Sir,—Allow me to express my grateful acknowledgements for this mark of the approbation with which the Council of the Geological Society have viewed my past labours. I can assure you that I value it highly, and I receive it as a pledge to future exertions in the same field of geology. It is true that I entered upon this field as a student and for relaxation, but the interest and difficulties of the subject speedily induced me to take it up with more earnestness and determination, and eventually led me to extend the inquiry over an area which I, at first, never contemplated.

The tertiary geology of the neighbourhood of London may be wanting in beauty of stratigraphical exhibition and in perfect preservation of organic types, but in many of the higher questions of pure geology,—in clear evidence of remarkable physical changes,—in curious and diversified palæontological data, however defaced the inscriptions, which is after all but a secondary point, few departments of geology offer, I think, greater attractions.

The pleasure I have derived from the study of the remarkable phænomena which have come before me in the course of the investigation, has far outbalanced the few obstacles I have had to contend against. I, in fact, feel deeply indebted to geology, as a source of healthful recreation, as an inestimable relief and abstraction in due season from the cares frequently attendant upon the active duties of life, for its kindly and valued associations, and above all for the high communing into which it constantly brings us in the contemplation of some of the most beautiful and wonderful works of the creation.

The President then addressed Mr. Bunbury:—

Mr. Bunbury,—This Society having a second time availed itself of an opportunity of assisting in the publication of the 'Paléontologie Française,' by awarding the unappropriated balance of the Wollaston Fund for the last year to M. Alcide d'Orbigny, pray express to him the high value we attach to his labours, and the interest we feel in the continuation of his 'Paléontologie Française,'—a work of so much importance to the progress of European geology.

Mr. Bunbury replied:—

Sir,—I will take care that this donation shall be transmitted to the gentleman for whom it is designed; and I am happy to be the medium of expressing to M. d'Orbigny the sense entertained by this Society of the great services which he has rendered to geological science, especially by the publication of his 'Paléontologie Française.'

The President then turning to Mr. Hamilton spoke as follows:—

Mr. Hamilton,—In transmitting to Mr. Lonsdale the proceeds of the Wollaston Donation Fund for this year, awarded to him in aid of his work on Fossil Corals, may we request you to assure him of the great satisfaction we experience in finding that the state of his health permits him to follow up investigations of so much importance to our science, and which at the same time add so justly to that reputation which he has acquired in this branch of knowledge? However small our aid may be, we trust that it will be received as a mark of the continued value our body attaches to the labours of one to whom while an officer of this Society it stood so much indebted for his great and indefatigable exertions.

Mr. Hamilton said in reply,—

Mr. President,—I shall lose no time in forwarding to Mr.

Lonsdale this award of the Council, and of assuring him of the interest still felt by the Society in the progress of his labours. I beg leave in Mr. Lonsdale's name to return you his best thanks for this mark of approbation, and to state that I am certain that it will derive its greatest value in Mr. Lonsdale's estimation from the circumstance of its assuring him that his memory still lives in the recollection of the Geological Society.

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

ANNIVERSARY ADDRESS OF THE PRESIDENT,

SIR HENRY T. DE LA BECHE, C.B., F.R.S. &c.

Gentlemen,—It again becomes my duty to address you on our progress during the past year. And first let me congratulate you on the state of our finances,—a subject of no small importance in societies such as ours, since so much of the good we can effect must depend upon it. You will have found from the Report of your Council that the receipts have so far exceeded the expenditure, that a considerable sum, beyond the balance usually retained, now stands in your bankers' hands. We have certainly to record a diminution, by three, in the numbers of our body; but when we view this with reference to the general state of public affairs during the past year, and to the total number of our Fellows (894), we may regard this also as matter for congratulation, more particularly when we compare our decrease with that which has been experienced by many other societies during the same time. Your Quarterly Journal has continued to be published regularly, making known the communications of our colleagues shortly after they have been read in this room, thus most materially aiding the progress of that branch of knowledge for the cultivation and advance of which we are associated.

Loss by death, which from our numbers it must always be the melancholy duty of your President to announce at this season, has diminished our body by seventeen.

We have to lament the decease of the Rev. John Hailstone, one of the first Members of our Society. He was born near London in 1759, and after receiving his early education at Beverley School, Yorkshire, removed to Cambridge, entering first at Catherine Hall and afterwards at Trinity College. He distinguished himself as Second Wrangler for his year (1782), Dr. Wood (late Master of St. John's) being Senior Wrangler, and Professor Porson and other distinguished men taking their degrees at the same time. In 1784 he became a Fellow of Trinity College, and in 1788 was appointed Woodwardian Professor, an office which he held for thirty years, until his marriage and retirement to the vicarage of Trumpington in 1818, when he was succeeded by our colleague Professor Sedgwick.

After his election to the Woodwardian Professorship he went to Freiberg, and studied under Werner for about a year. Upon his return to Cambridge he published a syllabus of a course of lectures on Geology and Mineralogy ; but it would appear that he never obtained a class. It has been supposed that he was discouraged by those then in power, and who entertained no favourable opinion of such studies. However this may have been, Mr. Hailstone never lectured as Woodwardian Professor ; and this from no want of zeal on his part, for he was much attached to geology, as his many additions to the Woodwardian Collection at Cambridge, and his various journeys in this, and other countries, sufficiently testify.

Mr. Hailstone was well-versed in general science, and esteemed as a mathematician. Even in his declining years he studied works of high modern analysis. He was the earnest and untiring promoter of the progress of knowledge, as well among the poor as among those placed in more fortunate circumstances. During the long period of his residence at Trinity, his exertions were unwearied in sustaining the high repute and usefulness of that distinguished College, and upon his retirement to Trumpington the education of the poor of his parish was his constant care. He was the chief contributor to the funds of his parochial schools, and at his death they were liberally endowed by him.

Mr. Hailstone contributed to our Society a paper on the Geology of Cambridgeshire, inserted in vol. iii. 1st series of our Transactions ; and he left behind him many journals of travels and correspondence, now in the possession of his nephew, the Rev. John Hailstone, of Bottisham, near Newmarket, understood to be interesting, as showing the state of Geology thirty and forty years since. He died at Trumpington, on the 9th of June, 1847, in the 88th year of his age, his mind clear until within a few hours of his decease.

In Mr. George Cumberland we have to lament the loss of one of our Honorary Members, of whom we have now only nineteen remaining. He was born in London on the 9th of December, 1752, and was the grandson of Mr. John Cumberland, the inventor of the process of bending ship-timbers by steam, in the experiments connected with which this gentleman expended his whole fortune, about £16,000. The patent for the invention is still in the Cumberland family. In early life Mr. George Cumberland attended as an honorary student at the Royal Academy, and there became intimate with Banks, Barry, Flaxman, Fuseli, and other distinguished painters and sculptors of the time. He spent many years in Italy, and returned to this country about 1792.

Mr. Cumberland early turned his attention to the study of Geology, and was elected one of our Honorary Members in 1810. He gradually formed an extensive collection, finally purchased and presented to the Museum at Manchester by Mr. James Heywood, M.P. This collection is rich in crinoidal remains, fossils which had much engaged the attention of Mr. Cumberland. He communicated two papers to our Society, one on a Pentacrinus from Lyme Regis, a new

Encrinus, and a Briarian Pentacrinus, inserted in vol. v. of the 1st series of our Transactions; the other memoir being Remarks on the Strata at Stinchcombe, near Dursley, Gloucestershire, published in vol. i. of our 2nd series of Transactions. We have also a MS. description by Mr. Cumberland, sent to us in 1818, of the portion of the Mountain Limestone series, exposed on the Avon, near Bristol, named the Black Rock. He also published in 1818, at Bristol, a work entitled 'Reliquiæ Conservatæ, from the Primitive Materials of our present Globe, with popular descriptions of some remarkable Encrinites and their connecting links.'

Late in life he occupied himself much with landscape painting, and he has left many hundred water-colour drawings, finished on the spot, of scenes in the vicinity of Bristol. These have been considered to possess much merit from their freshness and truth. For the last ten years he was afflicted by blindness. Though so great a calamity to one who could so well employ his sight, he still continued cheerful and happy, and retained his faculties until the day of his death. He expired at Bristol on the 8th of August, 1848, in the 95th year of his age.

Dr. Samuel Hibbert Ware was born at Manchester on the 21st of April, 1782, and was the eldest son of Mr. Samuel Hibbert, of Clarendon House, Chorlton, Lancashire. He was first destined for the army, and for some time held a commission in a militia regiment. Succeeding to an independent fortune, he passed through a course of medical studies in order the better to fit him for those pursuits to which he was desirous of dedicating his time, and took his degree of M.D. in the University of Edinburgh in 1816. In 1817 he made his first voyage to the Shetland Islands, to which the facility of access was then very different than at present; and among the other results of his visit, there found chromate of iron in considerable abundance. At the request, chiefly, of Professor Jameson, he again visited the Shetlands in the following year, with the view of rendering his discovery of the chromate of iron publicly useful, and of completing his geological survey of those islands. For his researches connected with the former the Society of Arts awarded him their Gold Isis Medal in 1820, and the results of his labours were given to the public in 1822, under the title of 'Description of the Shetland Islands, comprising an Account of their Geology, Scenery, Antiquities and Superstitions.' Though occupied much by antiquarian researches and other inquiries, including among the latter the philosophy of apparitions, upon which he first communicated a paper to the Royal Society of Edinburgh, and afterwards published, in 1824, a separate work, Dr. Hibbert did not neglect his geological pursuits. After examining the volcanic districts of Italy, France, and parts of Germany during two or three years, he published, in 1832, a portion of his observations in his 'History of the Extinct Volcanos of the Basin of Neuwied, on the Lower Rhine.' In 1833 he communicated to the Royal Society of Edinburgh a memoir "On the Freshwater Limestone of Burdiehouse, in the neighbourhood of

Edinburgh, belonging to the Carboniferous group of Rocks," a paper which you will recollect attracted no slight attention at the time. He would appear during the latter part of his life to have principally devoted his attention to archæology, respecting which he has left several important works. After his return from the continent he made a tour through Scotland, more especially examining the sculptured stones and Runic inscriptions of Forfarshire, Ross-shire, and other places, Mrs. Hibbert executing elaborate and beautiful drawings of them, which it was his intention to have published. In 1837, Dr. Hibbert took the additional name of Ware, by royal license, as the representative of the family of Mr. James Ware, the historian of Ireland. After long suffering from bronchitis, Dr. Hibbert Ware expired on the 30th of last December, in his 67th year, at Hale Barns, near Altringham, Cheshire.

Sir Thomas Dick Lauder, Baronet, was born in 1784, and was the son of Sir Andrew Lauder, of Fountain Hall, Edinburghshire. In early life he entered the army, but upon his marriage retired to Relugas, in Morayshire, where he passed many years. His active mind did not permit him to remain idle, and we find him early engaged in scientific pursuits. In the third volume of the Wernerian Transactions he gave an account of the transport, by means of ice, of a large boulder on the shore of the Moray Frith. Having made a minute examination of the celebrated Parallel Roads of Glenroy, he forwarded a memoir containing the results of this investigation to the Royal Society of Edinburgh, and the paper was inserted in the 9th volume of their Transactions. In 1829 he drew up an account of a great flood in Morayshire, full of most valuable information respecting that remarkable inundation. About 1830 Sir Thomas quitted his retirement in the country and became resident in Edinburgh. Some years subsequently he became Secretary to the Board of Trustees of Fisheries and Manufactures in Scotland. With his characteristic desire to promote all that was valuable in art as well as science, he exerted himself in instituting a School of Design at Edinburgh. Success attended his labours, and he had the satisfaction of seeing that establishment in a high state of efficiency before his death. Sir Thomas Dick Lauder was much esteemed in private life, and ever ready to encourage rising merit, wherever found. He was the author of several works in imaginative literature which have been extensively read, and some translated into French and German. He died in May 1848, in his 64th year.

Edmund Tyrell Artis was born at Sweflin, near Saxmundham, Suffolk, in 1789, and was the eldest son of parents in easy circumstances. In very early life he exhibited that talent for art which enabled him even to paint portraits and model busts in clay, and was of so much value to him afterwards, more especially in his antiquarian researches. He was much attached to the study of geology, and about 1816 or 1817, and for many years afterwards, spent much of his time in collecting fossil plants from the Yorkshire and Derbyshire coal-fields. He eventually amassed a very extensive collection of these and other fossils, and in 1838 published a work entitled 'Antediluvian Phytology,' containing numerous plates taken from his own drawings. The chief labours of Mr. Artis were antiquarian, and his principal work one which appeared in 1823, entitled 'Roman Antiquities, or the Durobrivæ of Antoninus identified, in a series of plates illustrative of the excavated remains of that Roman station in the parish of Castor, Northamptonshire.' The late Earl Fitzwilliam liberally assisted him in the publication of this work, and he also found most kind patrons in the late Duke of Bedford and Lord Holland. The last twenty-two years of his life Mr. Artis passed at Castor, near Peterborough, ardent in the pursuit of the Roman remains entombed beneath the surface around him. His labours were not without their reward, and eventually a mass of information and many objects of interest were obtained. It is recorded of him, as illustrating his persevering search for Roman remains, that having discovered at Sibson such antiquities (now in the Woburn collection), he bivouacked with his men in the depth of the winter of 1846–7 in a wood adjoining, until the weather caused his party to desert and leave him. He died at Doncaster on the 24th of December, 1847, and his remains were carried to the churchyard of Castor, where they now rest in the centre of his great field of research, the old Roman town.

We have to deplore the loss, from among our foreign members, of the great chemist, Jacob Berzelius. This justly celebrated man was born in 1779, at Linköping, in Eastern Gothland. He studied at Upsala, Göttingen, and Paris; Professor Afzelius, a nephew of Bergman, filling the chair of chemistry when he was at the former place. It is also stated that Gahn, the discoverer of phosphorus in bones, was the Swedish master of chemistry to Berzelius.

Berzelius would appear early to have turned his attention to mineralogy, a science which, when we regard its important bearing upon many points in geology, we may hope again to see more cultivated than it has lately been in this country by those who occupy themselves with geological investigations. In 1806, Berzelius and Hisinger commenced a periodical work, entitled 'Afhandlingar i Fysik, Kemi och Mineralogi,' which extended to six volumes, the last being published in 1818. These volumes contain forty-seven papers by Berzelius, the greater part consisting of the analyses of minerals.

In 1814 he published, in Swedish, an octavo tract, entitled 'An attempt to establish a pure scientific System of Mineralogy, by means of the Electro-chemical Theory and the doctrine of Chemical Proportions.' He therein lays it down as a principle that mineralogy is only a part of chemistry, and that the chemical is the only scientific mode of treating it. He viewed each mineral compound as a salt, consisting of an acid and a base, and considered that if each compound were exposed to the action of a voltaic pile, one part would be attracted to the positive, the other to the negative pole.

In a paper published previously (in 1811 or 1812), taking up an opinion, also thrown out by Mr. Smithson, that silica acted as an acid, he called the combinations of silica and of most of the bases, siliciates. Silicium being, as you are aware, (in the form of its oxide,) the most abundant of all the metals known on the surface of our planet, silica constituting from 64 to 75 per cent. of granites, whence so many other rocks have been derived, and about 55 per cent. of greenstones, the importance of the labours of Berzelius to geology in establishing the true character of silica will be at once appreciated.

In the work of 1814, above mentioned, he further explained his views respecting silica, and pointed out the mode of calculating mineral formulæ. He gave 49·64 as the atomic weight for silica (that now used is 51·96), for alumina 46·7 (still employed); and he also gave numbers nearly the same as now used for magnesia, lime, baryta, soda and potash. In his classification of minerals he divided them into—

I. Bodies formed according to the laws of composition prevailing in inorganic nature, *i. e.* combinations of two elements, or combinations of such combinations, or binary combinations.

II. Bodies formed according to the laws of organic nature, *i. e.* combinations of three or more elements, or combinations of these, or ternary and quaternary combinations.

The elements were divided into three classes: 1. oxygen; 2. metalloids, or simple combustibles the metallic character of which is not established; and, 3. metals. Each of the simple elements was considered to form the basis of a mineralogical family, consisting of itself and of all its combinations with bodies acting in an electro-negative manner towards it, *i. e.* occupying, with a few exceptions, a higher place in the series of elements which he gave. These families were then divided into orders, as sulphurets, carburets, arseniets, tellurets, oxides, sulphates, muriates, carbonates, arseniates, siliciates, &c., and specimens of such a system are given for silver, iron, &c. In an appendix to this memoir Berzelius gave an account of the method of determining the atomic weight of the elements, as also a table of them with their signs and numbers, and a second table of their combinations with oxygen.

In another memoir, published in 1815, he defended his system from objections that had been raised against it; gave a further explanation of his views of the constitution of minerals; criticised some other systems—those of Brunner, Werner, Hausmann, Karsten, Hauy, and others; and presented a complete view of his own classification, with the names of the species and their chemical symbols.

In his annual report to the Swedish Academy for 1822, Berzelius criticised Mohs' system, published in 1820, and noticed Mitscherlich's discovery that some compounds are dimorphous, and hence that Hauy's principle of similar primary forms implying similar composition could not be true. He also then noticed Mitscherlich's doctrine of isomorphism, as the most important discovery in chemistry since that of chemical proportions, and as likely to change the whole aspect of mineralogy. It may be here observed respecting dimorphism and isomorphism, that the known dimorphous bodies are very few, not more than about ten in 350 crystallized minerals, and that the isomorphous substances being ascertained, the great difficulty at first contemplated by the discovery of isomorphism has not been felt. M. Dufrénoy, in his excellent treatise on Mineralogy, well observes, that "It is not necessary to give the same composition, that minerals should exactly contain the same weight of their simple constituent substances; it is sufficient that there is an exact relation between the bases and the acids they contain, or between their isomorphous substances*."

In 1824 Berzelius published, in the Transactions of the Swedish Academy, a memoir "On the Changes in the Chemical System of Mineralogy, which the property of Isomorphous Bodies to replace each other in indeterminate proportions has rendered necessary."

In the 'Jahresbericht' for 1825 there is a critique on Gmelin's system of mineralogy, with some remarks on that of Mohs; and in that for 1846, Berzelius again returns to the subject of mineralogy. He there explains the changes in his views, and gives a new electro-chemical arrangement of the elementary bodies according to which minerals may be classified. The following are the orders he then adopted:—

I. Elementary bodies.

II. Combinations of metals with metals.

III. Combinations of simple elements with elements that form bases (Basenbildnern)—*seleniets, sulphurets*, &c.

IV. Combinations of simple elements with elements that form salts (Salzbildnern)—*haloid salts*, &c.

V. Combinations of the more electro-positive oxides (bases) with the electro-negative oxides (acids)—*hydrates, silicates, carbonates*, &c.

This system has been worked out by Rammelsberg. The great difficulty was still the isomorphous elements. When less than 2 or 3 per cent., Berzelius neglected them; when more, they were taken into account, so that some minerals, such as augite, hornblende and garnet, have to be repeated in different places, while others, having little in common, are brought together.

The 'Handbook of Chemistry,' in Swedish, by Berzelius, which contains much mineralogy, has been translated into German by Wöhler, and his 'Treatise on the Blowpipe' has become a well-known work in different languages. He made numerous analyses of minerals, besides those noticed above. Some of those of meteoric stones were published in 1832, and in the 'Jahresbericht' for 1836 he had much on the same subject.

The analysis of wavellite by Berzelius is a good example of the care needed in such investigations, and is useful in showing, though made so long since as 1819†, how desirable it would be if analyses

* Dufrénoy, Traité de Minéralogie, tome i. p. 19.

† Dr. Thomson remarks (History of Chemistry, vol. ii. p. 224) that an analysis by Fuchs had given him similar results in 1818, though Berzelius did not appear to have been acquainted with it.

were now undertaken, with all the aid the present state of chemistry could afford, of many minerals the supposed composition of which only rests upon old examinations. Berzelius found wavellite to be a hydrous phosphate of alumina, while Sir Humphrey Davy, in a previous analysis, had altogether missed the phosphoric acid. In his turn, however, Berzelius missed phosphoric acid in chalkolite, which Mr. Richard Phillips afterwards found, and Berzelius acknowledged as correct.

Berzelius was perpetual Secretary of the Academy of Sciences of Stockholm, and numerous academies and scientific bodies in various parts of the world honoured themselves by enrolling his name among their members. Such was the value attached to his labours by his sovereign, Charles John XIV. of Sweden, that he placed him among the hereditary nobility of his country, creating him a Baron. Though suffering from long and severe illness, with his lower extremities finally paralysed, Berzelius continued to labour in that science to which he had devoted himself, with his faculties unimpaired, until death terminated his bodily afflictions on the 7th of August, 1848, at the age of sixty-nine years.

With reference to the communications made to us since the last Anniversary, we will endeavour, as last year, so to classify them that our progress in the various branches of geological research may be the better seen.

GEOLOGICAL SOCIETY OF LONDON.

Accumulations of Mineral Matter now taking place.

Respecting the accumulation of mineral matter now taking place on the surface of the earth, mechanically and chemically, by aqueous and chemical means, we have had little brought before us. Mr. Dawson, in his communication "on the Colouring Matter of Red Sandstones and of Greyish and White Beds associated with them," mentions, as bearing on the manner in which variations of colour may have been produced, certain deposits in the harbour of Pictou, Nova Scotia. Three rivers and several minor streams carry large quantities of reddish mud during floods into the harbour. This mud settles on the bottom and undergoes a change of colour. Old mud taken up is of a dark tint, emitting a strong smell of sulphuretted hydrogen. When dry it is grey, and Mr. Dawson considers that the iron of the peroxide, giving the original red tint to the deposit, has combined with the sulphates in the sea-water, "by the deoxidating influence of decaying vegetable matter, the greater part of which appears to be furnished by the *eel-grass* (*Zostera marina*), which grows abundantly in the mud flats." This the author notices as explaining the occurrence of iron pyrites amid organic matter in rocks. The vegetable matter is mentioned as so completely decomposed in some parts of Pictou Harbour that no trace of it remains, as if the carbon had been entirely removed as carbonic acid also in part formed at the expense of the peroxide of iron.

I need scarcely remind you that the manner in which iron pyrites is formed under certain conditions, when organic matter is present, is now well understood. Perhaps one of the most illustrative cases is that of the formation of iron pyrites from the decomposition of the bodies of mice in a solution of sulphate of iron, described by Mr. Pepys, in 1811, in the first series of our Transactions, vol. i. There is also an instance of a dog having fallen down a mine-shaft near Mousehole, Cornwall, at the bottom of which there appears to have been a solution of sulphate of iron. Its remains, when discovered some time afterwards, were found surrounded by sulphuret of iron. In such cases, the hydrogen evolved from the decomposition of the animal matter would appear to take the oxygen both from the sulphuric acid and oxide of iron, so that iron pyrites, or bisulphuret of iron, is produced. Artificial iron pyrites has also been formed in the dry way. The ammoniacal liquor of gas-works contains much sulphuretted hydrogen. An instance is known where, in employing this liquid in the manufacture of sal ammoniac, the sulphur of the sulphuretted hydrogen combined with the iron of the vessel in which the operation was conducted, and formed crystallized iron pyrites of a bright yellow colour, which have retained their lustre during many years to the present time.

In a note on the Souffrière of St. Vincent, Major Henry Davis calls attention to the evidence of eruptions prior to that of 1812, when such an abundance of ashes was vomited forth from this volcano and scattered to great distances. He found beds of vegetable matter interstratified with volcanic layers, marking times of repose when parts, at least, of the mountain could be clothed by plants; and he observes, that in some instances we may conclude, from the thickness of the vegetable beds, long intervals of time to have elapsed between the eruptions. The manner in which a succession of volcanic eruptions may be thus geologically chronicled is not only interesting in itself, but such facts as Major Davis notices are valuable as illustrating the mode in which, during the long lapse of geological time since ashes were ejected from volcanic vents (and we have reason to conclude that such were driven out from various parts of the earth's surface at very early periods), not only may vegetable matter have been imbedded amid ashes, but the remains of animal life also. Certainly the chances of preserving these remains when the movements on the earth's crust were such as to depress volcanic districts beneath the sea are but small. We have only to consider the effects which would be produced by sinking any modern volcanic region, such as Etna or Vesuvius, or any district of extinct volcanos, such as Central France, beneath the sea, to judge of the slight chance of preserving such alternations of vegetable matter and volcanic ashes and cinders from removal by the breakers as they slowly worked upon the slightly coherent materials. Supposing a gradual descent of the land, so that finally the whole volcanic region would be submerged, we should scarcely expect any of the loose materials to remain as accumulated in the atmosphere, but to be spread about beneath the water by tidal streams, or ocean and sea currents. Under such conditions, perhaps, some of the harder remains of land animals, even of successive geological times, might occasionally be mingled with those of the marine creatures existing around the land as it became submerged. When we consider the effects which would be produced upon lands gradually sinking beneath the sea, and more especially when such lands are volcanic, we at once perceive the small chance of preserving any large portion of the loose materials, with or without animal and vegetable remains, in the state in which they may have occurred on such dry land. Curious associations of rocks might result from the harder parts of a volcano, those formed of various lava currents, remaining, while the softer portions, such as ashes and cinders, were removed by the breakers, new marine accumulations intermingling with the old lava currents. Should the sea again cover the Great Desert of Northern Africa, its sands would be remodelled into beds, and would contain, intermixed with them, such bones of men, camels and other animals as were sufficiently hard to resist the friction of the breakers until they were buried in the new marine beds with the remains, perhaps, of the marine creatures of the time. In such cases, as also in those of volcanos, there would be little trace of the old tracts of dry land, the portions of the latter preserved being chiefly beds, such as limestone, more or less consolidated from having been formed in lakes, rivers, or as subaërial travertine, and lava currents or other ejections of molten rocks upon the land, these latter, when covered by deposits formed in water, showing no traces of having been so thrown out on dry land, although sometimes the pumice character of such rocks, however the vesicles may be now filled up by solid matter infiltrated into them, may lead us to suspect that they may have been vomited upon dry land.

Mode in which Mineral Matter has been accumulated at previous Geological times.

Mr. Darwin, in his paper "on the Transportal of Erratic Boulders from a Lower to a Higher Level," after noticing the facts seen in various European and American localities, and which appear to show that such transportal had actually taken place, and after quoting the observations of himself, Prof. John Phillips, Mr. Hopkins, Mr. Maclaren, Mr. D. Milne, the Rev. J. G. Cumming, Mr. Mallet, Prof. Hitchcock, and Dr. Buckland, takes into consideration certain causes which have been thought to have produced this distribution of boulders at higher levels than the supposed parent rock is now known to occupy. After admitting that the destruction of rocks in some localities may have been such, that fragments from them may have been detached and drifted, when portions of them, since removed, occupied higher levels than they now do, levels sufficiently high to account for the removal of boulders to those places where they are now found, and having also taken into consideration the value of unequal elevations of parts of land since the boulders were dispersed, Mr. Darwin proceeds to investigate the effects which would be produced by coast ice upon a land gradually sinking beneath the level of the sea. He adverts to the transportal of boulders by glaciers and coast ice, as noticed by him in his communication to this Society upon the Boulders of the Southern Hemisphere*, pointing out the different effects produced by these various modes of transport. He remarks that the fragments of rock, "from being repeatedly caught in the ice and stranded with violence, and from being every summer exposed to common littoral action, will generally be much worn; and from being driven over rocky shoals, probably often scored. From the ice not being thick, they will, if not drifted out to sea, be landed in shallow places, and, from the packing of the ice, be sometimes driven high up the beach, or even left perched on ledges of rock."

Our colleague then proceeds to state the effects which would be produced by the slow sinking of a mass of land in regions where coast-ice could be formed, and the probable transportal of coast fragments to higher levels as the land descended, so that, at subsequent geological periods, when the land was again elevated, the hills and mountain sides might be strewed over with fragments of rocks, the parent mass, from whence they might have been derived, occupying lower levels.

Among the effects produced by the sinking of masses of land gradually beneath the level of the sea, and their emergence also in a gradual manner,—movements which the present state of geological knowledge would lead us to suppose had been common during the lapse of geological time, though not to the exclusion of more violent movements (which, however vast they may appear to creatures of our magnitude, examining minor portions of the earth's surface, are by no means so when we regard them relatively to the volume and superficies of the whole globe),—this removal of shingle and boulders, with occasional angular fragments, at times and places where coast ice could be formed, could scarcely but have happened. We have only to consider the coasts of Northern Europe or of Northern America to be gradually sinking to see how probable this would be. Indeed the facts seen in connection with the distribution of boulders and gravel in those regions, not forgetting a part of the scoring of the solid rocks, would seem to require an explanation of this kind in aid of other modes of the transport of rock fragments, none of which should be forgotten when we regard the sinking, rising, or stationary character of land in icy regions. Among these we should not omit, for any value it may possess from local conditions, the upsetting of icebergs of the kind noticed off Victoria Land. At one sudden twirl the relative levels of angular fragments, shingles and boulders may be changed by 1000 feet or more. What might become of such suddenly elevated portions of rocks would depend upon conditions; and we have to inquire, in the first place, by what geological changes the gravel and boulders thus picked up came into a position where there were no forces to round them. They might in the first instance have been carried from the land by coast ice, and drifted seaward, or may be submerged portions of old beaches, the relative levels of sea and land having changed. With regard, however, to this mode of suddenly altering the level of boulders, we have to re-

* Geol. Trans. vol. vi. 2nd series, p. 430.

collect that after the upsetting of an iceberg, such as those off Victoria Land and its adjoining icy barrier, there still would be a large mass of ice beneath the surface of the sea, preventing the iceberg from floating into shallow water. We endeavoured to show in the Address of last year what would happen to these icebergs as they floated into milder regions. From the thickness of the supporting ice becoming less, and merely sufficient to float the coating of gravel and boulders, not only might this detritus be borne to considerable distances, but be really elevated above its former level. We merely allude to this circumstance of mud, gravel and boulders being picked up at a depth of 1000 or 1100 feet, and brought by the upsetting of the iceberg to a higher level, that it may be borne in mind, though it would not so well explain the changes of level noticed within a few miles, since in its original climate there might not be sufficient waste of the supporting ice to allow of the whole floating into shallow water, the raising of coast ice, as supposed by Mr. Darwin, being apparently an efficient and much better agent.

The modification in the original levels of gravels and boulders by the sinking and rising of masses of land, more particularly in tidal seas, where the heights of tides in different localities, and therefore the height of coast-beaches, would vary considerably according to the conditions existing at particular times, is of itself highly interesting, and it becomes the more so when we have to consider the effects of ice, either in the shape of shore ice, common sea floes forcing shingles before them, or glacier ice on such coasts. Our colleague has therefore done good service in thus showing how important it is properly to value the effects of coast ice when we have to consider the manner in which gravel and boulders, now at higher levels than their known parent masses, may have been transported to such situations.

In the paper of Mr. Smith, of Jordan Hill, on Scratched Boulders, he alludes to his communication to this Society, in 1845, in which he mentioned two boulders on the shores of the Gare Loch, Dunbartonshire, half imbedded in the *till*, both grooved in the same direction, namely from N.N.W. to S.S.E., and concluded that the parallelism was not accidental. Other boulders were subsequently found by Mr. Maclaren and Mr. Smith grooved in the same direction, that of the axis of the valley forming the trough of the Gare Loch. Mr. Smith observes that, whatever may have been the cause of the grooving, the grooves themselves were made subsequent to the deposition of the till in that locality, and points out the difference between the till and glacier moraines to which it has been likened.

Without attempting to account for the particular phænomena mentioned, Mr. Smith thinks it must be admitted that scratches and furrows in rocks must, in many instances, be ascribed to glacial action, either in the shape of icebergs or of glaciers, and considers that such action must have been in force in Great Britain, supposing its general temperature to have once been sufficiently low. He alludes to the views of Mr. Darwin respecting the depression of land and the consequent relative raising of ice-borne boulders on the new shores ; and concludes that there is evidence of a descent of the land in the basin of the Clyde, when the climate was colder than at present, sufficiently rapid to have entombed alive the then testaceous inhabitants of the sea (littoral and sub-littoral creatures, *Mytilus edulis* among them), covering them with a considerable depth of finely laminated clay.

The shells in the shelly beds are noticed as in place, "the bivalves with both valves adherent, still covered with epidermis, and the borers in their vertical position." Under a movement of this kind Mr. Smith supposes the ice upon the shores to have been floated to a higher level, bearing up the fragments of rock encased in or supported by it.

Though many grooves and scratches observable upon the solid rocks and boulders may have arisen, as has been supposed, from the action of glaciers, coast ice, river ice, and the crushing of ice-floes against the land—all varieties of glacial action which have to be regarded when we consider the effects which may be produced over glacial countries and their shores,—there are other groovings which require to be carefully distinguished. In the contortion and squeezing of strata the movement has been sometimes such, that by the sliding of bed upon bed, friction grooves and scratches have been produced, which may be readily mistaken for the others. Again, we find detritus, the pebbles and boulders of which are scratched as well as the supporting rocks, as if the whole mass had had an onward movement with sufficient friction of parts to scratch the pebbles and subjacent rocks. Sheets of ice, resting upon the bottom, such as much of the great icy barrier appears to do near Victoria Land, might indeed press heavily and slowly over such a bottom, and, if it were formed of pebbles or boulders, scratch and groove the latter, as well as the supporting rock, in general directions. At the same time we have to regard the friction of a mass of loose materials moving by any means in some given direction, as has been brought under the notice of geologists by Mr. Mallet. Every block of rock in the course of a river which can be moved along during a flood, without being caught up in mechanical suspension, would grate along a bottom, tending to scratch and groove the latter, and its own lower portion. When the volume and velocity of the water were sufficiently great, and the form of the river course variable, the blocks caught up at one time in mechanical suspension and not at another, would fall to the bottom from time to time, grooving and scratching it. These and other causes of scratching and grooving have to be well taken into account, as also artificial scratches and grooves, sometimes without due investigation attributed to glacial action.

We have also carefully to look into the bars and mounds regarded as ancient moraines, since some of these, upon close investigation, have been found to show that their component parts have been arranged by moving water; the mode in which the blocks, pebbles and sand are distributed proving this. We have frequently also to guard ourselves from supposing that the larger blocks of such deposits as the so-called boulder clay and till of various districts in our own country, have been always accumulated in greater numbers on the top, or in the valleys, of such deposits; it being often clear that they only appear so thickly strewed over the surface because the smaller portions have been removed from the general mass, so that the blocks stand out in more salient relief and apparently in greater multitude.

In his observations on the recent formations in the vicinity of Edinburgh, Mr. James Nicol, after alluding to the general view taken by Mr. Milne of that district, and remarking that the '*till*' or boulder clay has been usually regarded as exhibiting no marks of stratification, and hence considered to have been the result of some sudden and violent action, adduces facts, brought to light by sections upon the Edinburgh and Leith Railway, which would show a gradual accumulation of the clays, sands, gravels and boulders there cut through. He refers the effects seen to continued and variable agents, the clays and sands derived from the adjoining coal-measures, and the boulders transported by ice and entangled in the roots of floating trees. He points to the mode in which boulders, dropped upon a mud-bottom, would descend irregularly into it, such mass of mud not necessarily being stratified although formed gradually.

Mr. Nicol considers that the facts observed would justify the conclusion that there had been elevation and depression of the sea-bottom during these recent accumulations. With respect to the erratic blocks, he thinks that, from the remarkable accumulation of them on the Pentland Hills, this range of mountains may have stopped their passage in a southward direction. A block of mica slate near Habbie's How, supposed to have travelled forty miles, is estimated to weigh six or eight tons. In some places they appear to form long and nearly straight lines, having a N.N.W. and S.S.E. direction, "without any reference to the present declivity of the ground, except that they seemed to become more numerous towards the summit of the ridge." With regard to their occurrence above the level of the sea, Mr. Nicol states, that upon one hill he found 'these travelled stones' particularly abundant at the height of from 1500 to 1600 feet.

Referring to certain sandstone and trap boulders at a higher level than the usual mass of the same rocks in the adjoining country, though there may be a few points at the same height, six or eight miles distant, Mr. Nicol thinks that the configuration of the shores and relative distribution of land and water, if the land were depressed, would scarcely be such as to justify the supposition that the blocks were gradually raised to higher levels by means of coast ice as the land became depressed. He rather supposes that there may have been unequal elevations of land, carrying up the detritus, resting upon the dislocated masses to different heights; or so changing the relative levels that the rocks whence the boulders were derived may then have been the higher though now lower. In proof of this he quotes Mr. Milne as enumerating 52 faults in this district "raising the strata to the south 5169 feet, and 37 others which raise them 2412 feet in the opposite direction; the most extensive slip having thrown the strata 400 to 500 feet down to the north." Calling our attention to the kind of movement now taking place in Scandinavia, Mr. Nicol remarks, that if there was a similar movement between London and Anglesea,—

the angular motion amounting to one degree, and therefore scarcely perceptible,—Anglesea would be sunk 20,000 feet below the level of the sea: and he proceeds to observe how far more probable such movements are, than that which lifts whole continental masses in an exactly vertical direction.

In his remarks on the colouring-matter of red sandstones and of greyish and white beds associated with them, Mr. Dawson describes the accumulations of Nova Scotia forming the lower part of the carboniferous system of that country, showing the manner in which the peroxide of iron, which forms the red colour of many of the beds, is diffused through the mass of the clays and shales, mingles with the cementing matter of the sandstones, and stains the surfaces of the pebbles. He also points to the admixture of these red beds with the other kinds of strata not so coloured, such as dark grey sandstones and shales, some beds with scarcely any ferruginous matter, others with small quantities of carbonate and sulphuret of iron. A considerable thickness of these dark beds contains fossil plants, bituminous matter, or thin seams of coal. He also mentions limestones and gypsum. Mr. Dawson supposes the peroxide of iron of the red beds to have been mainly derived from the decomposition of the iron pyrites contained in the Silurian and metamorphic rocks; and thinks that the sulphuric acid which may have been formed might have united with calcareous matter accumulated by molluscs and corals and have formed gypsum, and that decomposing vegetable matter prevented the iron from remaining as the peroxide in beds associated with the red beds, and not of a red colour.

The cause of the wide distribution of red beds of clays, shales, sandstones and conglomerates, occurring as they do of all geological ages, from the lowest to the highest sedimentary deposits, is one of much interest. We find these beds most frequently intermingled with strata of bluish green, greenish, and grey tints, some even quite colourless. Upon carefully examining many of these deposits we see that sometimes the different tints were original, the drift having been mingled with peroxide of iron at one time and not at another; and again we observe effects which, as you are well aware, have of late years been attributed to the action of decomposing organic substances upon the peroxide of iron, in the manner adverted to by Mr. Dawson, so as to convert the peroxide into a protoxide, carbonic acid being formed partly at the expense of the peroxide of iron.

Palæontology.

In his remarks on the internal structure of Halonia, Mr. Dawes considers that this fossil plant should be referred to the vascular Cryptogamiæ, and that when compared with the plants found in the coal-measures, its nearest affinity is to the Lepidodendron. He points out "that a narrow ring of very regular, compact, elongated tissue exists on the outer portion of the cortical zone, similar to the prosenchymatous arrangement mentioned as occurring in the corresponding part of the Lepidodendron." He also remarks that "the medullary column does not, either in the Lepidodendron or the Halonia, consist of the usual parenchymatous tissue, but seems to be composed of large quadrangular cells arranged in perpendicular series," and as if "each minute column was confined within a slight membrane or tube."

Remarks were also sent us by Mr. Dawes on the structure of the Calamite, which have, however, not been published in full, as subsequent observations have afforded him additional evidence respecting it. In the notice given in our 'Journal,' he mentions circumstances which induce him to infer that the Calamites will serve to connect three great classes of the vegetable kingdom.

We have again to record the advance of our knowledge in fossil fishes from the labours of Sir Philip Egerton, who has continued with unabated zeal to cultivate this branch of Palæontology. In the communication entitled "Palichthyologic Notes, supplemental to the works of Professor Agassiz," he points out that the study of fossil fishes had not kept pace with the advance made in other departments of palæontology, notwithstanding the eminent success which attended the labours of the Professor. He shows, by reference to the general table of fossil fishes accompanying the last part of Professor Agassiz's work, and deducting the fishes of the old red sandstone, which have been subsequently described, that 389 species, given in that table, have neither been figured nor described. As the return of Professor Agassiz to Europe would appear distant, Sir Philip Egerton intends from time to time to communicate to our Society notices of fossil fishes, which may be considered supplemental and auxiliary to the works of the Professor, a resolve upon which we have great reason to congratulate ourselves.

The first notice was a paper by Sir Philip Egerton and Mr. Hugh Miller, and those who were present in this room when the communication was read, will not fail to recollect the beautiful paper model made by the latter to illustrate the structure of that strange fish, the Pterichthys, and the anxiety of the former to do justice to the skill and perseverance with which Mr. Hugh Miller had laboured at the fishes of the old red sandstone. In this notice, after mention of previously known species, a new species, named *Pterichthys quadratus* by Sir Philip Egerton, is described and figured. The genus *Pamphractus*, of Agassiz, is not considered well-founded, the specimens which gave rise to it being portions of a Pterichthys.

Sir Philip Egerton considers, with Agassiz, that the Pterichthys was a ground fish, living on the mud and sand at the bottom of the sea, and shows that from the true position of the parts of this fish, as first shown by Mr. Hugh Miller, "the level ventral surface would glide with the slightest impetus over the slimy bottom," while "at the same time the vaulted carapace would afford a most effectual buckler of defence against injury from external violence." A view, Sir Philip observes, corroborated by a comparison with modern fishes of similar habits, the Sturgeon, whose plates along the dorsal line much resemble the central dorsal plate of Pterichthys, having strong bony plates protecting their arched heads and bodies.

In a paper on the supposed impression in shale of the soft parts of an Orthoceras, by Mr. James Hall of New York, after having noticed the observations of Mr. Anthony of Cincinnati, formerly communicated to this Society, our colleague proceeds to remark on the conditions favourable for the preservation of the solid portions of animal remains in the rock in which the supposed soft parts of the Orthoceras were found, and to show that appearances, similar to those observed by Mr. Anthony, had been seen by him for ten years in the shales of New York. Mr. Hall considers that these appearances are fallacious, and that the sac-like envelopes are merely concretions which are to be found enveloping other organic remains as well as the shells of the Orthoceras, instances of which he adduces in North American rocks. The extent to which animal structures may be preserved under favourable conditions forms an inquiry of much interest. As investigations have proceeded, facts as to the preservation of more perishable parts than we were once accustomed to consider probable, have accumulated. When the Dean of Westminster first brought forward facts respecting the preservation of the fæces of fish and of saurians in a fossil state, even before these fæces were excluded from the bodies of the animals themselves, much doubt was, you will recollect, cast on these views. Now, however, coprolites are as much admitted to be fossils as the bones of animals and the shells of molluscs. Last year we had occasion to notice the views of Dr. Mantell and Mr. Charlesworth respecting the preservation of the soft parts of molluscs by means of silica. The beautiful preservation of the fossil described by Professor Owen, from the Oxford clay, and of the Belemnites from the same deposit mentioned by Dr. Mantell, and many other cases of the fine preservation of organic remains under favouring conditions, will be in your recollection; so that while with Mr. Hall we may be prepared to consider the appearances he notices as simple concretions, such as surround other fossils, we may still expect to find the less firm portions of animals better preserved than might once have been supposed. We are more especially led to this opinion in consequence of some late researches of Dr. Lyon Playfair, who found that there was still much animal matter remaining in some fossil shells collected, during the progress of the Geological Survey, from certain Silurian rocks in Wales.

In a memorandum respecting certain fossiliferous localities, appended to a paper by Professor Ramsay and Mr. Aveline on the structure of parts of North and South Wales, Professor E. Forbes concludes, that the sandstones skirting the Longmynds belong to the upper beds of the Caradoc series, and were deposited in a deep sea around the margin of land, that land steep and high, and formed of the Llandeilo flags, or of older rocks. He also infers that they are in sequence with certain limestone bands at the base of the Wenlock series, and that the Meifod fossiliferous beds are of a somewhat older date, probably equivalent to the middle part of the Caradoc beds. Inferences regarding the condition of the sea as respects its proximity to land, and depth of water, drawn from organic remains, undoubtedly require very great care, more especially when the character of these remains is alone regarded, and the habits of the animals of which they have formed the harder parts considered to be the same with those of certain animals now existing; but when, as appears the case in the localities noticed, the structure of the rocks themselves would support such inferences, they become of great geological value. In this way we may advance towards much knowledge of the coasts and the depths of water around them at different times in various parts of the earth's surface, and from the local or extended distribution of particular marine animals, infer the physical conditions under which their remains have been entombed.

Connected with the same communication there is a note by Mr. Salter, on the fossils of the lowest Wenlock shales, east of Llandegle, Builth, in which he remarks on the mixture of Caradoc and Wenlock fossils (trilobites, brachiopod shells, and a single coral) there found. The absence of ordinary bivalve and univalve shells is noticed, as also that of terebratulæ, large flat orthides, corals, and trilobites, characteristic of the Woolhope limestone. This is apparently another example of the effects of local conditions, so needful to investigate when we attempt generalizations as to the kind of life distributed over a particular area at a given geological time.

We find our colleague, Dr. Mantell, as indefatigable as ever in developing the fauna and flora of the Wealden deposits. In his brief notice of organic remains recently discovered in these accumulations, he presents us with no slight additions to the list of the animal and vegetable remains formerly known. He notices additional and more instructive examples of Clatharia and Endogenites, and cones apparently referable to the same species of Abies or Pinus as those found in the greensand of Kent. As extending our knowledge of the European flora at the time of these deposits, Dr. Mantell refers to the labours of Dr. Dunker of Hesse Cassel, who has added to it no less than sixty species of plants, and other species are stated to have been found since Dr. Dunker's work was published*. Of the sixty species of plants, thirty are referable to seven genera of ferns, and twelve to Cycadeæ or Zamiæ.

Dr. Mantell is not aware of any new species of molluscs having been discovered in the Wealden deposits of Britain, but refers to the researches of Dr. Dunker for a list of 100 species found in the German accumulations of the same age. Respecting crustaceans, he notices the shields or cases of Cyprides and Estheria, of which four new species have been detected in Germany. For the insects, Dr. Mantell refers to the labours of the Rev. P. B. Brodie, and corroborates the occurrence of insects in the freshwater beds above the oolite in Buckinghamshire.

Under the head of fishes, the German accumulations of this age are stated to have yielded one species of Enchodus, two new species of Hybodus, two of Lepidotus, one of Sphærodus, and one of Gyrodus. Fine specimens of the previously well-known species of British Lepidotus are mentioned as having been discovered near Hastings.

* Monographie der Norddeutschen Wealdenbildung.

Regarding reptiles, the additional remains of Iguanodon, Hylæosaurus, Megalosaurus, Streptospondylus, Pœcilopleuron, Goniopholis and Cetiosaurus are mentioned, and specimens are also noticed of Trionyx, Plesiosaurus, and Macrorhynchus. But the discovery most gratifying to Dr. Mantell was that of the lower jaw of his Iguanodon, which, most properly, found its way to him for description*. He infers, from the examination of these remains, that there is "now unquestionable proof that the Iguanodon, like the colossal Edentata, possessed a large prehensile tongue and fleshy lips, capable of being protruded and retracted, and which must have formed most efficient instruments for seizing and cropping the foliage and branches of ferns, Cycadeæ and coniferous trees."

Dr. Mantell, referring to a previous notice of a jaw which he then (1841) thought might be that of a young Iguanodon, now proposes the name of *Regnosaurus Northamptoni* for the reptile to which it belonged, considering that it is subgenerically, if not generically, distinct from the Iguanodon, though evidently of the same family. In a summary of the Vertebrata found in the Wealden deposits, Dr. Mantell enumerates about thirty-two species of fishes, one a Cycloid, sixteen Placoids, and fifteen Ganoids. Of reptiles it is stated that there are twelve genera of saurians already determined, with indications of four or five others, one flying reptile,—the Pterodactyle, and four or five genera of Chelonians. There are also bones considered referable to birds. From the length of time (nearly thirty years) which has elapsed between the discovery of the teeth of the Iguanodon to that of the jaw with teeth in place above mentioned, our colleague is led to infer that the palæontology of the Wealden is as yet but imperfectly explored, and that many a relic of the past has still to be brought to light.

Though so much has been said, and well said, respecting the accumulations to which the name of Wealden has been given, the interest attached to them can scarcely be considered less now than when, in years past, we were first made acquainted with their general character. To detect fluviatile and estuary deposits of that geological epoch (a fortunate bending, squeezing, and denuding of the rocks of part of England, exposing them for examination) was no small advance in our knowledge of the distribution of land and sea of the period. Additions, as you are well-aware, have since been made to this first knowledge, and we see Dr. Mantell losing no opportunity of increasing it, so that now we can embrace a wider area upon which to reason, and can better understand the spread of dry land, in the area at present occupied by western Europe, anterior to the submergence of so much of it beneath the adjoining seas, in the waters of which the cretaceous deposits were effected. These great changes in the relative areas overspread by sea and land at different geological times possess the highest interest, particularly when we consider them with reference to the various ranges of high

* The original memoir on the Iguanodon having been communicated to the Royal Society, the paper in which these remains were described, with the assistance of Dr. Melville, was also transmitted to that Society.

land, the frequent contortions of the rocks in mountains and elsewhere, the different coast-lines, deep and shallow seas, the lakes and rivers, and all the modifications of animal and vegetable life attending such changes and alteration of conditions. Attempts have from time to time been made, from the facts known, to sketch the probable distribution of sea and land on certain parts of the earth's surface at what have been termed geological periods. No doubt we have much to consider when we attempt to define geological periods, such as the more sudden effects produced on some parts of the earth's surface, the more tranquil changes in others, and the inequality of these changes both as regards geological times, superficial modifications, and their consequent effects on mechanical accumulations and animal and vegetable life; yet all such attempts, if fairly worked out according to the existing evidence, may be considered as highly useful. We may expect in future years, as geological knowledge advances, that these sketches will more and more approach the truth, so that the probable great rivers and lakes, mountain-ranges and level tracts, forms of shores, and in fact the relief of the dry lands, and depressions of the sea-bottom, of many geological times, may, to a certain extent, be made apparent. And this we consider by no means so visionary as might be imagined by those who are not conversant with the kind of geological research now in progress.

To our old and staunch friend Mr. Lonsdale we are indebted for an elaborate communication on the fossil zoophytes in the deposits exposed between Atherfield and Rocken End, described by Dr. Fitton. In it he takes general views of the subject, and enters into details exhibiting that research and desire to attain the truth for its own sake which characterise our colleague, and which contributed, while he was an officer of our Society, so much to its welfare.

Mr. Lonsdale describes new genera and species, and enters largely upon the views and opinions of previous authors. Let us hope that the retirement, which ill-health compelled him to seek, may continue to afford him the leisure and quiet requisite for communications such as this, and that he will enrich our works with further contributions on fossil corals, a branch of palæontology to which he has devoted so much attention.

Among the labours of our Foreign Secretary, Mr. Bunbury, during his late travels on the continent, was included an examination of the fossil plants from the anthracite formation of the Savoy Alps. The results of this investigation he communicated to us in a memoir, in which he not only describes the species of plants that came under his observation, but also gave us a history of the researches and opinions connected with the mode of occurrence of these plants, adding general views of his own.

As you are aware, M. Elie de Beaumont was the first, in 1828, to announce the fact, that near Petit Cœur in the Tarentaise, beds containing an abundance of plants, of the same species as those discovered in the coal-measures of the palæozoic period, alternated with other beds containing belemnites, and referred the whole to the period of the lias. The plants were determined by M. Adolphe

Brongniart. Subsequently M. Elie de Beaumont published an account of beds occurring between Briançon and St. Jeane de Maurienne, and included them in the same series. Plants obtained from these rocks were examined by M. Adolphe Brongniart, and identified by him with those of the coal-measures. From all the facts M. Élie de Beaumont inferred, that the beds with belemnites and ammonites, and those containing the plants, were parts of one whole, and that whole referable to the date of the lias and part of the oolitic series.

This announcement was startling to those who were accustomed to consider that the animal and vegetable life existing at each geological period had been so entirely swept away, and replaced by new species at another, that no species of one geological period would have its existence prolonged into another. The view of M. Elie de Beaumont was in consequence considered to require confirmation, and thus the subject remained, as Mr. Bunbury has pointed out, until the meeting of the Geological Society of France, at Chambery, in 1844, when the observations of the members present led them to adopt the opinions of M. Elie de Beaumont.

When at Turin in 1848, Mr. Bunbury carefully examined the fossil plants from the Tarentaise in the Museum. In this examination he experienced difficulties from the imperfect preservation of the plants, their confused mixture and distortion, and from the injury to the structure caused by their replacement by a coating of talc. The specimens in the Turin Museum afforded Mr. Bunbury fourteen different forms, for he will not venture to call them species, of which nine are Ferns, two Calamites, and three Asterophyllites or Annulariæ. "Two of these ferns," he observes, "*Odontopteris Brardii* and *Pecopteris cyathea*, may be pronounced with tolerable certainty to be identical with characteristic and well-known plants of the coal-measures. Three, or perhaps four, others have a strong resemblance to coal-measure plants, with which they may probably be specifically identical, but," he continues, "I cannot feel certain of them. Another seems to be a remarkable and hitherto unnoticed variety of *Odontopteris Brardii*, connecting that species with *O. obtusa* of Brongniart. The eighth is perhaps a new species, but its nearest allies are plants of the coal formation. Of the ninth, the specimens are too imperfect to admit of determination. Of the remaining plants, *Calamites approximatus* and *Annularia longifolia* appear to be absolutely identical with coal-measure plants; and the other two, *Annulariæ* or *Asterophyllites*, are at least very similar to carboniferous forms. The other *calamite* is undeterminable."

The occurrence of similar plants at the Col de Balme, and in the mountains above Servoz and Martigny, is then noticed, as also the absence of belemnites in beds interstratified with the others in those localities. The plants obtained by Mr. Bunbury from the neighbourhood of Chamonix, and those seen by him in the Museum at Geneva, consisted of eight Ferns, one Calamite (species undeterminable) and one Asterophyllites. A well-preserved specimen of *Lepidodendron ornatissimum*, of Brongniart, was pointed out to him by M. Elie de Beaumont in the collection at the École des Mines at

Paris, brought from beds at the Col de Chardonet, near Briançon, referred "to the uppermost part of the Alpine Anthracite formation, and probably equivalent to the Oxford clay." It thus appears that the researches of Mr. Bunbury lead him to conclude, with M. Adolphe Brongniart, that the plants from the beds noticed present a general agreement with those found in the coal-measures.

It will be fresh in your recollection, that the mixture or rather alternation of beds containing belemnites with others full of plants resembling those commonly found in our coal-measures engaged the attention of my predecessor in this Chair, Mr. Horner, and that he pointed to the probability that it might be an instance of species which had a wide range in space having had also a long duration in time, calling your attention to the wide spread of similar plants over certain northern regions of our globe at apparently the same geological time. This explanation does not satisfy Mr. Bunbury, inasmuch as other plants are known to be found elsewhere in European accumulations between the periods of the coal-measures and the oolitic series inclusive, admitting however that in the Permian system of Sir Roderick Murchison the character of the entombed plants closely resembles that of those of the coal-measures. He more particularly observes on the difference of the plants in the *grès bigarré* of Alsace, remarking on the common spread of certain ferns at the present day over Europe, and of the same tribe of plants over wide areas at the period of the coal-measures. He also points out the small geographical distance of the localities in which the remains of these dissimilar plants are found in the rocks noticed, and calls attention to the observations of M. Scipion Gras, who states that the Jurassic rocks, occurring in their ordinary condition in the department of the Isère, contain impressions of plants entirely different from those of the Alpine anthracite. He admits however at the same time that there are instances of the isolated occurrence of tropical plants, especially Ferns and Lycopodia, in temperate regions, far beyond their ordinary geographical range, as, for example, the growth of *Trichomanes radicans* in Ireland, and of *Lycopodium cernuum* in the Azores. Mr. Bunbury then adverts to the hypotheses of M. Adolphe Brongniart, that the plants in question may have been drifted from regions in which the coal-measure plants still continued to grow,—in the same manner as seeds are now drifted from the tropical regions on the American side of the Atlantic to the shores of Europe, in part, perhaps, becoming enveloped in deposits near land, where plants similar to those producing such seeds do not occur. While he admits that this hypothesis is the most plausible under existing information, and that he has none more satisfactory to offer, Mr. Bunbury does not see his way out of the difficulty.

Of all organic remains, perhaps those of land plants would appear to afford us the least direct information as to the climate, at different geological periods, of the low or slightly elevated countries bordering seas in various parts of the world, except we can obtain something like evidence of the plants themselves having flourished so near the level of the seas of the time, that slight changes in that level produced alternations of deposits, which should at one time contain the remains of marine animals which inhabited the coast seas, and were quietly entombed, and at another the remains of plants, showing their growth on the spot. Such evidence we seem to possess at two distinct periods in the north of England, where we detect alternations of coal beds, with their underclays, and limestones with marine animal remains of the carboniferous time; and also find a coal accumulation, with some plants apparently in the position in which they grew, of the oolitic series. In both cases the evidence would be in favour of quiet depressions, low districts with land plants growing upon them so sinking beneath sea-water, that marine creatures swarmed over the previous dry land, their remains entombed amid detrital deposits effected at the time.

Viewing the actual and varied altitudes above the sea-level of lakes in different parts of the world, the plants which may be drifted into them and preserved amid any mud, sand, or calcareous matter deposited in such lakes, give us no just idea of the climate of the time at the sea-level in the same latitudes. For instance, the plants drifted into the lakes of Switzerland and Northern Italy, some of which may even be swept from heights approaching lines of perpetual snow, would not give us the climate of the coast of the Bay of Biscay between the Saône and the Gironde, though in the same general latitude. Then, again, as to the conditions for the transport of plants or their parts to situations where portions of them may be more or less preserved in detrital matter, much has to be considered. Though floods in high regions tear up trees and smaller plants in their course, the chances of any of the plants reaching sea-coasts depend upon a variety of conditions, among which proximity to the sea is one of no inconsiderable importance. Thus we have seen the arborescent ferns and other plants of the higher lands of Jamaica swept by floods into the adjoining seas (becoming entangled in part among the mangrove swamps at the mouths of the rivers), the distance having been so short, that many stems of the fern trees, their fronds, and those of other ferns of the higher regions, were not much injured. No mere swelling of the rivers from rains on the lower grounds, which did not cause torrents to wash away plants in the higher lands, would bring down a frond of these ferns; it would, however, sweep on many a lowland plant, and not a few of those which grew in the river courses during the dry weather, into the mangrove swamps and the sea.

In great rivers, the leaves, as they fall from trees overhanging the water, are floated onwards and often carried quietly to sea, sometimes from long distances inland. Plants and their parts may, under favourable conditions, be washed into, and be preserved in the mud of climates where they do not grow. They may be thus brought by the Mississippi, the Paraguay, the Nile, and the great rivers of Northern Asia flowing from south to north, and be preserved under climates differing from those where they flourished. We have no reason to suppose that the conditions of continents, as regards the flow of rivers into the sea, were not very various during long lapses of geological time, and we should very carefully avoid permitting our view of the relative disposition of land and water at former periods to be biased too far by their present arrangement.

Every autumn our European rivers are full of leaves which have quietly fallen into them. Some get washed on the banks, while others are left upon low grounds when the waters may have been more swollen at one time than another. Some get borne backwards and forwards by the tides in estuaries, and are accumulated in the mud, entangled with the remains of estuary animals and plants; but many get washed to sea, particularly if off-shore winds prevail at the time. Probably many of these become saturated with sea-water and fall to the bottom amid the remains of marine molluscs and other animals, and are thus entombed with them amid any detritus there accumulating. Some we know are thrown on shore, at various distances from the river-mouths, according to the prevalence of the winds of the time, and the relative bearing of these upon the coasts of the locality, and become intermingled with various marine animal and vegetable remains.

The extent to which trees and smaller plants are washed during floods out of the great rivers of the world, and floated outwards to situations where they fall within the influence of ocean currents and prevalent winds, is very considerable, and it is very needful to bear this in mind when we have no satisfactory evidence as to the growth of plants at or near the localities where we find their fossil remains. Little islets of matted plants are thus sometimes floated away, and it will depend upon the weather they may encounter how long they may keep together before they become broken up by the seas, and fall to the bottom. Although the counter-current along the Atlantic shore of the United States may tend to carry plants washed out from the rivers of that part of North America to the southward, the Gulf Stream is still enabled to transport plants and their parts from Cuba and the Bahamas (the prevalent trade-winds even perhaps drifting them from Haiti) northerly towards Newfoundland. Taking the Gulf Stream and its counter-current along the American shore as constants, we may have two north and south belts beneath, in one of which the remains of plants from the north are accumulated, and in the other those from the south, indicating climates which do not correspond with those of the dry land of America in the same latitudes. Such lines of transport—and there would appear to be many of them—and the probable falling of plants and their parts to the bottom during a long period of time, have to be regarded when we consider deposits wherein the remains of plants which may not have grown on the spot are entombed. There may be situations where little detrital matter now settles, but where drifted vegetable matter may accumulate from the repetition of certain annual effects continued through long time, as well as those deposits which we infer have been the result of the growth of plants on or near the spot where their remains are now found. When we consider all the conditions under which the remains of plants may be accumulated, and the difficulty often of determining the real character of the plants themselves *, it would ap-

* See Dr. Hooker's Remarks, Memoirs of the Geological Society, vol. ii.

pear desirable to obtain more information respecting the distribution of fossil plants at different geological times than we now possess, before we conclude that we have evidence enough to speak of the characteristic plants of different geological epochs with the confidence sometimes used. It would appear very desirable, under present information, to regard the subject more locally and always with reference to the probable physical conditions under which the plants may have been entombed.

In his communication on the Silurian slates and coal of the neighbourhood of Oporto, Mr. Sharpe gives descriptions of *Isotelus Powisii* ?, *Illænus Lusitanicus* (*n. s.*), *Orthis Noctilio* (*n. s.*), *Orthis Miniensis* (*n. s.*), *Orthis Duriensis* (*n. s.*), *Orthis Lusitanica* (*n. s.*), *Orthoceras remotum* (Salter MS.), and *Bellerophon Duriensis* (*n. s.*), all found in those beds.

To Professor Owen we are indebted for a description of saurian remains discovered by Professor Henry Rogers in a greensand deposit of the United States, considered referable to the age of part of the cretaceous accumulations of Europe. The specimens placed before Professor Owen enabled him to add some facts to the osteology of the Mosasaurus, and to discover some species of saurians, especially of the procœlian form of crocodile, not previously known in strata older than the tertiary deposits termed eocene. After very important osteological details respecting the Mosasaurus, which require to be studied in the memoir itself in order fully to appreciate the labours of our colleague upon this subject, he states that, considering certain of the bones to belong to the Mosasaurus, "they indicate the extremities of that great saurian to have been organized according to the type of the existing Lacertia, and not of the Enaliosauria or marine lizards," and adds, "two species, at least, of true Lacertia have left their remains in our English chalk."

Professor Owen next notices some remains of a procœlian reptile, and proposes to indicate the saurian, and probably mosasauroid genus to which it belongs by the name of Macrosaurus. Upon other remains he establishes the genus *Hyposaurus*, an Amphicœlian crocodile, and then notices specimens from the same localities laid before him by Professor Henry Rogers, which he remarks are "the first evidences of the genus of the modern Crocodilus or Alligator that have been discovered in strata older than the eocene tertiary."

The accumulations amid which these saurians have been detected are inferred, from the marine remains found in them, to be of the same age as part of the cretaceous series of Western Europe, similar marine molluscs having been considered to exist and to have been entombed in mineral matter at the same geological period in the seas surrounding the shores of land in the areas now occupied by the United States and Western Europe. The remains described by Professor Owen thus possess not only high interest as additions to the forms of life which have existed at different times on our earth, but also as showing the co-existence of certain saurian and molluscous forms at equal geological times. We have thus the modern crocodile or alligator (living probably much in the same way as the species of the same genus do in the present day, namely in rivers and estuaries), borne into seas in which molluscs of the same kinds as have their remains entombed in our cretaceous rocks, were living.

From the general characters of the other saurians found we should also infer that their habits were not such as to render the sea among their usual haunts, but rather that they lived in rivers and estuaries, occasionally coming on the adjoining lands. When we look at the lithological characters of the beds in which these remains are entombed, as well as to the state in which the bones are preserved, it at once becomes evident that they have been carried to the situations at or near which they are now discovered, by being rendered specifically lighter than they now are, or formerly could have been. In fact we seem required to consider that flesh was on the bones when they were borne into the seas, amid the deposits and creatures living at the time, in which they are detected. However difficult it may be to wash crocodilian animals into the adjoining seas from out many of the great rivers of the world where these creatures live in multitudes, more particularly where mangrove swamps abound at their embouchures, this is not the case with the short torrent rivers descending from high lands into the seas surrounding islands, as for instance Jamaica and Hayti. During a great flood in the Yellahs river, one which takes its rise in the Blue Mountains of Jamaica, and at whose mouth and in the adjoining mangrove swamps the caimans are common, the body of water was so great as to sweep these crocodilians off to sea, where it may be presumed some perished, to leave their bones, at least such as were not swallowed by the large fish, to be mingled with the remains of marine molluscs now living in those seas. In cases of floods of this kind, the suddenness of which can be scarcely appreciated by those who have not witnessed the waters of heavy tropical rains discharged by means of a short steep course from high mountains into the sea, many a river and estuary air-breathing creature gets overpowered and carried off before it can reach the protection of eddies near the banks; and should there be a heavy sea going at the time, as sometimes happens when a hurricane is accompanied by floods of rain, there is a poor chance of their escape from drowning, however well-fitted for living in rivers and estuaries under ordinary conditions.

True to his promise to add to our palichthyological information, as given in his first memoir read during the past year, Sir Philip Egerton communicated at our last meeting a paper on the affinities of the genus *Platysomus*. After adverting to the opinions of different authors, and especially to that of Agassiz, Sir Philip mentions that Mr. King, of Newcastle, had recently submitted to him a specimen of *Platysomus macrurus*, from the magnesian limestone of Ferry Hill, revealing its dentition, whence it became evident that this genus was a true Pycnodont. A detailed account of its dentition is given, and it is stated that the genus *Globulodus* must be cancelled. Conferring with his friend Professor Agassiz, Sir Philip Egerton received from him a complete agreement in the view that the genus *Platysomus* should be included among the Pycnodonts; and alluding to the difficulty he had experienced with respect to its heterocercal tail, the Professor remarks that he now expects to find that character in fishes of various families detected amid the oldest accumulations as well as in the youngest embryo state of our actual fishes. Sir Philip Egerton has satisfied himself that "the generic characters of Platysomus are in close affinity with those of Gyrodus and Microdon, but that it differs from these and all other known Pycnodonts in having a heterocerque tail." It is gratifying thus to see two cultivators of the same branch of science working so completely in harmony, and conferring with each other so amicably on points of difference; so that instead of conclusions being hostilely retained which may no longer be tenable,—and the progress of all branches of science shows us how first-impressions have to be modified,—truth becomes the only object, no matter by whom it may be brought to light.

To Mr. Morris we are indebted for a communication on Neritoma, a fossil genus of gasteropodous molluscs allied to Nerita. He shows that the shells in question, though allied to Nerita, are yet aberrant from it, and that they become interesting from connecting the true Nerites with Amphibola, and as adding another instance of certain genera of molluscs with analogous forms presenting the similar character of a greater or less sinus on the outer lip. The fossil whence the generic description is given was from the upper portion of the Portland beds, at Swindon, Wiltshire, and was also interesting as distinctly exhibiting the markings on the surface.

Though this is the only communication from Mr. Morris during the past year in the form of a single paper, we have to thank our able colleague for his constant readiness to assist the labours of others of our contributors of memoirs whenever they may request him so to do, and for thus adding to our stock of that knowledge which the talents of Mr. Morris so qualify him to advance, and for the furtherance of which we could wish him more leisure than his occupations now present.

Superposition of Rocks, their supposed equivalents in different regions, and general classification.

In a memoir on the principal geological features of the salt-field of Cheshire and the adjoining districts, Mr. Ormerod has presented us with numerous facts respecting the occurrence of rock-salt and brine-springs in that part of England, the beds in which the salt and brine are found, and the older rocks on which these beds repose. The latter constitute the range of coal-measures running northerly from Cheadle and Newcastle-under-Lyne on the south, towards Manchester and Stayley Bridge on the north, a small portion of mountain or carboniferous limestone rising in an elongated anticlinal ridge near Congleton. These older rocks are well-known to have been disturbed, crumpled and fractured anterior to the deposits commonly known as the New Red Sandstone, the latter resting unconformably upon and entering valleys in the former, many a patch, not yet removed by denudation, showing the covering of these red marls, sandstones and conglomerates to have been once far more extensive than it now is.

The details given by Mr. Ormerod respecting the occurrence of the brine and rock-salt are not only valuable as regards geological information, but important practically, as he touches upon many points which cannot fail to aid those who may be seeking for brine and salt in that district.

It may be scarcely needful to remind you that the beds containing the salt and brine (the latter merely a solution of the former, by means of the water percolating amid the saliferous beds in those upper marls of the new red sandstone series of the central portion of England,) are referred to a series of deposits known in Germany as the *Keuper*; a term employed by Mr. Ormerod in his descriptions of these beds. The salt would appear to be distributed in flattened portions of irregular figures, and disseminated through certain beds. As might be expected, sinkings of the upper ground take place when the brine-springs have removed the salt in situations sufficiently near the surface for this effect to be produced.

At Northwich the upper bed of salt is considered to vary in thickness from 84 to 90 feet, thinning off to the south-west, and losing 15 feet of thickness in about a mile. Its upper surface is uneven, presenting cones and irregular figures. Beneath this bed is one of indurated clay, traversed by veins of salt, and 30 feet thick. Under this comes the second or great bed of salt, for the depth of 60 to 75 feet containing a considerable admixture of earth, so that this portion is not worked. The next 12 or 15 feet is more pure, and the salt is extracted from it. Beneath the earthy admixture becomes so considerable, that, like the upper portion, it is unworked. At a pit at Marston, northward from Northwich, the second bed of salt was sunk through, and found to be there 96 feet thick. In other places it was not passed through after sinking 117 feet.

Mr. Ormerod estimates the thickness of the gypsiferous and saliferous beds at Northwich and Middlewich at more than 700 feet. The strata technically termed *water-stone beds*, supporting these, he considers to be 400 feet thick, and others beneath, to which he applies the name Bunter sandstein, from their supposed identity in geological position with the beds so termed in Germany, at 600 feet; thus giving 1700 feet for the total thickness of the new red sandstone accumulations of Cheshire, one which Mr. Ormerod nevertheless considers as far below the real depth.

From the care taken by Mr. Ormerod, his paper becomes a valuable addition to our knowledge of the upper parts of that remarkable accumulation of beds, a group of much interest, to which the English geologists have given the name New Red Sandstone. With regard to the saline character of its upper part, as shown in the district described by Mr. Ormerod, you are aware that many hypotheses have been brought forward to account for the occurrence of rock-salt amid rocks of this and other geological periods. No doubt we should not limit ourselves to one view of the mode of occurrence of salt and beds highly impregnated with saline matter, when several explanations may be open to us; but looking at the distribution of the salt amid such accumulations as those noticed by Mr. Ormerod, and at the information (scanty though it may be on some very essential points) which we possess respecting the saline lakes and salt deposits of the great depression of Asia, it would be very desirable to have careful comparisons made as regards the probable accumulation of the saline deposits of England from the evaporation of salt water in minor basins amid mud and sand. There are many interesting facts of importance in this inquiry known as to the isolation of minor portions of the lakes in the great depressed area of Asia, the evaporation in which appears more considerable than the supply of water. After a long lapse of time salt not only constitutes great cakes, or lenticular masses of various dimensions and forms, but remains also in the dried-up ground; the latter finally so deprived of moisture in many localities as to be blown about, forming deserts. The water eventually remaining is gathered here and there in salt lakes, more or less modified in their saline contents by the various salts carried by running waters into them, and they will remain as such so long as the supply of rain- and river-water equals the evaporation. We should expect salt to be well-diffused amid sands and mud accumulated in the sea, and not to be washed out except under conditions, such as that of the so-formed beds being elevated above the ocean-level, when the percolation of waters derived from the atmosphere would carry off in solution the chloride of sodium and soluble matter, restoring to the sea that which had been entangled amid the deposits previously formed in it. In point of fact, we find chloride of sodium a very common substance in spring and river waters.

From the pattering about of reptiles at the period of our new red sandstone, as shown by their foot-marks left in certain localities, we may infer, whatever the inequalities and varieties of depths may have been after the exertion of the force which so disturbed the coal-measures and other older rocks of the British area, and thrust a portion of them as dry land into the atmosphere, that as the deposits went on very shallow water skirted the lands. With shallow water slight changes of the relative level of sea and land would produce considerable surface modifications. Many depressions around the coast of the British islands would be converted into salt lakes if the bottom of the surrounding seas were elevated, and the sea-water left evaporated, should there then be an insufficient supply of rain-water.

The mode of occurrence of the footprints above noticed is such, more particularly when we regard the evidence of cracks filled up in the same beds, that we can scarcely doubt the mud or silt upon which the animals trod to have been subaërial at the time, and that it was afterwards covered by water bringing detritus with it. In estuaries or gulfs where spring tides attain a great height, such as in the Bristol Channel or in the Bay of Fundy, the space left between spring and neap tides is often considerable, and the tracks of birds and mammals are common upon the mud so exposed, particularly those of the former. In summer weather this may be well seen on the shores of the Bristol Channel near the embouchures of the Avon and Wye. The geologist who observes these tracks, their hardened state from exposure to a hot sun, and the cracks in the general surface of mud, will not fail to see the resemblance of such surfaces to those laid bare in quarries, where the tracks of animals are found. He has but to suppose a gradual sinking of the mass of such land beneath the sea, and take into account all the modifications which would arise from alterations in the heights of tide, and spread of mud flats, to see how readily the results would resemble those deposits in which bird-tracks have been found by Professor Hitchcock and others in America, and amid the new red sandstones in Europe.

A communication was made to you by Professor Ramsay and Mr. Aveline, giving the results of examinations by the Geological Survey of parts of North and South Wales, it being thought highly desirable that this branch of the public service should aid the progress of the Geological Society whenever opportunities might occur. In this communication the authors point out that, on the south and south-east of the Dolgelly and Bala district, certain bands of sandstone, though comparatively of trifling thickness, are important as explaining the structure of Wales. These are local and intermittent, in part skirting the base of the overlying rocks through Montgomeryshire and Radnorshire far down into South Wales. Above these sandstones are slaty shales, 1000 to 1500 feet thick, and, resting upon the latter, sandstones, mingled with occasional shales, about 2000 feet thick. These the authors refer to the Caradoc sandstone of Sir Roderick Murchison. They support the Wenlock shales, in their turn surmounted by the Ludlow rocks of Montgomeryshire.

It is shown that the slates and associated contemporaneous igneous rocks of the country north of Bishop's Castle rise from beneath the Wenlock shales of Montgomeryshire, and present the same characters as the slates and igneous rocks of Merionethshire, resting on the purple, green, and grey sandstones of the Longmynds, which occupy the same position as the Barmouth sandstones of Merionethshire and Caernarvonshire. A mere trace of Caradoc sandstones is occasionally seen between the Wenlock shales and the older rocks of the Bishop's Castle district. The Wenlock shales run across the strike of these older rocks.

On the north-east of Welshpool, black slates and associated contemporaneous igneous rocks again emerge from beneath the Wenlock shales. On the north of Builth the same rocks are seen lapped nearly round by Wenlock shale, without the intervention of Caradoc sandstone. At Llanwrtyd and Baxter's Bank, Radnorshire, similar rocks rise up amid black slates, and at St. David's, Pembrokeshire, contemporaneous igneous rocks with associated black slates come to the surface, and repose on rocks similar to the Barmouth sandstones and the old deposits of the Longmynds.

It is incidentally noticed that "the igneous rocks which occasionally appear in the line of the great Shropshire and Radnorshire fault are of different date and structure from those heretofore alluded to. They are always massive (greenstones, syenites, &c.); they invariably appear in the line of great dislocation, and alter by baking, or semi-fusion, whatever strata they may chance to come in contact with, of whatever age those strata may be."

From the mode in which the equivalent of the Caradoc sandstone reposes on the Longmynd beds, lying unconformably upon them, and from being composed of water-worn pebbles derived from them, the authors infer that this accumulation formed the coast boundary of the sea of the time. So that from this circumstance and other facts noticed, Professor Ramsay and Mr. Aveline consider the Longmynd country to have constituted dry land washed by a sea at a level equal to the Caradoc sandstone accumulations of the vicinity.

Tracing the western boundary of the Caradoc sandstone northward it is found several hundred feet above the Bala limestone, north-east from Dinas Mowddy, and in its progress north and west it gradually creeps over the various beds, so that at Yspytty Evan it occurs at the level of that limestone, proving an overlap. Approaching Builth, the Caradoc series turns off eastward, as if the boss of older rocks to the northward of that place had formed a barrier to their further extension in that direction. Further south they have not been seen, and they would appear there and around the older rocks of Builth to be overlapped by the Wenlock shales.

The authors infer, from the unconformity of the Caradoc and Wenlock deposits, in connection with the old coast-line of the Longmynds and Bishop's Castle series, that both at Builth and Bishop's Castle, the older rocks rose above the level of the sea at the time when the Caradoc sandstone was formed, this land becoming gradually depressed during the deposit of the Wenlock and Ludlow rocks. Thus this dry land became covered by thousands of feet of sands and mud mingled with the remains of marine animals, geological changes having now again brought this old surface, denuded of its great covering, above the level of the sea, so that it again forms dry land.

It will be scarcely necessary to call attention to the importance of these facts and the views connected with them. Deposits of the age of the Llandeilo flags, with the older strata on which they repose, upset and bent, rising above a sea, and by their loss from breaker-action on the coasts and the abrasion from atmospheric influences inland, forming sand and mud beds around them, in which the remains of the marine animals of the time became entombed, and this at a period when, as far as our present information extends, the earliest kind of life established on our globe was yet unchanged in its general character. Thus it is that by careful and minute study we obtain a glimpse of the probable distribution of land and sea at this period in part of the area now occupied by the British islands,—much doubtless that was then contemporaneous as dry land being cut away by denuding forces during the progress of geological time, the matter removed transported around, much of it often used over and over again, constituting other rocks, and a large portion of the old rocks which may be still remaining in their places of original deposit being covered over by these more modern deposits, or concealed beneath the sea.

Mr. Beete Jukes and Mr. Alfred Selwyn have presented us with a sketch of the structure of the country extending from Cader Idris to

Moel Siabod, in North Wales, also the result of their labours on the Geological Survey. They show that a series of sandstones and conglomerates, with some beds of purple and blue slates, and occasionally trap rocks, about 3000 feet thick, constitute the base of that part of Wales. These are known as the Barmouth and Harlech sandstones, constituting the land which borders the coast, at and between those places, and forming the lower part of an irregular dome-shaped mass, dipping, where covered by other rocks, beneath the next or trappean group. This, with some flexures belonging to it, is well known to you from the descriptions of Professor Sedgwick, constituting his 'Great Merioneth Anticlinal.'

The trappean group is so named from containing igneous rocks, some felspathic, others hornblendic, with beds of 'ash,' probably ejected into the air from volcanic vents and, falling in water, arranged like ordinary detritus by tides and currents, as noticed in the address of last year. The authors separate this group, to the whole of which they assign a thickness of 15,000 feet, into two divisions, the lower containing blue and grey slates and flagstones, and known as the Lingula beds, an abundance of that shell, with some other fossils, being discovered in them. In the upper division are many interstratified beds of black slate, often occurring as irregular and lenticular masses, and graduating into 'ash.' Lingulæ and graptolites are found in these beds, though not very abundantly.

Upon these deposits rests the Bala group, estimated at 9000 feet thick. This is divided into a lower series, composed of black slates, of variable thickness, fine-grained and brittle, the true lamination being often entirely concealed by cleavage and numerous joints;—and an upper series formed of a grey arenaceous slate, often passing into a hard splintery grit. In the lower part of this latter division there are one or two beds of trappean ash, and in its centre occurs the limestone so well known as the Bala limestone, celebrated for its organic remains. Sometimes, but very rarely, there is a band of limestone in its upper part, of which the Hirnant limestone is an example.

The authors state that almost all the igneous rocks of the trappean group are contemporaneous with the beds amid which they are found, the ash beds formed from igneous materials arranged in water,—the gradual passage above and beneath the more solid trappean rocks showing that "its exhibition was intimately connected with the commencement and end of the igneous action which produced them."

It may not be here out of place to mention that the progress of the Geological Survey has shown, that after the dip of the Barmouth and Harlech sandstones north-westward beneath the trappean group of Snowdon and its associated mountains, they rise again, though with diminished thickness, in the line of country passing across the Llanberis lakes, resting upon those highly cleaved purple beds, so extensively employed for roofing-slates, in the valleys of Nant Francon, Llanberis, and Llanllyfni. These slates repose on and are interstratified with sandstones and conglomerates, mingled with trappean rocks, in their turn resting upon a mass of black slates, which cover other sandstones and conglomerates well-seen in the vicinity of Bangor. Still lower rocks are found in Anglesea, chiefly micaceous and chloritic slates, mixed occasionally with quartz rocks, of which those forming the Holyhead mountain afford excellent examples, with here and there also some calcareous matter, even forming limestone.

Having received a letter from Professor Naumann of Leipsic respecting certain sandstones and schistose clays of the environs of Oschatz, referring these rocks to the Permian system, Sir Roderick Murchison communicated this letter to the Society, with a few remarks recalling your attention to the reasons which had induced him to assign the name of Permian to the accumulation of deposits of which the roth-liegende of German geologists forms the base, and which also includes their zechstein and kupferschiefer. Professor Naumann mentions the discovery in these deposits of *Calamites gigas*, a fern allied to *Sphenopteris erosa*, and many plants differing from those of the coal-measures, and stated that many of the ichthyolites are similar to the Palæoniscus or Amblypteris, and to the Xenacanthus of Beyrich. The general mineral aspect of the lower beds, white sandstone and greyish schists, referred to the roth-liegende, and about 800 feet thick, is stated to resemble that of the coal-measures, above which come (1) quartziferous porphyry, (2) red sandstones, (3) zechstein (30 to 60 feet thick only), and (4) red and mottled clays.

Although generally in the British islands we have so much evidence of a great disturbance of deposits, after those to which we have given the name of coal-measures, so that the various beds of the new red sandstone series of English geologists are discovered resting unconformably upon such portions of these older rocks as may have been beneath the waters in which the newer accumulations were effected, we should expect to find beyond the area so disturbed, evidence as to a passage of the one series into the other. Moreover we are not to suppose the ocean blotted out from the face of the globe, while deposits, marking the growth of plants over great areas, were taking place in apparently fresh waters during our coal-measure period. We have to expect also equivalent accumulations in equal geological time entirely marine, from equivalents inclusive of the carboniferous limestone, which of course need not contain a limestone bed in them where there was no supply of calcareous matter from the harder parts of marine animals or from springs, to equivalents of the oolitic series of western Europe inclusive, and which may also have been formed in certain regions under totally different conditions.

By regarding deposits on the great scale, particularly when land plants that may have grown upon the beds above which their remains now form coal, or that may only have been drifted moderate distances, are concerned, and thus a fair admixture of land and water be inferred, we shall eventually arrive at real equivalents in geological time, and at the desirableness of particular groups and divisions in geological accumulations. It is interesting to consider that within so moderate a distance as southern and northern England, while the coal beds of the south do not contain marine admixtures for several thousand feet in thickness, this is not the case when we proceed northward, where we find coal beds, with deposits formerly mere gravels, sands, clay and mud, intermingled with the marine animal remains and calcareous strata of the carboniferous limestone period.

There would appear little doubt, that while we take the remains of animal and vegetable life entombed in rocks for our chief guides, dividing off vertically, so to speak, various portions of the deposits which have taken place on the surface of our planet, it is extremely useful to have many divisions made in different situations for reference. Thus eventually, when larger portions of the earth's surface become more known than they now are as regards the distribution of land and water at equal geological times, the classifications of the various accumulations in vertical divisions according to the remains of animals and plants found in them will be the better effected, and the combinations of physical conditions with the distribution of animal and vegetable life at equal times will be the better understood.

As far as the series of deposits in this country, known to us as magnesian limestone (equivalent to the German zechstein, with its associated beds), and certain inferior and perhaps superior strata, are concerned, it forms part of a greater series formed under similar general physical conditions, and subsequently to a very important physical change effected in the same area,—a great twisting, crumpling and squeezing of previous deposits, so that part of the latter were above the seas of the time and part beneath. The general evidence is that the parts above water became gradually depressed to a certain level, gravels, sands and mud accumulating as a whole in water containing much iron, probably mechanically suspended as a peroxide, the gravels forming old beaches often traceable, even up to the time of the mixture of calcareous matter and mud of the lias, as is well shown in Somersetshire, Gloucestershire, and South Wales. Hence in our land the Permian series would become one wholly founded upon palæontological considerations, inferences as to the physical conditions under which it was here formed, leading us to suppose it the base of deposits to the upper part of which the term 'trias' has of late years been applied. This may, however, turn out to have been a mere local condition of part of western Europe, undisturbed accumulations elsewhere having been effected much more generally, in which it may be as useful to make divisions as in other deposits classified under the head of palæozoic rocks, which we sometimes find graduating into one another, and at other times in contact in unconformable positions, according as the inferior rocks may or may not have been disturbed anterior to their deposit. Much has yet to be accomplished as to the history, so to speak, of the rocks of this geological period, and more particularly as to the probable distribution of the land whence the gravels, sands and mud of which they were formed have been derived. In the mean time all aids towards this history are highly valuable, and hence such communications as that of Professor Naumann are important, illustrating as they do divisions in the accumulations of a particular geological time, which Sir Roderick Murchison considers it is desirable to establish, from his researches in Russia and elsewhere, in Europe.

We are indebted to our Secretary, Mr. Carrick Moore, for an account of some fossiliferous beds in the Silurian rocks of Wigtonshire and Ayrshire, in which, after alluding to the labours of Mr. Nicol, and stating that in the main the description given of Peebleshire by Mr. Nicol is applicable to Wigtonshire and the south of Ayrshire, he mentions that the rocks consist of coarse and thin-bedded greywacke, clay-slate in which true slaty cleavage cannot be detected, and igneous rocks, in Wigtonshire "usually felspathic, varying from a nearly pure felspar rock to a syenite." Though the igneous masses appear to follow the range of, and be interstratified with, the sedimentary accumulations with which they are associated, our colleague considers the coast sections as showing that when the igneous beds are properly traced, they can be seen to cut the sedimentary rocks, generally afterwards, nevertheless, resuming their course with them. It is also remarked that these latter are altered at the contact, becoming more or less porphyritic, dark shales changed to white, and sometimes to red ; and these effects observable on both sides of the dykes.

Mr. Carrick Moore then describes in detail the section exhibited along the Irish Sea from the Mull of Galloway to Corswall Point. He mentions a patch of granite near Dunman Hill, not previously noticed, as worthy of attention from its being the only piece hitherto observed on the surface between the granite of Carnsmuir on the Cree, Kirkcudbrightshire, and that of the Morne Mountains, in Ireland. A mass of syenite at Cairngarroch alters the adjoining sedimentary rocks, and dykes of it are seen to cut them. Black slates full of graptolites are mentioned at Morroch Bay ; slaty shales and flags contain graptolites at Porto Bello Bay, and these fossils also occur in a red flag or tilestone at Dally Bay, and in the continuation of the same range of rocks at the Cairn. A limestone in the valley of the Stincher afforded fossils, for the most part ill-preserved and not numerous. Orthides however are well-preserved, and they were abundant at Knockdolian.

It may be scarcely necessary to allude to the value of the organic remains thus obtained by Mr. Carrick Moore, and the aid they afford towards a good understanding of the geological age of the beds in which they are found. Mr. Salter, who examined the collection, obtained from the limestones of the Stincher river and the slates of Loch Ryan, considers that these beds may be referred to the age of the Lower Silurian rocks.

One of those conglomerates which may mark shores at this period, or at all events conditions under which water-action could round and transport pebbles and portions of rock having considerable size, is noticed as occurring near the Corswall Lighthouse. The boulders are sometimes as much as three, four, and even five feet in diameter, showing the effects of no slight abrading force. Among the pebbles and boulders, chiefly consisting of red quartziferous porphyry and grey syenite, serpentine and red jasper are found, and Mr. Carrick Moore remarks, though serpentine occurs abundantly at the Bennan Head, that that mass penetrates and alters sandstones newer than the coal-measures. It might be hence inferred that in this locality serpentine had been ejected at different periods. Indeed igneous rocks seem to have been thrown out in this vicinity in no little abundance and variety, and in tracing their connection with the sedimentary deposits it becomes very desirable to study the different dates at which they became intermingled. It may be expected that while the igneous rock broke through existing deposits, altering the latter when traversing them as dykes, or where the molten mass may have overflowed them, yet that the superincumbent sedimentary bed was deposited after such ejection of the igneous rock, which thus at the same time appears to cut the beds of an association of deposits, to which we may assign some given name, and yet is contemporaneous with the deposits taken generally. Indeed such facts are sufficiently common.

Dr. Gesner, in that spirit which marks the cultivator of science for its own sake, finding that his views respecting the geological position of the gypsum of Nova Scotia, and which you will remember, were different from those of Sir Charles Lyell, has informed us that in a new work by him on the industrial resources of Nova Scotia he gives his reasons for not further supporting his first impressions on that head. He now agrees with Sir Charles Lyell that the gypsum occurs with the limestone beneath the coal-measures. Although we know of no good reason why sulphate of lime should not occur, as well in the geological situation noticed, as in those with which we are more familiar in western Europe, it is still very useful to have this disputed point as regards a particular district settled.

In his further observations on the geology of Ridgway, near Weymouth, Mr. Weston states that the variegated clays and sands which he had noticed in that vicinity are not local, but to be traced in Kent, the south of Sussex, in the Isle of Wight and in other parts of Dorsetshire, and that they are exposed upon the Brighton and London Railway, in the vicinity of Balcombe and within Tilgate Forest. In Sussex these variegated beds are very subordinate, but become more developed to the westward. Mr. Weston cites the notice of these beds by Dr. Fitton in his 'Geological Sketch of the vicinity of Hastings.' He remarks that they occur beneath the sandstone, with iron-ore, noticed by Mr. Webster, and rest upon the shale with round masses of sandstone and layers of argillaceous iron-ore of the same author. Referring to the view of Dr. Mantell, that this shale forms the upper part of the Ashburnham beds of the Wealden series, Mr. Weston places these variegated clays in the lowest part of the Worth and Tilgate group, separating it from the Ashburnham beds. The various colours of the clays he attributes to the different states of oxidation of the iron in them.

In this communication many details are given of the author's observations on the Hastings beds, equivalent to those of the Ridgway, from Hythe, Kent, by Hastings, the Isle of Wight, Swanage Bay, Warbarrow Bay, Lulworth Cove, and to the Man-of-War and Durdle Coves, where the last coast exhibition of the Wealden rocks is observable. Mr. Weston considers that he has fully established the extension of the Hastings sands as far westward as Ridgway, and he mentions finding the Purbeck beds at the end of the Corton Range, spreading therefore with the Portland beds to the vicinity of Portisham.

From the different physical conditions under which the oolitic series, and that of the Wealden above it, have been accumulated, all facts tending to throw light on the extension of the various beds composing the latter are valuable, as they enable us the better to judge of the configuration of the area under the fitting conditions for the minor and successive deposits. The oolitic series of southern England, there is reason to believe, was accumulated within a gradually diminishing area, from a gradual rise and filling up of the sea-bottom, so that finally dry land with soil and trees growing on it was established, as for instance near Weymouth. The detritus afterwards accumulated in part of the previously marine area of England, and in some parts of the continent of Europe, is now well understood not to have reached a sea; and we may suppose the elevation of the land to have gone on gradually for some time, throwing perhaps the sea-coasts further off, though not of course preventing marine accumulations of great importance of the same date in the area now occupied by Europe and even probably in parts of England. As careful observation becomes more extended we may hope to obtain some evidence of the coast-lines of the time, as also of the boundaries of freshwater accumulations, whether in great lakes, like those of North America, or on the sides of large rivers. The occurrence of freshwater deposits is a considerable aid towards our knowledge of land and sea at different geological times, and the value of getting the extreme points to which certain of them, even minor divisions of a series like that of the Wealden, may be found to range, is always important. If we imagine a large part of Europe to be now gradually raised 1000 feet, and then as gradually depressed 2000 feet, and consider the various figures which the different intermixtures of land and water would present, when the solid land was most elevated and most depressed, as also all the modifications during the period of rise and depression, from altered sea-coast lines, the direction and force of tidal streams, changed sub-aërial drainage areas, the courses and variable magnitude of rivers, and the like, we may obtain somewhat of an idea of the physical modifications of various kinds effected during the accumulation of the deposits known to us as the Wealden and cretaceous series. We must however carefully guard against supposing that this kind of rise and depression, with its consequences, was anything out of the ordinary course of geological events. Every day brings us evidence of the probable change of even the European area, as regards land and water, at different geological times; though, of course, as those changes were the more ancient, the more difficult it may be, from continued denudations and a multitude of overlaps by less old deposits, to trace them, and find satisfactory evidence connected with them. How far these great changes in various parts of the earth's surface may have been sometimes very gradual, at other times marked by great local disturbances, remains to be carefully ascertained. We seem to possess good facts respecting some of them, but it will be evident that we must wait for very careful examinations of many regions, including some supposed to be fairly known in this part of the world, before we can gather together sufficient data on which to reason correctly even respecting the European area.

From Mr. Prestwich we have had additional information respecting the tertiary accumulations of Southern England, in a paper "On the Position and General Characters of the Strata exhibited on the Coast Section from Christchurch Harbour to Poole Harbour." In this communication, after alluding to the change apparent in the lower tertiary or eocene beds between the sections exposed at Alum Bay and Whitecliff Bay, and to the descriptions of the coast he was about to notice by Sir Charles Lyell, he proceeded to consider the relations of the beds seen to the Barton clay, and to make some remarks on their physical conditions. Reference was made to the interest afforded by the physical structure of the district, so much variation in the deposits of the same age being observable. It is pointed out, that while, on the east of the Isle of Wight, the series of accumulations between the London and Barton clays consist of a thick repetition of sands and clays, in which "the absence of strong drifts is denoted by the abundant fossils and by the beds of shells in their normal position, uninjured as at the moment of their entombment," and vegetable remains being scarce, at Alum Bay the case is different. There "the remains of drifted vegetables are common; the strata are strongly marked,—fresher, as it were, from their source; exhibit the action of stronger drifts, and do not contain a single fossil to represent the 200 species abounding in the synchronous strata at so short a distance eastward."

Following up this view, Mr. Prestwich points to still further irregularities of accumulation towards Poole, indicating an approach to the sources of the transport of detritus into the seas of the time, and calls attention to the geological interest arising from a proper study of the ancient physical conditions obtaining at the period of these deposits, however barren and unattractive they might at first sight appear.

Researches of this kind are in the right direction. By them we shall gradually approximate towards the causes of difference or resemblance observable in the accumulations of equal geological times, —not only as respects such tertiary deposits as are here noticed, but those of various ages,—which are so needful to consider when we endeavour to account for the spread of varied mineral accumulations over wide as well as minor areas. By carefully weighing the evidences afforded of the physical conditions of given times with those of the contemporary animal and vegetable life, by no means neglecting the position as to latitude on the earth's surface of any deposits examined, we may hope to attain a far greater knowledge of the relative disposition of land and water, of climates, and of the spread of animal and vegetable life as geological time rolled on and the surface of our planet became modified in various ways, than by forcing local classifications beyond their worth, or by merely taking one part of the evidence without the other, as has been too frequently done.

In a memoir on the geology of the neighbourhood of Oporto, including the Silurian coal of Vallongo, Mr. Sharpe furnished us with a detailed account of a part of Portugal, of which, in 1832, he presented a brief notice to this Society. After mention of the crystalline rocks near Oporto, his section showing the granite of Oporto covered on the W.S.W. and E.N.E. by gneiss, micaceous schist and chloritic schist, he describes a band of rocks, chiefly formed of clay-slates, resting upon the eastern flank of the latter, and which, from the character of the organic remains obtained from it, he refers to the Lower Silurian deposits. The lowest part of this series is remarkable for containing several beds of anthracite, worked at San Pedro da Cora, eight miles E.N.E. from Oporto. Mr. Sharpe states that the section is clear, and that these lower beds, which repose on chloritic schist, evidently dip beneath deposits containing Lower Silurian fossils. The upper part of the group is formed of a thick accumulation of micaceous sandstone, usually yellow, with some grey carbonaceous sandstone near the bottom. This rests on a black carbonaceous slate, among which are bands of indurated ferruginous clay, passing into clay ironstone. Beneath this comes a dark grey or black hard clay-slate, with softer chloritic beds of a pink or yellow colour in the lower part. Notwithstanding its contortion, this slate series is considered to have considerable thickness. The lower beds of the dark grey slates, and those lighter coloured and softer at the base of the series, are rich in organic remains (*Calymene*, *Ogygia*, *Isotelus*, *Illænus*, *Chirurus*, *Beyrichia*, *Orthis*, *Orthoceras*, *Bellerophon*, *Graptolithus*, and others), possessing a character from which Mr. Sharpe refers these deposits to the Lower Silurian period.

Beneath these strata, in descending order, the carboniferous accumulations of San Pedro da Cora occur, gradually passing into the beds above them. These carboniferous beds consist in descending order of (*a*) red sandstone, (*b*) coarse conglomerates alternating with black carbonaceous shales, (*c*) coal, 6 feet thick, (*d*) coarse micaceous conglomerate, alternating with black carbonaceous shales, (*e*) coal, thin bed, (*f*) coarse carbonaceous conglomerate, (*g*) coal, four beds, from 2 to 5 feet thick, variable however in thickness in different places, the beds separated from each other by 3 or 4 feet of black shale, and resting on black shale, and (*h*) slates apparently composed of the débris of the chloritic schists on which they rest. The carbonaceous series is estimated at from 1000 to 1500 feet thick, and is seen on the north bank of the Douro, at Jeremunde, twelve miles from Oporto. North of San Pedro da Cora this series rapidly thins away, and disappears about a mile and a half from that place.

Having given a detailed account of the rocks referable to the Silurian series, noticed by him in Portugal, Mr. Sharpe refers to the beds described by Dr. Rebello de Carvalha as forming the chain of the Serra de Marão, near Amarante; those mentioned by M. Schulz on the eastern side of Gallicia, by Link in the province of Tres os Montes, and by Le Play in Spanish Estremadura, and infers that these also may belong to the Silurian series.

The lithological characters of the carboniferous deposit of Vallongo, thus plunging beneath beds containing organic remains referred to the date of the Lower Silurian deposits, are important, as showing the physical conditions under which the accumulations have been effected, and their general agreement with many other deposits, in which sheets of vegetable matter have been so formed, as eventually to have been turned into coal and anthracite, amid mud charged with carbonaceous matter and beds of shingles. Why we should not expect accumulations of the kind at this period, the fitting conditions for the gathering together of plants or their remains, either by growth on the spot or drift from their place of growth, so that they were mixed with little or no common mud or other sedimentary matter, does not appear. We find old mud accumulations, now forming black slates, common enough in some parts of the Silurian series, and there is no want of carbonaceous matter in the black slates of North Wales and Ireland beneath the whole mass of the beds commonly referred to that series.

The occurrence of the anthracite beds in the position and under the conditions stated by Mr. Sharpe, would be highly interesting in itself, as showing to what extent clean or nearly clean accumulations of vegetable matter may have been effected amid deposits in which the carbonaceous, and, we may fairly conclude, vegetable matter was generally more diffused amid mud and gravel; but the remains of fossil plants detected in connection with this carbonaceous series are still more interesting, always assuming that the sections seen by Mr. Sharpe are unequivocal, as his certainly would appear to be, unless we suppose a most enormous reversal of these deposits.

The remains of the plants found by Mr. Sharpe were submitted to the examination of our Foreign Secretary, Mr. Bunbury, who, though the specimens of ferns were in bad preservation, considered that one bore a strong resemblance to *Pecopteris Cyathea*, of the coal-measures; another reminded him of *Pecopteris muricata*, and a third of *Neuropteris tenuifolia*. Mr. Sharpe calls attention to the evidence, as far as it goes, afforded by these plants, of a vegetation having existed similar to that of the coal-measures at a geological date long anterior to them. It would indeed be of the greatest geological importance to arrive at an insight into the kind of vegetation that clothed the land, which furnished by its disintegration, abrasion, and removal by river and breaker action into fitting places of deposit, those thick accumulations now known as the Silurian series. We appear to have fair reason for concluding that, while the seas swarmed with trilobites and molluscs, the dry land, supplying the detritus amid which these remains were entombed, was not a desert waste, a mere mass of rocks decomposing under the action of the atmosphere, and worn away along the sea-level by the breakers; in fact nothing but a storehouse for the production of the marine sediments of the time. We require a marine vegetation as a base for the existence of the sea animal life of the period, and we may fairly infer no lack of terrestrial vegetation, flourishing beneath the atmosphere at the same time. What that vegetation may have been we have yet to learn; but as the range of the Silurian deposits becomes more known over the earth's surface, in regions where they have either never been covered by more modern deposits, or having been so covered, are now bared by denudation,—and every day we learn more and more of their distribution,—we may expect to obtain a better insight into the kind of plants existing at that remote geological period.

During his late absence on the continent, our indefatigable colleague, Sir Roderick Murchison, for many years one of the largest contributors of memoirs to our Society on many important geological subjects and districts, did not forget us, and we find him bringing before us, under the head of "Notes on the Geological Structure of the Alps, Apennines, and Carpathians, more especially to indicate a transition from Secondary to Tertiary types, and the existence of Eocene deposits in Southern Europe," the result of his own researches and those of preceding labourers in the same regions; thus endeavouring to gather up the whole into one systematic view. This is a labour which cannot fail to be properly appreciated by those who have themselves studied the geological structure of the Alps, Apennines and Carpathians, and are acquainted with the works and memoirs written upon these mountains, from the researches of the justly celebrated De Saussure to the present time, and among which are included the writings of Sir Roderick Murchison and Professor Sedgwick, published in our Transactions, and an account by Sir Roderick, in 1829, of the sections observed at Asolo and Bassano.

Amid masses contorted and broken at different periods, accumulations of sedimentary matter, effected under various conditions during a long lapse of geological time, changes in the character of many deposits after they were formed, and huge portions of dislocated rocks thrust up into the atmosphere, so high in some situations as to be covered by perpetual snow and glaciers, and in others most difficult of access, the determination of the state of the general area as regards land and water, conditions for detrital accumulations, and the distribution of animal and vegetable life at given and successive geological times, becomes no easy task. We have merely to crumple up the present geological surface of Great Britain into a great north and south range of mountains, accompanied by huge fractures, parts of the general mass, sometimes altered in mineral characters, and here and there forced up so high above the level of the sea as to become covered by perpetual snow and ice, to feel how much the difficulty would be increased of determining the varied relation of its parts from that which we now experience. When we complicate this state of things still more by previous movements, overlaps, differences in the range of original deposits, alterations subsequently effected in them, and by modifications in the physical conditions under which animal and vegetable life has been placed, we can the better understand many of those difficulties which have attended the examinations of the Alps especially, and the length of time during which such examinations have been continued with differences of opinion and varied results.

After a notice of previous writers and a glance at the first removal of masses of the Alps, by M. Brochant, from the so-called primary to the transition series, and the still further removal of supposed very ancient accumulations to the secondary series, including the cretaceous group, by Buckland, Brongniart, Von Buch, Elie de Beaumont and others, and adverting to his labours with Professor Sedgwick on the Gosau deposits, Sir Roderick Murchison notices the occurrence of portions of Upper Silurian, Devonian and carboniferous rocks in the eastern Alps, as determined by organic remains, giving an account of those seen by M. de Verneuil and himself, and of the researches of others respecting the same rocks. Proceeding to the westward, evidence of these rocks ceases, and it is inferred that this may have arisen from the greater metamorphic action to which they may have been exposed in that direction. While no traces of the Permian series have been detected in the area treated of, the trias, including the muschelkalk, noticed by Von Buch, Emmerich, Von Hauer and other geologists, reposes on the palæozoic accumulations above mentioned in the South Tyrol and Salzburg Alps. These deposits are not traceable in the Western Alps, it being inferred that they are not recognizable there from metamorphic action, extended through the palæozoic deposits to them in that direction. Special mention is made of the trias of the South Tyrol, and of Recoaro and adjacent tracts.

The Lower and Upper Alpine limestones are described under the names of Liasso-Jurassic and Oxfordian Jurassic. The lower division contains characteristic fossils. In the Venetian, Tyrolese and Milanese Alps, there are tracts in which the *Gryphæa incurva*, liassic ammonites and small saurians have been found, and the same zone has been traced by Studer, Elie de Beaumont, Sismonda and other geologists in Switzerland and the eastern Alps. In following this band of limestones, the light-coloured beds of the eastern Alps, often dolomitic, become, for the most part, dark and even black on the westward. From the mode of occurrence of the dolomite amid the limestones of the eastern Alps, Sir Roderick agrees with Von Buch in considering it a modification or metamorphism of the original deposit; and he also refers the great masses of gypsum to the same action, carbonate of lime having been converted into the sulphate. In illustration of this view he points to the effects now produced by the thermal waters of Aix, in Savoy, the sulphuric acid contained in the vapours from which converts the limestone of the fissure through which they rise into sulphate of lime, and supposes that when the Alps were uplifted, the more copious discharge of such waters and gases would produce the changes required.

The beds containing belemnites alternating with coal-measure plants, of which mention has been above made, were examined by Sir Roderick, and are noticed in connection with the Lower Alpine or Liasso-Jurassic limestones, the blackness of which in their course to the south-west is a point of some interest. He agrees so far with M. Elie de Beaumont and M. Sismonda, respecting the section at Petit Cœur, as to admit that the coal-measure plants and the belemnites do really appear to lie in the same formation.

Proceeding in the ascending order, our colleague then notices the Upper Alpine or Oxfordian Jurassic limestones, reminding us of the labours of M. Merian and other Swiss geologists in the Jura, of M. Studer in the Swiss Alps, and of M. Sismonda in the French and Savoy Alps, adding a notice of those of M. de Zigno, of Padua, in the Venetian Alps, and giving an account of a section from Pedescola, in the valley of Attico, to the plateau of Setti Communi. This section, examined during the Scientific Meeting at Venice, extends from dolomite, of great thickness, and inferred to be of the liassic age, upwards to the nummulitic limestone and grits of Gallio.

The cretaceous series is treated of under the head of lower and upper Neocomian limestones, gault, upper greensand, and chalk, and represented as reposing conformably upon the Jurassic or oolitic series beneath. And here Sir Roderick remarks that, with a few local exceptions, there appears to have been a continuous series of marine deposits in the Alps, as in the Jura, with no great disseverments to the completion of the cretaceous series, and, in most instances, not until after the deposit of the still higher nummulitic group. Looking at the Alpine cretaceous series generally, our colleague points out, that its lowest member, named the Neocomian limestone, is the thickest and most important of its formations. Above this comes a deposit referred to the greensand or gault, in which the well-known summit of the Montagne des Fis, with its fossils, is included. This in its turn is surmounted by the equivalent of the white chalk of Northern Europe, which Sir Roderick considers he has discovered with certainty in a clear natural section exposed at Thones in Savoy.

After numerous details and sections connected with the accumulations above noticed, Sir Roderick Murchison proceeds to the chief object of his communication, viz. that the flanks of the Alps exhibit a true transition from the younger secondary into the older tertiary strata, and that the older supracretaceous rocks occur abundantly, and well-characterized, in the south of Europe, extending thence eastward into Asia. To prove this view, numerous sections are described in Savoy, Switzerland and Bavaria, through beds considered equivalent to the lower greensand, the gault, and upper greensand of the British series, to a limestone containing *Inocerami* and *Ananchytes ovata*, and referred to the white chalk. Conformable transitions from this Inoceramus limestone into the nummulitic and shelly rocks above are adduced, particularly near the Hohersentis in Appenzell and near Sonthofen in Bavaria, where the beds, having all the characters of the great supracretaceous groups, or *flysch*, still contain a Gryphæa, not to be distinguished from the *G. vesicularis*. Above this zone, fossils known to be contained in the true cretaceous series are not found. The overlying nummulitic and shelly deposits are linked together by position and fossils, and on the north flank of the Alps, especially at Sonthofen and Kressenberg, as well as on the high summit of the Diablerets and Dent du Midi, represent the lower tertiary of the Vicentine. The upper portion of this group is the *flysch* of the Swiss, the Wiener Sandstein, and to a great extent the Macigno of the Italians; and Sir Roderick remarks, that the whole group of the nummulitic rocks and "flysch" is not, as many geologists suppose, an upper portion of the cretaceous series, but really represents the true eocene tertiary accumulations. Seeing the conformable state of the various deposits noticed, and the apparent continuation of physical causes which has permitted a kind of passage, lithologically, of the one deposit into the other in succession, our colleague maintains that under such conditions the limits of formations can be alone defined by their imbedded organic remains. In concluding this part of his communication, he refers to the aid he has received during his Alpine researches from Prof. Studer, M. Escher of Zurich, Prof. Brunner of Berne, and M. Zigno. Having thus referred the nummulitic group to the lowest supracretaceous accumulations, Sir Roderick adverts to the marked interval in nearly all parts of the Alps between the last-formed strata of this group and the next overlying deposits, so generally admitted to be tertiary. He then passes to the Molasse and Nagelflue of the northern Alps, citing the labours of Prof. Studer, M. Escher and other geologists, and divides the mass into lower deposits considered to have been formed in fresh water, central accumulations of marine origin and of Sub-apennine or Pliocene age, and an upper group, the great overlying portion of Molasse and Nagelflue, of terrestrial and freshwater origin. Still following up an ascending series of accumulations, we attain the well-known lacustrine deposit of Œningen, remarkable for having entombed in it only lost species of animals and plants, though formed after marine pliocene beds, containing shells not distinguishable from those of molluscs now living. And here Sir Roderick remarks that the terms Miocene and Pliocene cannot be correlatively deduced from submarine and freshwater accumulations, for if this be done in Switzerland, miocene types of lost species overlie marine pliocene forms.

Our colleague then considers the cretaceous and nummulitic rocks of the Carpathians, with reference to the different ages of the so-called Carpathian sandstones, giving an account of an examination of them by him, in 1843, in company with Professor Zeuchner, a sketch of which only had previously appeared in his work on Russia and the Ural Mountains. In the general succession of rocks between the Tatra chain and the low country of the Vistula near Cracow, a mass of nummulitic limestone reposing upon secondary rocks (among which some, from their fossils, are referred to the Liasso-Jurassic beds of the Alpine limestone, and others above them may represent the upper Jurassic beds and even part of the cretaceous deposits,) dips beneath shale and sandstone resembling the flysch of the Alps. The fossils are noticed as such that no doubt can be entertained of these beds being of the same age with the nummulitic rocks of the Alps. Mention is made of sandstones with green grains and Neocomian fossils having a wide range, a large portion of which have been termed

Carpathian sandstones. It is remarked that, in such districts, where the cretaceous series presents an arenaceous and earthy character, and the nummulitic rocks are absent, it is extremely difficult to draw lines of separation between sandstones of secondary and tertiary age. Sir Roderick considers that hence, under the term Carpathian sandstones, cretaceous and eocene deposits have been confounded, the confusion not a little aided by the dislocated condition of the district.

We were next presented with a general view of the chief formations of the Apennines and Italy. In this Sir Roderick Murchison, referring to the labours of General della Marmora in Sardinia as showing the existence of Silurian rocks in that island, considers that there is at present no evidence of older accumulations in Italy than those found at La Spezia and in the adjoining district of the Massa Carrara Mountains, or Apuan Alps as they have been termed. These are referred to the age of the lower or Liasso-Jurassic division of the Alpine limestones, and are noticed as covered by a limestone, which from its fossils and frequent red colour is called *ammonitico-rosso*, and considered to be equivalent to the Upper Alpine limestone or Oxfordian Jurassic series. Surmounting these deposits come the equivalents of the cretaceous series of our country, well-exhibited on the flanks of the Venetian Alps in one direction and in the Nice district in another, and in their turn covered by the nummulitic accumulations, observed by Sir Roderick twenty years since, to graduate into the deposits beneath them in the sections presented near Asolo and Bassano. He adverts to a recent description by M. Zigno of a series of accumulations in the Euganeans from the Upper or Oxfordian Alpine limestone, through the cretaceous group, including the equivalent of the white chalk, to the nummulitic series, and remarks that in Liguria, Modena, Lucca and Tuscany, such evidence of clear succession is absent, the rocks above the Oxfordian group in those districts being singularly devoid of fossils, and the beds intermediate between it and those of the miocene age assuming an arenaceous character, with the exception of certain flaggy limestones. The nummulitic deposits are found at rare intervals, and chiefly southward of Florence. Where they occur, Sir Roderick refers the Macigno associated with or overlying them to eocene deposits, and such rocks are stated to be undistinguishable from the Alpine flysch and macigno. The thick Alberese limestones on which these deposits rest, so well displayed in the Apennines between Bologna and Florence and in the northern part of the Tuscan Maremma, it is thought may in part represent the chalk, the fucoids in these rocks, though of the same species as those which overlie the nummulitic rocks of the Alps, ranging from the lower chalk high up into the eocene deposits, and a hamite and one or two ammonites having been discovered in these beds in Tuscany. Passing southwards into the Roman States and Naples, the superposition of the nummulitic limestones, with their associated fossils, to the hippuritic limestones, is seen in the same succession as in the Alps and Carpathians.

The Superga section, near Turin, is noticed as highly instructive, a coralline concretionary limestone forming its base, and being either at the upper limits of the eocene or at the bottom of the miocene deposits. This is covered by a succession of conglomerates, marls and sandstones, full of the miocene types of the Superga, passing upwards into the blue Sub-apennine marls and yellow sands. Throughout these deposits the per-centage of fossil species is of so mixed a character, that MM. E. Sismonda and Bellardi, after careful examination, are unable to draw a line between those termed miocene and pliocene. The tertiary deposits near Bologna and the Tuscan Maremma are noticed, the coal beds of the latter being referred to an old miocene date, and the relations of these marine tertiary deposits to the more modern terrestrial and freshwater travertines are traced.

The chief object of this memoir, as previously observed, is to establish a true equivalent of the eocene deposits in Southern Europe, and to show that the rocks so termed do not merely represent, as suggested by M. Elie de Beaumont, the interval which has occurred in Northern Europe between the upper part of the chalk, as there exposed, and the commencement of the plastic clay series, but actually constitute deposits effected at the same time with the eocene beds of the Paris and London supracretaceous accumulations. Sir Roderick Murchison particularly observes on the presence of species identical with those of the Paris and London tertiaries in the nummulitic rocks, and remarks that no characteristic fossil of the cretaceous series has been continued into the nummulitic group, two or three species of Gryphæa being alone common to the upper beds of the one and lower deposits of the other. He examines the writings of the geologists who have described the nummulitic accumulations of Southern Europe, and infers that the facts noticed by him and them are in harmony.

It would be impossible, in the necessary limits of an address of this kind, to attempt any detailed observations upon the mass of information brought forward by our colleague in this communication. In all such investigations, tracing great deposits of mineral matter over large areas, it becomes of importance duly to consider the physical conditions which may have obtained at different times over the whole or parts of it. This we obtain by careful study of the lithological character of the deposits themselves. Among the most striking geological features of the wide area noticed, is the mass of calcareous accumulations, which have been effected from the date of the great Alpine limestone to the modern terrestrial travertines of Italy inclusive. No doubt much of this calcareous matter may have been in parts used over and over again, portions only of different dates remaining to show us what we seek, both as to the physical conditions under which the deposits of different geological times in certain areas were effected, and the life of the time, so far as can be inferred from the remains of it entombed in such deposits. Nevertheless, regarding it as a mass, the amount of calcareous matter in the region noticed, and in the extension of the same deposits in Northern Africa and away into Asia, shows a certain continuance of physical conditions fitted for its production, which requires to be taken into account when we regard the subject as a whole. The variations of these conditions in certain minor areas, while they remain more constant in others, will, doubtless also, eventually give great insight into the distribution of land and water at equal geological epochs, and all the intermingling of ordinary detritus, gravels, sands and mud will have to be well studied for their extent, and modification both as regards surfaces overspread and differences in the kind and direction of supply.

Waiting these more detailed investigations, and the modification of views which may result from them, Sir Roderick Murchison has taken marine life as his guide, and more particularly points to a vast sheet of matter, including certain animal remains, as, to use the happy term of Alexander von Humboldt, a geological horizon; assuming that the animals, of which these are the remains, lived at the same geological time, and therefore that the mineral masses in which they have been entombed will bear classification in one group. We have seen that in the case of the nummulitic rocks, he refers the deposits including these shells to the age of the lowest tertiary accumulations, or the eocene rocks.

Whatever views may be entertained of the existence of centres whence species have to be distributed during the lapse of time, and the consequent changes that all our classifications of the deposits upon one portion of the earth, such as Europe, may eventually have to undergo, as regards fine divisions made in accumulations from the absence or presence of certain species or their representatives of the same time, when other regions of equal area have been carefully examined, the gathering up of evidence in favour of the distribution of similar life in the seas of equal geological time, as has now been done with respect to the nummulitic rocks of Southern Europe by Sir Roderick Murchison, is very important. Under our present amount of information respecting the wide area noticed, extending even to India, it gives a leading object for a guide; and whether some of the myriads of nummulites found in these beds first existed or not at the time of the chalk in particular districts, is unimportant as regards the progress of the inquiry. If they be shown in given areas to be limited to certain periods, the facts are at least good as respects the reasoning for those areas.

From the accidental circumstance of the tertiary rocks having been made known to us by the labours of such men as Cuvier and Brongniart, working around such a seat of science as Paris, a desire to perpetuate very marked distinctions between the cretaceous and supracretaceous accumulations has not unnaturally been experienced. Those among us who are old enough, either to remember the actual announcement of the labours of these distinguished men, or who entered upon geological life sufficiently near that time to recollect the feeling then existing among those who cultivated our science, will not be surprised at the reluctance which has been so long experienced at considering the accumulations of mud, sand, gravel, calcareous or other matter of the one time as a mere sequence of those of the other, and the breaks in this sequence in particular areas as no more than other breaks in the general deposits of other geological times, even in the same areas. We are not to suppose that all the rivers of the world suddenly ceased to transport detritus into lakes and seas; that the breakers no longer wore away the coasts, or that animal and vegetable life was entirely destroyed, because we find a break in the sequence of accumulations in a particular portion of the earth's surface. We have now learned, by the progress of our science, to account for such local breaks, and among other things, that dry land cannot fail to show them, when such dry land, after submergence, is covered by marine deposits, and is again upraised above the water. Hence all evidence as to the passage of supracretaceous into cretaceous deposits, such as that noticed by Sir Roderick Murchison in this paper, is important; and the Society has reason to be satisfied that our colleague has selected it as the channel through which to convey his extended researches on the region noticed to the public.

Movements which Mineral Masses may have sustained subsequently to their Accumulation.

Mr. Weston, availing himself of the means afforded by a railway cutting (upon the Wilts, Somerset and Weymouth line), points out the facts he considers to be shown where the railway crosses the great Ridgway fault, one formerly described in your Transactions by Dr. Buckland and myself from appearances exhibited on the ground by ordinary sections. It will be in your recollection that the great movement which throws off the rocks on the north and south, thus thrusting up the Wealden country of Kent and Sussex, and which extends westward so as to form a marked anticlinal line to the frontier of the greensand and chalk escarpments on the south of Frome in Somersetshire, is accompanied by a more southern and parallel line of movement, crossing the Isle of Wight and extending into Dorsetshire. It seems clear from the rocks disturbed, that this movement took place after the Headon Hill tertiary deposits of the Isle of Wight, since they have been included in it. Faults having a general east and west character are seen on this line of movement, but as faults having the same general direction are sufficiently common in districts merging into this, and where flexures of the kind previously noticed are not to be found, it is not so clear that faults such as those of the Ridgway are really contemporaneous with the arching and bending of the beds by the side of, and through which they run.

It will also be in your recollection, that after the dry land of the Wealden time became depressed beneath the level of the sea, the marine deposits of the cretaceous series covered them over, and in such a manner that the chalk and upper greensand extended over the first-formed and lower part of the series, overlapping various older beds in succession, even reaching as far as the coal-measures of Devonshire on the westward, and over the oolitic districts of Yorkshire on the north. Probably also this overlap was far more extensive, though denuding influences have so acted during the lapse of geological time, that no certain marks remain to prove the amount of area covered by the cretaceous series in Great Britain. We are certain at all events that in Ireland conditions permitted the deposit of the cretaceous rocks in that portion of the British area.

Ranging down from Somerset and Wilts into Dorsetshire, the cretaceous rocks are seen overlapping various members of the oolitic series, so that in the vicinity of the country noticed by Mr. Weston, the great clay deposit known as the Oxford clay supports cretaceous rocks. In a section given by Mr. Weston he shows a continuation of the Hastings sands as reposing on the Purbeck beds, founding this view on the organic remains discovered in the beds, and on their general character; and he also shows some tertiary accumulations where they had not been previously noticed. The line of section where the Ridgway fault traverses it exposes a clay, which from its appearance and fossils Mr. Weston regards as a portion of the Oxford clay beneath, forced up through the line of fracture, so as to occupy a position between the greensand beneath the chalk and the beds, supposed to be Hastings sands. In a district of this kind, where one series is overlapping another, where there has been much movement producing bending of the beds, and where denudation acting unequally exposes the beds cut into under various aspects, much care and circumspection are necessary; and Mr. Weston, while he gives his own views on the subject, wishes them to be recorded merely as appearing to reconcile apparent difficulties.

In his paper on the salt-field of Cheshire and the adjoining districts Mr. Ormerod notices numerous movements of the beds and faults. He infers that "dislocations affecting the North Staffordshire coal-field, the chief Cheshire coal-field, and a considerable part of Cheshire, centre in or near Shutlingstow."

With regard to the movements to which the coal district in question has been subjected, we must take them in connection with the irregular protrusion of the mountain or carboniferous limestone of Derbyshire, the coal district of the same county, and the continuation of the whole northerly into Yorkshire; and by so doing we find,—though minor squeezes have depressed or elevated areas of greater or less dimensions, these minor portions taking a variety of forms,—that a great uprise has taken place in a north and south direction for a considerable distance, throwing off coal-fields to the right and left. As we find dislocations in other parts of England, breaking through the mountain limestone and coal-measures, some evidently after their beds had been contorted and bent, anterior to the deposit of the new red sandstone series, since the latter repose quietly without break upon faults, sometimes great, denudation having planed away the broken surface, so that horizontal beds could be continuously deposited, while other dislocations have affected all the rocks, it becomes interesting to learn how far the Cheshire and Staffordshire faults may be separated as regards geological time.

It will have been seen from the communication of Professor Ramsay and Mr. Aveline, taken in connection with the memorandum of Professor E. Forbes on the organic remains in part of the district noticed by them, that there would appear to be evidence of coast deposits on the previously disturbed bed of the Llandeilo flag and more ancient rocks. From the mention made of the accumulations emerging on the north-west, from beneath the trappean groups of Snowdon and the more ancient beds of Anglesea, it will also have been seen that there had not improbably been a still more ancient movement of rocks in the North Welsh area. Taking that area, we would appear to have had many important movements of rocks in it. First the old micaceous and chloritic slates of Anglesea, apparently moved, (the evidence is not yet complete, though the probabilities are considerable,) prior to the Bangor conglomerates and sandstones. After which, whatever minor disturbances there may have been during the period when igneous agency was so common, and the trappean group was accumulated, no marked and great movement is apparent until the date of the Bala beds. We then find the Caradoc sandstone series reposing upon the disturbed and older beds. All the deposits of the Wenlock and Ludlow accumulations continued tranquilly, making all allowance for minor movements.

The Wenlock and Ludlow series then became included in the great movement which took place anterior to the deposit of the old red sandstone and mountain limestone. In Flintshire, Denbighshire and Caernarvonshire, we see these rocks overlapping disturbed beds from the Ludlow rocks to the Anglesea micaceous and chloritic slates inclusive. The region was again disturbed after the deposit of the coal-measures, and the new red sandstone series was deposited upon the uplifted, bent, or contorted beds, as the case might happen to be, of all the first-formed rocks. The new red sandstone itself was not destined to remain quiet, and taking in the adjoining district of Cheshire, we find it also bent and broken, anterior to the drift, including large boulders, too often spread over the rocks beneath to be pleasing to the geologist.

When we contemplate the many strange twists and complication of fractures which must exist in the rocks of such an area, particularly among the older accumulations, those consequently the longest exposed to these various movements and breaks, there is enough to point out how much caution is needed in our explanations of minor portions of such an area, particularly when we reflect upon the complicated arrangements produced by denudations at different times in parts of the general mass, as at various periods it became elevated, so that breaker action and atmospheric influence wrought out coasts and all the modifications of dry land—mountains, hills, valleys and plains; or depressed in various ways beneath the sea, it became coated with the detritus derived from portions of the still dry land.

While lately in this country, Professor Henry Rogers brought before the Society a comparison of the structural features of the Appalachians of the United States with those of the Alps and other disturbed districts of Europe. He divided his communication into facts in connexion with flexures and fractures of the rocks composing the Appalachians, the Alps, the Jura, and the palæozoic districts bordering the Rhine, and the manner in which he and his brother, Professor W. B. Rogers, of Virginia, proposed to account for the production of such flexures and fractures.

Upon careful study of the Appalachian zone, as the Professor terms that region, one having a length of about 1300 miles and a mean breadth of 150 miles (an area therefore of about 195,000 square miles), he and Prof. W. B. Rogers found that it was marked by five great belts. These, when crossed from S.E. to N.W., exhibited the greater flexures in the first belt, or that on the S.E. of the Blue Ridge or Green Mountain Chain and within this chain, old semi-crystalline schists and the oldest palæozoic rocks were doubled into enormous, closely-compressed, alternate folds, dipping almost exclusively to the S.E. at angles varying from 45° to 70°. In the third belt, the oblique flexures of the older palæozoic rocks are less compressed, the north-western side of each anticlinal curve approaching near to verticality. In the fourth belt, that of the central Appalachians of Pennsylvania, Virginia and Tennessee, the convex and concave flexures progressively expand, the steepness of the N.W. side of each anticlinal gradually diminishing. In the fifth belt, that of the bituminous coal region of the Alleghany and Cumberland mountains, the curves dilate and subside into broad symmetrical undulations with very gentle dips. We thus have five belts; the greatest flexures and folds in that on the S.E., the least in that on the N.W., the prevailing dip towards the S.E. Prof. Rogers then showed that the folds and undulations of the strata lie in groups, the several axes being very nearly parallel and similar in their style of flexure, many of the larger anticlinals having a length of 80 or 100 miles. With regard to the distances of the contiguous great folds, they are stated to be, in the south-eastern belt, less than one mile; in the central belt between one and two miles; and in the north-western belt the flexures have an amplitude of from five to ten miles. With regard to dislocations of the beds, two systems are noticed—one of short fractures, nearly perpendicular to the strike of the anticlinals; the other ranging with them, and often of considerable amount. The longitudinal dislocations, some in Virginia having a length exceeding 100 miles, are considered as broken flexures, the fracture almost invariably occurring on the north-western or inverted sides of the anticlinals, and having a moderately steep south-eastern dip. Some of these great fractures constitute faults of not less than 8000 feet.

Upon looking at all the facts adduced by the Professors Rogers, who have thus so well worked out the flexures and fractures of the rocks composing this part of the United States, we cannot but be struck with the evidence of an exertion of force along a line no less than 1300 miles in length, folding the component beds of rocks in such a manner as to show that the effects of that force gradually diminished towards a parallel line some 150 or 200 miles distant on the N.W. from the first line. We have thus some 200,000 square miles of rocks, the thickness of which we do not know, though from faults being ascertained of as much as 8000 feet, we may at least give them a mile and a half in depth, ridged and furrowed in great parallel bands, with minor flexures dependent on the same great exertion of force. The effects produced, for the careful examination and full description of which we are so much indebted to the Professors Rogers, are also of a kind leading us to infer that the resistances to the force, let it have been what it might, were somewhat uniform, so that the great flexures, however far they were removed from that force, preserved an uniformity of character during their range.

The hypothesis advanced by the Professors Rogers to explain the facts observed is, as you have been some time aware, that the solid crust of the earth, resting on liquid matter, having been exposed to excessive tension, was ruptured along great lines; that the sudden relief of this tension produced in the liquid mass beneath two receding sets of huge waves of translation, one on each side of the line of fractured crust, which threw the crust into corresponding undulations, and at the same time pressed and partially carried forward the two pulsating zones, in the direction of the advancing waves. The crust beneath each concave bend is supposed to have cracked and opened downwards, during this wave-like motion, so that molten matter beneath rushed in, filled the rents thus formed, partially congealing in wedge-shaped masses, which assisted, in combination with other pressures, in preventing the mass from again flattening out, and thus the temporary flexures were braced into permanent arches.

In the first stage of their formation the flexures are supposed to have been broad and gently curved; even then, however, the arches steeper on the forward sides of the waves. A succession of similar waves of translation, starting from the same or parallel lines of rupture, are considered to have acted on the flexures already formed, contracting their horizontal width, increasing their curvature, and augmenting the difference in the anticlinal dips, even to the inversion of the forward side, with the production of parallel folding. The minor folds and contortions are referred to the crumpling of the softer beds on the bends of the principal flexures.

With respect to this view you will observe, that it is to waves of translation frequently repeated, and starting from the same or parallel lines of rupture, that the final highly crumpled and contorted state of the parallel bands is attributed; and hence that the tension of the rocks and their rupture have also to be repeated, so as to produce these waves. If we should admit, which we confess we should have great difficulty in doing, that the external crust would conform, in the manner supposed, to the undulation of the waves produced in the fluid mass beneath by the rending of this crust in long lines, in consequence of tension, we have to reproduce similar conditions to cause similar effects; that is, to obtain each set of pulsations we must have the needful tension and fracture. We have thus to infer that the rent, which so long as it existed would give way before any repetition of the force that caused the first tension, was cemented up in such a manner as again to permit tension of a kind and order similar to the first, and so on. It is supposed that at every pulsation the beds were crumpled up and driven aside from the original rent, or others parallel to it, so that unless the superficial area of that part of the earth were diminishing, each impulse would drive the once continuous beds further from each other, the intervening space gradually increasing, and requiring to be filled up by the liquid matter from beneath to an altitude corresponding with that at which it could stand relatively to the spheroidal mass of which it is considered to have formed the upper part.

The amount of separation between the original beds, supposing no contraction in that part of the earth's surface, would correspond with the difference which the folding and crumpling of the beds would make in the length of the section across them prior and subsequent to their contortion. If we assume a fracture from tension along a line of 1300 miles, and the section across the beds so broken through to be one-sixth less now than prior to their movement, and 150 miles their present measurement, after contortion, on both sides, we should have an opening of sixty miles between the edges of the first fracture, if there be no evidence of fractures parallel to the first. Now in the case of the Appalachian region the facts would appear to show that the force had always been exerted in the S.E. for at least the mean breadth of 150 miles, and hence the tension-fractures,—considering them to have been repeated, and thus to have produced waves of translation more and more bending up the beds, so as even to throw them over with folds dipping towards the force employed,—would have to be made in the mass of matter occupying the space between the edges of the original great rent. We should thus have to consider it as from time to time consolidated in such a manner as to offer resistance and be fractured by tension in the manner required.

After carefully considering the facts brought forward by the Professors Rogers, for which the best thanks of geologists are due to them, it appears to us that lateral pressure, not from the mere injection of some liquid and molten matter, which, as Professor Rogers observes, could scarcely produce the effects observed, when such molten matter is considered to form a portion of a general mass beneath, but from the pressure of masses of the crust of the earth against other masses along great lines of fracture on the surface, has been the cause of these flexures. Under any hypothesis, the sliding of a portion of the earth's crust would appear to be essential, as also a flexibility of the component beds sufficient to admit of folding and contortion. The greater the power for both, the less the necessity for the rise of the squeezed mass into mountains. Under the hypothesis of lateral pressure, considering that to have been exerted with an uniform intensity for 1300 or more miles, and the thickness and resistance of the crust sufficiently uniform also, we do not perceive anything to prevent the general mass from sliding over a fluid body beneath, and being crumpled and folded as in the Appalachian region.

The visit of our colleague Professor Henry Rogers to Europe was for the more especial purpose of comparing other contorted, ridged and furrowed regions with that which had afforded to the labours of himself and brother those facts. Examining the structure of the Devonian formation on the Rhine, he considers that the entire region of the Devonian and carboniferous rocks exhibits the same laws of flexure and plication observable in the Appalachians, and he points to a section from S.E. to N.W., either through the Taunus to Westphalia; or by the Rhine from Bingen to Remagen, or from the Hundsruck to the coal region of Liege, as showing an almost universal south-eastern dip, resulting from the close oblique folds with steep or inverted dips to the N.W. of each large anticlinal. He further remarks, that on approaching the northern side of the district the flexures become progressively more open, and that the inequality in the dip of the sides of the anticlinal diminishes, so that in this case also the force would have been applied on the S.E.

In the Jura Professor Rogers found the anticlinals to have one side of the arch more incurved than the other, but not inverted; and some of them snapt near the point of most abrupt curvature. It is stated, that while the ridges are higher next the great plain of Switzerland, all the individual flexures are steepest towards the Alps. The average dip of the N.W. sides of the Jura anticlinals scarcely amounts to 40°, while on the S.W. it exceeds 70°. A great fault is supposed to occur on the southern side of the Jura, arresting the expansion and subsidence of the flexures in that direction.

It is stated that in the Alps the axis-planes dip inwards from both flanks towards the central portion, so that the masses are folded in opposite directions; the plications of the Bernese Oberland dipping south, those of the chain of the St. Gothard and the Simplon towards the north. In these mountains therefore the exertion of force would be from the great central axis outwards towards the flanks on the N.W. and S.E.

Those familiar with the Alps must be well-aware of the great dislocations and folds exhibited, and of the whole presenting a crushed appearance, such as we might expect from the heavy pressure of the masses composing them against each other on a line corresponding with that of the main range. If the various dislocated parts were reunited, and the folds flattened out, and the component beds restored to the condition in which they were formed, the area now occupied by the region of the Alps would have to be expanded to various distances parallel to the main range,—the flanks pressed out into Italy on the one hand, and towards the countries on the N.W. and W. on the other. In looking at the flexures and dislocations in the Alps we have to regard the mass of them, and in doing so we seem scarcely to arrive at the conclusion that the flanks have been driven outwards by impulses acting upon a fluid mass beneath in consequence of tension along the central axis; but rather that the component beds were squeezed from both sides up against a main central line, extending along the main range of these mountains, so that the effects produced upon the partly flexible and partly more unyielding rocks would throw them into flexures and break them in directions, as if from a force acting from the central portions outwards. The contorted, broken and jammed masses would struggle to expand themselves, and to avoid being squeezed and piled up into the atmosphere, would act with all the power due to their gravity in forcing the rocks which could yield into flexures, breaking others more rigid, and even the flexures themselves when too sharp for the cohesion of the beds, so that towards the central axis the anticlinals would be sharper and more folded, with inversions, and become less so towards the extreme flanks.

However divided opinions may be as to the hypothesis advanced by the Professors Rogers, in explanation of the order of the flexures and dislocations observed by them in the Appalachian region, and by Professor Henry Rogers on the Rhine, in the Jura and in the Alps, they can scarcely differ as to the importance of the observations themselves. By their multiplication we should eventually obtain a vast body of evidence as to the directions whence the forces contorting and crumpling beds of rock have been derived, and we have to recollect that many of the effects of pressure on the earth's surface, whence we may conclude that many elevated regions have resulted, have since, by denuding action, been more or less planed down ; so that cubic miles of the materials, in all probability once piled up in ridges and masses, have been removed and used again as the component parts of more recent deposits, often again to be partially removed and employed anew for a similar purpose. Sections, therefore, carefully executed, and upon a true scale, alike for height and distance, become as valuable in a contorted district, though not marked by any great range of mountains, as amid the latter, where there are more direct evidences of the piling up of mineral matter above ordinary levels from the causes producing contortion and fracture of the component rocks.

In his memoir "on the Geological Structure of the Alps, Apennines and Carpathians," Sir Roderick Murchison presents us with a notice of the ancient changes of surface in the Alps, in which he points out the contortion and fracture of the deposits, the mode of occurrence of which he has previously described. He observes that, when we regard any one region of the Alps, whatever may be the major axis of the crystalline mass in its centre (including under the terms crystalline mass, gneiss, mica slate, marbles, &c., as well as granite), that such is also the prevailing direction of the sedimentary deposits on either side. Sir Roderick illustrates this in the eastern Alps by referring to the various accumulations, up to the tertiary deposits inclusive, which surround two ellipsoidal masses of granite, having a range from E.N.E. to W.S.W. Minor and parallel ellipsoids of crystalline rocks are noticed in the Venetian Alps, and the same range is shown to occur for the crystalline rocks of the central part of the Tyrol, the chief part of the Lombardy Alps, the nuclei of the Swiss Alps, and for the associated sedimentary deposits. The change of direction to one more N. and S., westward of Berne, is noticed, and it is inferred that in the Maritime Alps the uplifted masses trend round so as to become confluent with the Apennines.

Our colleague considers it clear that in parts of the Alps there has been a continuous series of submarine deposits from the Jurassic rocks to the flysch inclusive which have been thrown into various folds, so that sometimes great inversions are produced, the various deposits having had no more consolidation than many accumulations even of old date now found in Russia, and hence that this folding took place after the deposit of certain supracretaceous rocks. Details of good examples are given, and the kind of folding above-mentioned as observed by Professor Rogers is stated to be observable, instances being adduced in illustration. A great fault is noticed at the Righi, bringing a younger portion of the molasse and nagelflue, with an inverted dip, against the lower cretaceous rocks, and its range is indicated. Sir Roderick refers to the labours of M. Studer, which will show all the modifications arising from the folding of the various contorted beds round the ellipsoids of crystalline rocks, modifications which require to be understood when the general strike of the mass is under consideration. He gives a detailed account of the great inversion of the masses in the Canton Glarus, by which beds of supracretaceous age are brought beneath a covering of limestone containing Ammonites, in its turn surmounted by talc slate.

Our colleague calls attention to the necessity of most careful examination of the contortions and fractures (many of which he mentions) before we proceed to account for the forces and the direction to which such contortions and fractures may be due. A most needful caution, and one which cannot be too much borne in mind in such regions as the Alps. He adverts to the effects produced by the partial dislocations and overlapping of deposits, so that the sequence is disturbed in one minor region and not in another, whence the independence of certain accumulations may be too hastily inferred, remarking that the molasse and nagelflue present the finest example of true independence of deposits in Switzerland, both lithologically and zoologically. Finally Sir Roderick observes that he does not doubt "that great mutations of outline have taken place at different periods, not only in and along the same chain of mountains in lines parallel to each other, but even at different periods upon the very same line."

Changes and Modifications which Mineral Masses may have suffered since in the Accumulation, either before or after any Movements which they may have sustained.

Mr. Sharpe, in a second communication on the subject of slaty cleavage, infers that the facts observed in connexion with this structure in the mountain district of Westmoreland and Cumberland show it to be due to causes solely mechanical, thus confirming his views founded on the examination of slaty cleavage in North Wales, Devonshire and Cornwall, and previously brought before this Society*.

Our colleague passes in review various facts, under the heads of (1) compression of slate rocks in a direction perpendicular to the planes of cleavage; (2) two planes of cleavage in slate; (3) slate-pencil rock; (4) cleavage not connected with crystallization; (5) irregularities in the direction of cleavage planes; (6) arrangement of the cleavage planes in the Cumbrian mountains, and their relation to the position of the beds; (7) northern area of elevation; (8) southern area of elevation; and (9) conclusions, which are as follows:—

"The direction of the cleavage planes is in direct relation to the movements of elevation of the strata, being everywhere at right angles to the direction of the elevating force; and when the beds have been raised with regularity over a single axis, the cleavage planes appear to be portions of curves of which the width of the area of elevation is the diameter. In slaty rocks there has been a con-

* Quarterly Geological Journal, vol. iii. p. 74.

siderable compression of the mass of rock between the planes of cleavage; that is, in the direction corresponding to that of the elevating force: this compression being shown by the distortion of the included organic remains and the flattening of the component portions of the rock, and bearing a proportion to the degree in which the cleavage is developed. The compression of the mass in a direction perpendicular to the cleavage has been partially compensated by its expansion along the dip of the cleavage, in which direction only its expansion was permitted as the elevation of the beds enlarged the area occupied by them. The difference between the amount of compression in one direction and expansion in another, is accounted for in the greater density of the rock after compression. No connexion has been detected between cleavage and crystallization beyond a tendency of plates of talc and mica to arrange themselves along the planes of cleavage; but as on these planes there would be the least resistance to their intrusion or formation, this may have been a subsequent operation, and should not alter our opinion of the cause of the cleavage."

You will necessarily refer to the communication itself for the facts considered to justify these views, and take them in connexion with the former memoir on the same subject by Mr. Sharpe. The fragments found in certain brecciated beds of Patterdale, Langdale, and other places, are inferred to have been flattened by the pressure consequent on the elevation of the strata, and to have been thus squeezed into planes parallel to those of the cleavage, therefore by the same force which lengthened organic remains in the cleavage planes of certain fossiliferous rocks. Though difficult otherwise to observe, it is stated that by means of a lens the constituent particles of good roofing slates are found to be "flattest between the cleavage planes and longest along the dip of the cleavage." The double cleavage, producing the prismatic solids worked for slate-pencils near Shap, is inferred to have resulted from a second compression.

In the address for last year attention was called to a memoir by Mr. Hopkins on the internal pressure to which rock masses may have been subjected, and its possible influence on the production of laminated structure, a memoir to which we would again request your attention with respect to the arrangement of the component parts of strata consequent on their pressure, bending, and contortion.

There can be little doubt that it is highly needful, when we regard a mass of rocks, divided by cleavage planes, thoroughly to weigh the effects that may be due to mechanical pressure alone. When therefore we find beds, so cleaved, to have been removed from horizontality, or that approach to it which we infer the original mud, silt, sands, or gravels to have taken from deposit, we have in the first place to inquire what would be the effect of the amount of elevation, bending, or contortion observed, regarding the mass of rocks on the large scale. In so doing we have carefully to examine the rocks themselves, to see if we can learn, from the structure of the component beds, the probable cohesion of the parts of the various strata when the elevation, bending and contortion were effected. More can often be seen for this purpose than might at first sight appear probable.

We have also to regard the varied resistances which beds of dissimilar cohesion and composition would offer to the bending or contorting force, the slipping of beds on each other (a very common circumstance in some contorted countries), and, in certain regions, the complication arising from beds moved more than once and in different directions.

Whatever, therefore, our views may be as to the cause of cleavage planes, the effects which can be produced by mechanical action alone demand our attention; and hence the Society stands much indebted to Mr. Sharpe for bringing this subject so pointedly before it. The hypothesis he supports Mr. Sharpe considers sufficient to account for the facts he has noticed, and those who were present here when the discussion upon this communication took place, must have fully appreciated the desire of our colleague to arrive at the truth, regardless of his own hypothesis or that of any one else, so that the facts be explained.

We had occasion in the address of last year, while alluding to the memoir of Mr. Hopkins, before noticed, to express our participation in the view that cleavage was due to the action of a force by which the component particles of the rock were arranged in a manner analogous to crystallization, pointing to the discoveries of Faraday and others respecting the properties of matter as affording grounds for such a view. At the same time we fully admit, with Mr. Sharpe, the importance of ascertaining the laminating effects which may be simply due to mechanical pressure, and the necessity of not attributing to one cause the effects which may really be due to another.

It may be fairly asked, if the casts of fossils are found elongated in the planes of cleavage, why not included fragments of rocks also, supposing a motion of their component particles, from some efficient cause? In the first place it would be desirable to ascertain, though the fragments may be in the planes of the cleavage, if they may not have been deposited in the planes consequent on the original drift of detritus, these fragments included, along the bottom of water, so that they were accumulated in planes sloping from the upper surface of the bed to its base, in the manner commonly known as 'false bedding.' If the angle of the plane of cleavage (to which such fragments are parallel) be too great for this view, then we have to regard the lengthening of the apparent fragments, and how far they may have really been hard when acted upon; and in doing so we have to consider, if the fragments be those of some hardened rock or rocks, the effects that would follow from the pressure of bodies of unequal resistance in the bed of which they constituted the parts, as for example clay beds holding fragments of previously consolidated slates, or pebbles of sandstone or hard trappean rocks. Mr. Sharpe has called attention to the shape of the component particles of fine roofing-slates, and the probability of their having been lengthened in the lines of cleavage; a very important fact, whatever our views of the kind of force employed.

It would be out of place further to dwell on this subject, one of great geological interest, more particularly when combined with the divisional planes termed joints. Examples of rocks cut by two cleavage planes and two planes of joints, besides the planes of the original bedding, are occasionally seen, so that the most complicated appearances are produced, particularly when the cleavage is neither parallel nor at right angles to the planes of deposit. Cleavage may be sometimes seen to have produced ridges of hills, during denudation, in a direction different from the strike of their beds, even diagonally to that strike, as, for example, the range in Ireland, known from one of the hills as the Chair of Kildare. We there see a variety of substances, slates, sandstones and trappean rocks, even a hard and beautiful porphyry among the rest, all cut by a general line of cleavage, ranging diagonally to the strike of the beds. Again, we, in some regions, find beds contorted in all directions, as well horizontally as vertically, cut by some general line of cleavage, one common to some great district, and of which these contortions constitute only a minor portion.

To bring the subject within grasp, great districts have to be carefully worked out for their cleavage planes, not neglecting any of their modifications. The conditions of the rocks themselves, their varied compositions, flexures, and probable state as regards cohesion at the time of one or more compressions from the exertion of mechanical force, have to be carefully weighed. Neither should those divisional planes, the joints, be neglected, cutting, as they often do, through a variety of rocks, and yet no trace of the least shift of their sides observable. We are indebted to Professor Sedgwick for general views as to the direction of cleavage in parts of our island, and Mr. Sharpe has brought the movement of the particles of rocks in planes of cleavage, also noticed by Professor John Phillips, prominently before you, and at the same time has directed your attention to the general character of cleavage planes in certain extended districts. Let us hope that those who have taken part in this important investigation, whatever their views of the cause of cleavage may be, will continue their labours in this field, and that we may have the results communicated to this Society for that honest discussion which usually follows the reading of papers in this room.

In his communication on the comparison of the structural features of the Appalachians with those of certain disturbed regions in Europe, Professor Henry Rogers considers cleavage, and points out that the alterations of internal structure and texture of the rocks in the Appalachian region prevail much further to the north-west than the limits of the igneous rocks. These alterations are noticed as an induration of all the rocks, the crystallization of the limestones, the debitumenization of the coals, and an extensive cleavage of the argillaceous masses. The planes of cleavage are remarked as dipping almost invariably with the closely-folded beds towards the south-east, and it is stated that the cleavage is approximately parallel to the axes-planes, a position inferred to be in accordance with a law applicable to all plicated districts. According to the Professor, the cleavage dip of the Alps is in consequence directed inwards from both sides along the great axes-planes, so that the arrangement of the plications and the cleavage dips produces the fan-shaped stratification noticed in that range of mountains. His explanation of the cause of cleavage is that every plicated mass of matter, after flexure, consisted of hotter and colder planes, so that an agency was exerted analogous to that of a thermo-electric pile, inducing in the surrounding unsolidified materials the special and symmetrical polarities of the particles, which have been supposed the proximate cause of cleavage.

In his paper on the Silurian rocks near Oporto Mr. Sharpe mentions that the cleavage and foliation of the gneiss, mica schists and Silurian accumulations of that district would appear to form an irregular arch over the Oporto granite, of which the diameter, if it could be fully seen, would be about twenty-five miles. The perpendicular cleavage observed about two miles east of Vallongo, in the middle of clay slates, forms its limit in that direction, and the commencement of another arch, extending to the N.E., and in which the igneous rocks to the southward of Baltar would occur. The strike of the cleavage would appear to be N.W. and S.E.

In the address of last year we had occasion to call your attention to the case adduced by Mr. Charlesworth of the preservation of the soft parts of a Trigonia by means of silica, and to remind you of the observations of Dr. Mantell respecting the preservation of the remains of the soft parts of molluscs by the same substance. During the past year Mr. Bowerbank brought before us a paper on a siliceous zoophyte, *Alcyonites parasiticum*. He describes a small agate, the locality of which is not known, as containing a body which appears to have been of a fleshy texture and semitransparent, like that of *Alcyonidium gelatinosum* of our coasts, encrusting the fibres of a species of Verongia, the tubular fibres of the sponge being in many places beautifully preserved. The surface of the polypidom is stated to present a strongly mammillated or tuberculated appearance, which Mr. Bowerbank thinks may possibly have resulted from the exhaustion of the animal, anterior to death, having prevented its complete withdrawal within the polypidom. Our colleague then refers to the rapid deposit of silica which could thus preserve animal tissue before it was decomposed, and considers that after the first quick deposit of the siliceous matter, the filling up of the interstices of the tissue proceeded more slowly. Mr. Bowerbank afterwards discusses the mode in which silica has been deposited. Having examined microscopically siliceous deposits from the Geysers, brought to this country by Mr. Babingdon, he does not find the parts arranged in a fibrous crystalline manner as in chalcedony or agates, but more like a mass of melted glass, not having had the conditions for crystallization afforded. In the fossil noticed he also found no appearance of crystallized arrangement of the silica, and concludes, from what he has observed during the crystallization of certain salts beneath the microscope, that even in the case of chalcedony the crystallization of silica may be achieved in much less time than is commonly imagined.

Respecting the production of artificial quartz and siliceous coatings, Mr. Bowerbank quotes a communication of Mr. Warren de la Rue, in which that gentleman, after adverting to fluoride of silicon being decomposed by contact with water, part of the silica being deposited as a jelly, and silicated hydrofluoric acid produced, and to the solubility of the deposited silica in water, remarks that he had always observed that the separated silicated hydrofluoric acid contained uncombined silica, deposited after the lapse of some months in minute crystals of quartz. Upon microscopically examining these siliceous bodies, Mr. Bowerbank found not only crystals of quartz, but also chalcedonic deposits in the form of filmy plates, composed of two and even three layers of characteristic acicular crystals.

Our colleague then proceeds to inquire whence the abundance of silica was obtained which we observe amid deposits of various geological dates. After adverting to the action of high pressure and temperature in aiding the solution of silica, Mr. Bowerbank is disposed to think that the supply of this substance to fossils has been more from the waters of the ocean than has been supposed, being there greatly diffused. He adduces the infusoria, abounding in all parts of the seas of the world, as proving this diffusion, and remarks on the amount of soluble silicates borne into the ocean from the decomposition of felspathic minerals, and observes on the appropriation of silica by animals and by plants. He also adverts to the possibility of animal and vegetable matter exercising an attractive influence on silica.

With respect to the dissemination of silica by means of solution in the crust of the earth, we have sufficient evidence that it has been most abundant and extensive. Not only does it occur as the chief cementing substance uniting the grains of so many sandstones, but it is also found disseminated in clays and in a variety of other rocks, even certain limestones, far more than, without minute investigation, might be supposed. When previously mentioning the labours of Berzelius, we had occasion to notice the abundance of silica among the various mineral masses known to us. Silica exists in large quantities in the igneous rocks (indeed the mass of them is formed of little else than various silicates), and from these rocks the detrital deposits have been chiefly formed*.

It would be scarcely necessary to remind you, that among other sources, the decomposition of that abundant mineral family, the felspars, readily affords the means of throwing silica into conditions for solution. Nor need we advert to the facilities afforded by solutions for the transport of silica from one situation to another by geological means, nor of the ease with which it would pass through the pores of rocks, even of many supposed to be very compact. We may, however, recall your attention to the experiments of Sir James Hall, who many years since (twenty-four) showed that by mingling common salt (chloride of sodium) with grains of sand and exposing the mixture to sufficient heat, even beneath water, that consolidation was

* Taking a general view of the relative abundance of the metallic bases of the earths and alkalies, they would stand, as we had occasion formerly to notice ('Researches in Theoretical Geology,' 1834, p. 24), as follows:—1. Silicium, 2. Aluminium, 3. Potassium, 4. Sodium, 5. Magnesium, and 6. Calcium.

effected,—in fact, that a potter's glaze, as Sir James pointed out, was made, or in other words, that a silicate of soda was produced which cemented the grains of sand, forming a sandstone. If we follow out this view, and bear in mind that every detrital deposit in the sea,—mud, silt and sand,—is well saturated with sea water, and consequently has much chloride of sodium disseminated amid silicates and silica, often in a minute state of division, we shall see that if sufficient heat be applied to such detrital sheets of matter so saturated, we have the conditions for the formation of the silicate of soda. The needful amount of heat may either be applied by the intrusion of a mass of molten rock, such as granite, or by sinking the mass of matter to great depths, and beneath coverings of more recent accumulations.

No doubt, when we regard the subject in this light, there are very many other things to be considered than the mere application of heat, and the presence of silica and chloride of sodium. Many of the complications which would arise will readily suggest themselves to you. We merely desire to call your attention to the production by such means of silicate of soda, among other changes and modifications. Certain of the silicates of soda which might be so formed may be soluble, so that during the circulation of moisture amid the fissures, joints, cleavages, beds and pores of rocks, they may be removed, while others may not be so, under the conditions, but remain cementing the portions of detrital matter together, turning parts and even whole sheets of friable deposits into hard rocks.

We are far from supposing that silica may not be, and is not obtained in solution in various other ways, and be thus transported from one place to another. Other means are sufficiently obvious; but it seemed not undesirable to recall your attention to the experiments of one, who laboured so earnestly in the promotion of our science, at a time when experimental investigations were less appreciated than many an unsupported and often wild assumption. It may scarcely be necessary to remind you, that when such a solution as we have noticed met with carbonic acid it would be decomposed, and the silica set free, to be borne onwards with the moisture or water, and deposited, according to conditions. You are fully aware of the decomposition of the silicates of soda or potass of the felspar family by means of carbonic acid, even that in the atmosphere, and the consequent state of the silica under such circumstances.

Although springs show us many solutions which have been effected by means of water traversing rocks, especially when percolating through mineral masses elevated above the level of the sea, thus washing out many a substance from them which became disseminated amid their constituent parts when accumulated beneath the sea, or produced by subsequent conditions,—chloride of sodium very commonly,*—they do not always give us the conditions of the substances

* This common presence of chloride of sodium is a very interesting circumstance. When submarine-formed deposits, moistened with a solution of it, are elevated into the atmosphere, it becomes by degrees washed out of them, so that the longer they have been exposed during the lapse of geological time to this

in the interior of the mineral masses themselves. An illustrative example of this fact is to be found in the chalk beneath the London clay, on which, with its covering of gravel, we are now assembled. The springs from the chalk, where it crops out to the north, west, and south of us, show no want of the bicarbonate of lime in solution; it is sufficiently abundant; but in the water of the wells which have been sunk in London through the clay into the chalk this substance is scarce, and has even been found absent. In the well at Trafalgar Square out of 68·24 grains of solid matter in an imperial gallon, 3·255 only were carbonate of lime, while there were 18 grains of carbonate of soda; and, as illustrating the dissemination of chloride of sodium, 20 grains of that substance. In the deep well at Camden Town, also in the chalk, out of 44 grains of solid matter in an imperial gallon, 17·6 were composed of carbonate of soda, 11·1 of chloride of sodium, and no trace of carbonate of lime was detected*.

To explain these interesting circumstances Dr. Lyon Playfair has suggested to me that the first effect arising from water containing carbonic acid, and filtering through chalk in which there was silicate of potash or soda, would be to dissolve the carbonate of lime, so that if soon thrown out as spring-water it would contain the bicarbonate of lime in solution. When however this water percolated through a very extended bed of chalk (containing an alkaline silicate as the chalk usually does), the free carbonic acid in the water would seize the alkali and form a carbonate, while the carbonate of lime deprived of its solvent would fall down. Hence it is, he concludes, that the deep well water of London obtained from the chalk beneath the London clay is comparatively soft, containing only a few grains of bicarbonate of lime, and even sometimes none at all, while carbonate of soda is found in considerable abundance, as also some free silica. Alluding to the observations of Mr. Clutterbuck, who found that there was an intimate connexion between the fall of water at Watford and the deep wells in London, the wells at Watford rising on Monday

action, or to any circumstances decomposing the salt, the less amount of chloride of sodium, all other conditions being the same, should we expect to find in the springs from such rocks. Among those other conditions we should have to regard as important the relative porosity of rocks and their exposure to atmospheric waters, which should abundantly percolate through them, and not readily run off their exposed surfaces.

* The following are the analyses of the waters at the wells in Trafalgar Square and Camden Town, the first by Messrs. Abel and Rowney, the second by Mr. Richard Phillips:—

	Trafalgar Square.	Camden Town.
Carbonate of lime	3·255	——
Phosphate of lime	0·034	——
Carbonate of magnesia	2·254	——
Sulphate of potash	13·671	——
Sulphate of soda	8·749	13·00
Chloride of sodium	20·058	11·10
Phosphate of soda	0·291	——
Carbonate of soda	18·049	17·60
Silica	0·971	trace.
Organic matter	0·908	2·30

when there had been no pumping at the large breweries in London from the deep wells on Sunday, Dr. Lyon Playfair remarks that this would give about twenty miles for filtration through the chalk to the deep wells in London, for so much water as may be supplied from the direction of Watford.

The agricultural importance of phosphate of lime has of late years caused more search to be made for this substance than formerly, though its occurrence as a component part of certain organic remains and of some rocks has been long known. Mr. Paine, of Farnham, having pointed out that certain beds contained phosphate of lime in sufficient abundance to render them of much agricultural value, our colleague, Mr. Austen, was induced to investigate the mode of occurrence of the phosphate of lime in his own neighbourhood, that of Guildford. He found that the phosphate of lime nodules are abundant in the upper greensand. They also occur in the gault, in two distinct beds, remarkably persistent in the district. In describing the position of these beds, Mr. Austen takes occasion to point out the inaccuracy of the published geological maps and sections of the district, calling attention to the beds of very different parts of the cretaceous series which are brought up along the escarpment of the North Down range. Having ascertained the facts connected with the layers of phosphate of lime nodules in the vicinity of Guildford, Mr. Austen examined the neighbourhood of Farnham, and found the component parts of the cretaceous series the same as near Guildford, with the exception that sandstones, occasionally cherty, represent near Farnham the firestone on the eastward and the malm rock on the west, differing however from them in containing scarcely any carbonate of lime. This Mr. Austen infers to have happened from a stream of water, having a course somewhat north and south, drifting rather coarse materials with little calcareous matter in this locality.

Mr. Austen regards the phosphoric acid of the nodules as of animal origin. When the nodules are rubbed down they present a concentric arrangement of parts, resembling bodies formed, like agates, by infiltration into cavities ; and our colleague points out that, where the casts of bivalve shells and ammonites are filled with matter containing phosphate of lime, these forms must have been first inclosed in the sand, that then the proper shelly matter was removed, and finally that the earthy phosphate occupied the place of the hollow. He supposes that the phosphoric acid may have formed part of the coprolitic matter of the time, this matter in part preserved with its original external form, while more frequently it was broken up and the component portions diffused amid the sand and ooze. He also draws attention to the conditions to which the beds containing these substances have been exposed since their formation, having been covered by thick deposits and having descended to depths beneath the level of the sea, where they were exposed to an elevated temperature corresponding with the depth and the amount of bad heat-conducting bodies above them, so that many chemical changes were effected, and among them a more general diffusion of phosphoric acid in the mass.

Mr. Nesbit has also communicated to us some remarks on the presence of phosphoric acid in the subordinate members of the cretaceous series. He states that he mentioned to Mr. Paine, in November 1847, the existence of a large amount of phosphoric acid in a fertile Farnham marl, and that he subsequently obtained 28 per cent. of phosphoric acid from portions of this marl, the general mass containing about 2 per cent. Nodules from the Maidstone gault also gave him 28 per cent. of phosphoric acid. Other localities are noticed, and as much as 69 per cent. of phosphoric acid is mentioned as contained in a dark red sandstone rock occurring in masses in the upper portion of the lower greensand at Hind Hill.

Mr. Wiggins has sent us a notice of the fossil bones and coprolitic substances discovered in the crag of Suffolk, remarking on the value of the latter for agricultural purposes, 200 tons of them having been obtained from about a rood of ground,—an additional instance of the remains of animals and their fæces entombed in rocks of different geological ages becoming available for the growth of existing plants.

As regards phosphate of lime and its dissemination, which modern researches have shown is much greater, when sufficient quantities of rocks are examined, than appeared from the analyses of the small portions usually employed,—a matter of interest when we consider the phosphate of lime required for certain plants,—we should recollect that when free carbonic acid is present in water, the phosphate, like carbonate of lime, though not to the same amount, is very soluble. Hence, especially when, as noticed by Mr. Austen, phosphate of lime is disseminated in the state of fresh coprolites amid detrital matter, and water containing free carbonic acid is present and can have access to it, the phosphate of lime would be in a condition to be removed and disseminated. Mr. Austen has alluded to the mixture of such bodies with vegetable matter, to the decomposition of which, with animal matter also, we might look for some, at least, of the carbonic acid that would aid the solution of the phosphate of lime. As in the case of the carbonate of lime previously noticed, when the solution of this phosphate met with the silicates of potash or soda, whilst percolating amid the rocks, the silicates would be decomposed by the carbonic acid, and the phosphate of lime thrown down. We should expect,—in the same manner as carbonate of lime often replaces the original matter of a shell which has been decomposed and removed from the body of a rock, leaving those cavities commonly termed casts,—that phosphate of lime, in localities where from accidental circumstances it was somewhat abundantly filtering through rocks, would also enter these and any other cavities, filling them under the needful conditions of deposit. In like manner as we find carbonate of lime separating itself from mud and silt in which it was disseminated, forming the nodules so common in calcareo-argillaceous deposits, should we also expect disseminated phosphates of lime to do the same under fitting conditions; so that it would not necessarily follow, however true in numerous cases, that nodules containing much phosphate of lime were coprolitic. We can readily imagine circumstances very favourable for the solution and spread of these phosphates

f 2

amid layers of mud and silt. We find such phosphates surrounding some fossils, such as crustaceans from the London clay, leading us to infer a connexion between the animal matter and this substance.

We had a note from Mr. Farrer on Ingleborough Cave, accompanied by a plan, in which its extension in the Great Scar limestone beyond an old barrier of stalagmite, cut through in September 1837, is shown. The length thus exhibited is considerable, and sand and gravel of limestone and millstone grit are mentioned in the narrower parts of the course of the cave. Basins of stalagmite occur, and the accumulation of this substance is inferred to have forced the water flowing in the cavity into a new channel. The detailed study of caves in limestone countries will frequently be repaid, independently of the discovery of any remains of animals in them, by much information as to their origin. Sometimes we find a crack or joint enlarged by the removal of the carbonate of lime of the rock by means of free carbonic acid in the waters flowing into them from the surface; at others no fissure or joint is apparent, and the loss of matter carried away in solution has been effected in the space between two beds, or by the gradual action of this cause from either fractures, joints, or planes of bedding, in such a manner that the connexion between the hollows of the cave and these fissures through which water can find its way is out of sight. Limestone regions, as you are well-aware, from the spaces between their joints and beds, which get gradually enlarged, often swallow up rains, so that streams in them are few, the absorbed water abundantly bursting out at some level beneath where the physical conditions are such that the waters can no longer freely descend downwards. The replacement of carbonate of lime in these caves by means of stalagmites and stalactites is another matter of interest. These may be so continued as to fill up the greater part of such cavities, cementing at the same time many a fallen mass of limestone. So long as the fissures were replete with water flowing outwards at some convenient level, the loss of limestone would continue, supposing the presence of the needful carbonic acid; but when by changes effected, such as the elevation of the land relatively to the discharge of drainage waters, the level preventing the escape of the water became lower, and the atmosphere could enter the cave, the stalactites and stalagmites would be formed, the component parts of which entering slowly into the cavity would have been readily removed by the water when it filled up the whole space.

Geological Changes from Alteration of the Earth's Axis of Rotation.

Respecting a possible change of climate resulting from a change in the earth's axis of rotation,—an hypothesis which has from time to time engaged attention as one which might serve to account for the occurrence of organic remains, supposed to be those of animals and plants requiring a higher temperature than that of the regions where such remains are found, we have had two communications. In one from Mr. Saull, he calls attention to the undoubted evidences of the land being at intervals above and beneath the waters, and to changes of temperature over the same area. These effects he attributes to a change in the earth's axis of rotation arising from astronomical causes, and describes the results which would follow from such conditions. As to the possibility of a change in the earth's axis of rotation, we had a paper from Sir John Lubbock, in which he first adverts to the revolution of a solid body on its principal axis, and its continuing to do so for ever, unless such solid body be acted upon by some extraneous force. He further observes that on this supposition no change of climate would obtain on any given latitude on the earth's surface except from a change in internal temperature or the heat of the sun.

He then notices that a change of climate alone is not sufficient to account for geological changes, such as water covering a part of the earth's surface at one time and not at another: and remarks that the moon's attraction and the causes which produce the precession of the equinoxes do not modify these conclusions.

Sir John Lubbock then states, that "it is unlikely that when the earth was first set spinning, the axis of rotation should exactly coincide with the axis of figure, unless indeed it were all perfectly fluid." He subsequently takes a period not so remote, when the earth, from the different fusibility of its component parts, might have been partly solid in irregular masses and partly fluid, and afterwards a still more advanced state, in which land and water irregularly occurred on its surface, suited to the existence of animal life, always supposing the axis of rotation not to coincide with the axis of figure. If any resistance exists, "the pole of the axis of rotation would describe a spiral round the axis of figure, until finally it would become, as at present, identical with it." Supposing a displacement of the axis, the movement of the water from one equator to another and the consequent changes of climate are pointed out. Glancing at friction on the surface of the earth rendering the invariability of geographical latitude, otherwise existing, not a necessary consequence, at our ignorance of the earth's structure beneath its crust, and of the history of the changes effected during the process of cooling, Sir John considers that "the utmost that can be accomplished by mathematics is to explain under what hypothesis a change of the position of the axis of rotation is possible or not." Adverting to the dictum of Laplace, that the changes on the earth's surface and in the relative positions of land and water cannot be accounted for by a change in the position of the axis of rotation, he observes that in this statement Laplace did not take into consideration either (1) the dislocation of the strata by cooling, or (2) the friction of the surface. Finally, our colleague, after admitting that if at any remote period the earth had been a homogeneous spheroid of any pure metal in a state of fusion, it would in cooling always revolve about the principal axis of rotation, that of figure, considers that there is sufficient evidence of want of homogeneity on the earth's surface to bring a change of axis of rotation within the limits of possibility.

It is always gratifying to find mathematicians so far interested in our science as to occupy themselves with the solution of problems, which, when we consider their important bearing, scarcely seem to occupy the attention they would appear to deserve. The early condition of our planet is one of these. By carefully considering the possible and probable conditions connected with that state, we dismiss or retain, as the case may be, much that is of great importance in theoretical geology. Hence the value of such communications as this before us, wherein the conditions for a possible change in the earth's axis are considered. As you are familiar with the reasoning founded on the figure of the earth, it is merely necessary to remind you of its bearing upon the original fluidity of our planet, a fluidity which there has been a difficulty in referring to any other cause than to a heat sufficient to keep the component particles asunder, in such a manner that even to the centre of the mass the pressure was insufficient to prevent a free motion of the particles of matter.

Sir John Lubbock would appear to have adopted the idea of a cooling body, but referring to the want of homogeneity observed among the parts of the earth thrust up into the atmosphere, and known to us, he calls attention to the effects which might follow this want of homogeneity in our globe. It hence becomes important to learn the value which can be attributed to such a cause. The depth to which we may limit that portion of our spheroid, which is formed of such substances as we find composing masses of rock exposed to our examination, is necessarily very difficult to fix. The highest mountains, rising even in the warmest regions of our globe so far into the atmosphere as to feel the influences of the low temperature surrounding our planet, however vast they may appear to us, merely give a few miles of thickness; and when we fairly estimate the real depth of the various ascertained accumulations of different geological ages, we still arrive at such an insignificant portion of the earth's radius, as to see how very little of the component parts of its mass can be known to us. Still we are bound to examine the evidence as to the differences which may exist as regards homogeneity in the rock masses. Some years since (fifteen), having occasion to estimate the probable specific gravity of fifty miles in depth of the earth's crust *, we found, from direct experiment upon such rocks as appeared important, that these varied from 2·49 (chalk) to 3·03 (diallage rock from the Lizard, Cornwall). Upon estimating the masses, taking the surface into consideration, and therefore probably giving more differences to the depth supposed, fifty miles, than should be allowed, the mean specific gravity came out as 2·59, higher than the density of 2·5, that commonly adopted, and yet sufficiently near that density for the purpose intended.

Laplace estimated the mean density of our planet as 1·55, the solid surface being considered as 1, hence taking the interior density higher than that of the external parts. We see, looking at such mineral substances as form masses of rock, that they are all oxides, but of the depth to which these oxides may descend we know nothing. Unless we suppose them oxides from the beginning, that is, from the time the matter of our earth may have been gathered together as a body revolving around the sun, an hypothesis for which it would

* Researches in Theoretical Geology.

appear difficult to find much reason, the various metals, such as silicium, aluminium, calcium and the rest, became oxides from coming in contact with oxygen. We have sufficient oxygen in our atmosphere, supporting the animal and vegetable life which now exists, and which probably also during a long lapse of geological time has existed on the earth's surface, to permit the assumption that in an early state of our globe oxygen may readily have been far more abundant among the gaseous portion of the matter forming our planet, including its atmosphere, than at present, when animal and vegetable life is adjusted to the quantity remaining.

As far as we are acquainted with the substances forming our globe, we may have an oxidized solid crust, supporting in parts a comparatively thin and irregularly-disposed covering of saline water, and enveloped by a gaseous covering, the interior not composed of oxides, but more or less homogeneous, allowing for the effects of any heat which may be supposed to remain in it, and for the densities due to the gravitation towards its centre of all the particles of matter of which the earth is composed.

When we have to consider any changes in the earth's axis of rotation due to the absence of homogeneity in its component parts, we have also to regard the probability of this want of homogeneity extending to a depth at which it would have any appreciable value. As far as the distribution on the face of the earth of the igneous rocks is known to us,—rocks whence, with the exception chiefly of limestone deposits (many of which have been accumulated by means of animal life), so many others have been formed,—we do not find any accumulation of masses of very different density in one part more than another, so as to have produced very marked differences in density on at least the surface of our spheroid. On the contrary, we find the probable distribution of granite and granitic rocks with the same density, very uniform in various parts of the earth's surface, and their abrasion has furnished abundant materials for other rocks. The like happens with the heavier compounds of hornblendic and felspathic substances, and the strata derived from them. Masses of limestone are indeed here and there more irregularly distributed, but as the limestones do not much differ from the granites in specific gravity, no great effects would follow their unequal distribution, more particularly when we take into consideration the small depth to which they would probably descend in the earth's crust.

We have also to regard the effects arising from the dislocation of the strata, as noticed by Sir John Lubbock. There are few geologists who are not now prepared to admit that the surface of the earth, since we may assume any solidity in that surface, has been in an unquiet state, some large areas moving upwards, some downwards, and these movements sometimes repeated in the same area: deposits crushed and folded against each other here and there in long lines, so that parts of them are thrust high up above the level of the sea, while masses of accumulations are forced asunder in other situations, and mineral matter raised from beneath occupies parts of the area over which they previously spread. Up to the present time mineral matter is here and there vomited forth in fusion, or blown out of vents by the discharge of vapours and gases, and large tracts of the solid surface of the earth are violently shaken, and portions of land raised or depressed. We also know that at the present, slow changes in the relative levels of sea and land are being effected. Thus from our own experience and from the study of what has formerly happened, we find that the surface of our planet is and has been, during the lapse of such geological time as we can trace, in an unquiet state. We of course know nothing of the height to which the crushing or elevating of rocks into mountain-chains may have forced mineral accumulations, though we may often infer that very great heights are but the remains of rocks, the removed portions of which rose still further into the atmosphere; but, taking the Himalayan chain as the highest land, we have nothing rising six miles above the sea-level. If we increase this height to ten miles, we should still have an insignificant fraction of the earth's radius.

The researches of Mr. Hopkins lead him to infer that at present the solid crust of the earth cannot be less than 800 to 1000 miles thick. Supposing this to be so, the hypothesis of a cooling globe would give a less thickness in past geological times, one gradually diminishing to the early period when solid matter could be first formed. I need scarcely call your attention to the view which has been taken of the forcing-up of mountain-chains, and the unequal tilting and adjustment of masses of the surface to accommodate the crust to the still fluid mass beneath, as cooling proceeded. Neither need I speak of the effects which would follow from the action of the heated and still fluid mass upon the portions of the fragments which may have descended different depths into its surface, or of the intrusion of the molten matter amid the broken masses; we have only to inquire how far these breakings-up and squeezings of the previously solid crust at different times is likely to have interfered materially with its general uniformity, so that any important change in the earth's axis, with its geological consequences, may have resulted.

As regards the mineral matter thrust up into the atmosphere, we see that, as soon as this is effected, it is attacked along the sea-level by the breakers, and both on coasts and inland by atmospheric influences, all tending to lower the altitude of the mass so elevated, and to carry its component parts into the sea, filling up any inequalities which may have been formed beneath it, in consequence of this surface-movement of the rocks. It is during this removal of mineral matter and its spread in various directions, that the remains of the animal and vegetable life of succeeding geological times become entombed, adding, and in many instances most materially, to the masses accumulated in various ways upon the previously moved rocks. This action therefore tends to plane down the unequal surface above the sea and fill up inequalities in its bed. While this proceeded, we should expect that the heated matter beneath would also melt down any portions of the solid masses, squeezed and forced into it by these movements, to a distance from the surface corresponding with the general heat of the globe at the time, and therefore the deeper as geological time advanced and the earth gradually parted with its heat by radiation into surrounding space.

Under this view there would be a tendency over the face of the globe to retain a general crust upon it of a thickness increasing with the lapse of geological time, less uneven beneath as a whole than above from the kind of action to which it would be subjected, and yet no part protruding so far as to cause any very material difference in the figure of the earth or of density in the parts of such crust, viewing the subject on the large scale. It would not appear improbable, that notwithstanding the dislocation, unequal tilting, and squeezing together of masses, the adjustments were such as to keep a spheroidal coating of the mass beneath which did not very materially differ as a whole in density. Should this not have been so, we have in our geological hypotheses to take into account the effects pointed out by Sir John Lubbock as resulting from the modification or absence of the general conditions above inferred, their amount or geological value necessarily depending upon the magnitude of the causes to which he adverts.

Such have been the labours of our Society during the past year. They embrace most varied subjects, all tending to the advance of our science, and certainly showing no decrease in the zeal of our members or in the importance of the matter brought before us. The discussions which have arisen upon the communications have been characterized by the same kind feeling and love of truth, for its own sake, as heretofore, and we may congratulate ourselves with the certainty that the energies of our body are unimpaired, that the feeling of brotherhood is as strong among us as ever, and that the Society never was in a more efficient condition for the promotion of the branch of knowledge we cultivate than at this our forty-first anniversary.

Other Geological Societies of the United Kingdom.

While we have been thus engaged, the other geological societies of our country have also been occupied with their duties during the past year.

The Geological Society of Dublin has continued to aid the progress of geology, though its meetings, now held at Trinity College, Dublin, were suspended in May and June, from the occupation, in part, of that college by troops in consequence of the disturbed state of Dublin at that time. There were two communications from Mr. Mallet. The first on molecular changes observed in the structure of recent shells. He found that in some recent oyster-shells, imbedded at about tide-level in red and grey marl cliffs, occurring on the north of Belfast Lough and eastward of Carrickfergus, the cavities between the nacreous plates were in progress of being filled up by calcareous spar, in rhombs, whose minor axes were perpendicular, or nearly so, to the plates of the shell. When this filling-up had been nearly perfected, the whole substance of the shell had undergone a change of molecular structure, and in place of the parallel plates presenting the usual character under the microscope they were obliterated, and the whole substance of the shell had assumed the crystalline form of calcareous spar, with the axes of the rhombs perpendicular to the original plates of the shell. Thus, Mr. Mallet considers, a molecular induction of crystalline form appears to have been propagated from the primary nuclei of crystals deposited in the original cavities of the shell, such that all the calcareous particles of the latter took a new arrangement in obedience to the form and position of these primary rhombs. He infers a change without solution, and therefore that the fact observed belongs to a class that might be much extended with valuable results. He remarks that belemnites in calcareous strata always assume the form of arragonite and not of calcareous spar.

The second paper by Mr. Mallet was on the adoption of an uniform principle of making geological sections. He proposes that all geological sections should be made in north and south and in east and west directions. He showed by a map of parallel sections of an imaginary country, so laid down on the same sheet at equal distances, that a complete picture of the interior of the country may be produced, and that from such a set of parallel sections, at right angles and equidistant, other sections at any required angle between north and south and east and west may be derived and laid down by well-known mathematical methods. He considers that if this system were adopted it would give uniformity and mathematical precision to all future sections, as from them, without limit, any other sections might be derived. Mr. Mallet remarks, that as our globe has all its great forces in connexion with lines of symmetry on its surface, *i. e.* north and south or east and west, there is reason to desire that our geological sections should also be in lines of symmetry, as at some distant time they must connect themselves with the great cosmical forces concerned both with the apparent unsymmetrical confusion of the surface, and with the real order of forces ever acting within and upon our globe.

Mr. M'Adam communicated a notice of the cuttings of the Belfast and Ballymene Railway, describing the appearance of the trappean rocks and of the drift cut through.

The other papers were from officers of the Geological Survey. Professor Oldham, the president of the Geological Society of Dublin, described in detail and exhibited a map of the area covered by drift in the county Wicklow. He also exhibited and described the maps and sections of the same county lately published by the Survey, and Professor Edward Forbes gave a detailed notice of certain fossils, apparently the oldest that we are yet acquainted with, to which he assigned the name of *Oldhamia*, having been first observed by Professor Oldham, near Bray, in 1844. Professor E. Forbes also communicated to the Society an account of the researches of the Survey into the Silurian fossils of Ireland, especially those of Portrane, and Mr. Du Noyer read a paper descriptive of the mode of occurrence of certain interesting dykes, so well exposed by the railway cuttings of the Belfast Junction Railway, near Dundalk.

The Geological Society of Cornwall has continued to advance. Mr. Pattison communicated "A brief description of the coast of Cornwall between the Padstow River and Perran Sands," in which he notices the fossiliferous beds of Dinas Cove, containing *Turbinolopsis celtica* and Encrinites, and of Permizen Bay, in which *Turbinolopsis celtica*, and another coral, Crinoidea, Spirifera, and *Orthoceras ludense* (common) are found. He further mentions the greenstone and associated rocks of Trevose Head; the fossiliferous beds of Bodruthan Steps, where among other remains those of a trilobite are discovered; the quartzose rocks of St. Eval cliffs; the discovery of a Spirifer near Trevarrian; the variegated slates, cut by a great north and south elvan, of Watergate Bay, these variegated beds resting upon the greenish and brown slate, with limestones, of St. Columb Porth, in which Mr. Pattison found Turbinolopsis and another coral, probably Favosites, Crinoidea, Spirifera (*S. disjuncta* and another), *Orthoceras ludense*, a Goniatite and a Calymene. He states that, nearing New Quay, a hard blue calcareous rock contained Favosites, Orthis or Terebratula, and numerous remains of Encrinites. In the fine raised beach at New Quay Mr. Pattison detected the remains of shells, determined by Mr. Couch as those of *Modiola vulgaris*, *Cytherea chione*, and of a Patella and Ostrea, all molluscs now living in the adjoining sea. Crinoidea were found in the brown sandstones and slates of East Pentire Point.

In a notice of the trap veins and limestone rocks of Towan Head, St. Columb Minor, Mr. Tweedy describes and gives a map of that interesting point of land, where fossiliferous argillaceous slate and calcareous beds, one worked for limestone, are traversed by numerous veins of trappean rocks. He notices nine or ten of these veins as occurring in one locality within a distance of fifty feet, the igneous rock of some dykes being vesicular.

Mr. Peach has again added to his lists of Cornish fossils in a paper "On the Fossiliferous Strata of part of the South-east coast of Cornwall." He mentions additional specimens of Onchus, supposed to be *O. Murchisoni*, from Lantivet Bay, as also a portion of an Asterolepis. He traces the fish-beds from near Pencarra Point, by Tregabrown Hill, with strata termed *Bellerophon-beds*, across Fowey Harbour. Quartzose strata and claret-coloured slates accompany these beds. Detailed accounts are given of the localities in which the fish remains have been discovered. Hard rocks, intermingled with soft red sandstones, some brown beds and thin layers of impure limestone, run from Lantick Bay across to White Horse Ferry, and contain corals, crinoidea, orthoceratites, large shells and trilobites, the latter rare. In the slaty beds, seaward from Black Bottle, Lantick Bay, large corals are detected, and in thin seams of impure limestones crinoidea, large Turbinolopsides and shells are abundant. A fine specimen of a trilobite is described and figured, from Punch's Cross. Mr. Peach mentions the surface-markings, commonly termed ripple-marks, of some localities, and thinks that the marks upon one bed-surface, from Highgate quarry, St. Veep, may have been due to the effects of rain, as has been supposed the case with certain surface-markings in the new red sandstone of Lancashire.

In a paper "On an insulated patch of Devonian strata in the parish of St. Stephen's by Launceston, Cornwall," Mr. Pattison describes certain beds apparently intermingled with the carboniferous rocks of the district. He notices "dark slates and limestones, with traces of plants, goniatites and other remains analogous to mountain limestone fossils," as forming the beds on the south, on which certain hard sandstones and shales repose. Beyond the latter, northward, instead of the common carboniferous rocks of the district, beds of flagstone, a thin-bedded slate and a calcareous rock come in. These are succeeded on the north by coarse gritty rocks, interstratified with shells of the coal-measure series. The flagstones are worked at Yeolmbridge, Werrington Park. Fossils in the quarry are rare, and consist of *Turbinolopsis celtica, Sanguinolaria elliptica* and *Bellerophon hiulcus*; but in an old quarry in the range of the same beds, near Underwood farm, about a mile distant, organic remains are more numerous. Mr. Pattison there found *Turbinolopsis celtica, Amplexus tortuosus*, Crinoidea, *Sanguinolaria elliptica*, Avicula, Orthis, Acroculia?, Orthoceras, Goniatites?, Clymenia?, *Bellerophon hiulcus* and *Phacops Latreillii.*

The Rev. D. Williams communicated a paper "On the several Volcanic interferences which alternate and are concurrent with, and eventually supersede, the Old Red Sandstone of the British Isles." In it he considers that there have been three protracted periods of volcanic interferences during the accumulation of the old red sandstone of this country.

Mr. Richard Edmonds noticed his further success in finding the abundant remains of *Helix pulchella* beneath the sand-hillocks on the coast of Cornwall, a fact of interest, he observes, inasmuch as the author of the Cornish Fauna has remarked that if the remains of these land shells be of frequent occurrence in such situations, "we must come to the conclusion that they were once abundant in Cornwall, but are now gradually becoming extinct in this locality." As bearing upon this point, Mr. Edmonds gives the following list of land shells found beneath the surface of the Phillack Towans (Sand-hills), with the exception of *Zonites pygmæus*, taken from Whitesand Bay Towans. Those marked with an asterisk are not now found living within ten miles of Penzance :—*Bulimus acutus, B. obscurus, Carychium minimum, Clausilia biplicata, Conovulus bidentatus, C. denticulatus, Helix aspersa, H. caperata, H. ericetorum, H. fulva*, H. fusca, H. hortensis, H. nemoralis, H. pulchella, H. virgata, Pupa Anglica, P. marginata*, P. umbilicata, Vertigo edentula, V. palustris*, V. pygmæa*, Vitrina pellucida, Zonites alliarius, Z. cellarius, Z. nitidulus, Z. pygmæus**, and *Z. rotundatus.* It may be needful to observe that Phillack Towans are seven miles from Penzance, and that though now receiving additions, the mass of them belongs to a relative level of sea and land on the Cornish coasts different from the present, the north-western part having been formed at the period anterior to the raising of so many beaches on this coast. Indeed these Towans constituted the contemporaneous continuation of those beaches, being composed of the sand drifted by the winds from the shores then existing.

Mr. John Garby presented to the Society a very valuable catalogue of the minerals found in Cornwall, with their localities. In this he enumerates no less than 159 mineral substances as discovered in that county, one furnishing such excellent opportunities for the study of the mode of occurrence of numerous minerals. For facilitating that study the catalogue of Mr. Garby cannot fail to be of very great service.

Mr. Henwood communicated a Description of the Brazilian method of Washing (dressing) Gold, and Mr. William Vivian, a practical miner, a paper on the Formation and Direction of Mineral Veins.

The Geological Society of Manchester had the following communications made to it:—"Notes on a section from Parkgate to Buxton," by Mr. Ormerod; "A Catalogue of Geological Specimens from Van Diemen's Land, with some observations on them," by Mr. Moore; "A short account of the Geology and Natural History of the Orange River, South Africa," by Captain Miller; "An account of Excursions in Van Diemen's Land, and notices of its Geology," by Mr. Moore; "An account of the Island of Labuan, East Indies," by Mr. Bellot; "An account of the Coal District of Tyrone," by Mr. Griffith; and "Notes on the Coal Districts of Munster and Tyrone," by Mr. Elias Hall.

Palæontological Society.

This Society, which we may consider as one very intimately connected with our own, has continued to advance steadily and prosperously. Its members are now increased to 728,—a large number when we consider that the Society was only founded in March 1847. The Monograph of the Univalves in the Tertiary deposit, named the Crag, by Mr. Searles Wood, has been published, and the Descriptions of the Reptiles of the London Clay, by Professors Owen and Bell, is in a forward state. The Society has been most fortunate in having induced Professor Owen to publish his great work on the British Fossil Reptiles through it. A work of this magnitude and character cannot fail firmly to establish the Palæontological Society in the good opinion of the scientific public. The Monograph of the Fossils of our Magnesian Limestone, by Mr. King, is far advanced, as also the Cephalopoda of the London Clay, by Mr. Edwards. The Bivalve Shells of the Crag, by Mr. Searles Wood, will be ready in 1850.

Geological Survey of the United Kingdom.

Some of the results of this Survey have been communicated to our Society by Professors Ramsay and Edward Forbes, and by Messrs. Beete Jukes, Selwyn, Aveline and Salter, in their papers and notes read before us, and previously noticed, the officers of the Survey thus endeavouring to assist in the general progress of this Society. Notwithstanding that the wet character of the past summer was by no means favourable to field investigations, more particularly in mountainous districts, much progress has been made in this branch of the public service. The complicated district of North Wales has now been so far examined that its completion may be expected during the present year. The various overlaps of the different accumulations, the modifications of the conditions under which they have been formed, the intermingling of igneous products, the great thickness of the deposits, and the distribution of the remains of life entombed in them, render this region one of great interest, and well-worthy the searching investigation that it has undergone. The maps of Cardiganshire and Montgomeryshire, including the mineral veins of those counties, have been published during the year, and maps of other portions of North Wales are now in the hands of the engraver. Dorsetshire is nearly completed, and much information will be found in the map of that district, not only as respects the range and mode of occurrence of the oolitic and cretaceous series, but also as regards the fractures or faults by which it is traversed, and which have been surveyed in great detail. The examination of the tertiary deposits of Dorsetshire and Hampshire has also far advanced. Derbyshire is approaching to completion, and much progress made in the coal district of Staffordshire.

The map of the county Wicklow has been published, and with it sections, on the usual scale of six inches to the mile for both height and distance, which exhibit the mode of occurrence of the various rocks of that district. The sections more particularly exhibit the manner in which masses of pre-existing deposits (Silurian and Cambrian) have been hoisted up upon the granite of the great range of that rock extending through the county Wicklow by the counties of Carlow and Wexford to the southward. The general curve of the uprise is well seen in these sections, with portions of the uplifted and altered sedimentary rocks still sticking upon the granite, showing that the movement was effected posterior to the deposit of the Silurian rocks of the counties Wicklow and Wexford, and anterior to the deposit of the mountain limestone. Indeed, more to the southward it is found that the uprise of the granite was anterior to the deposit of the old red sandstone, since the latter contains pebbles and smaller detritus of the granite upon which it is seen quietly to repose. The manner in which the mountain limestone overlaps the old red sandstone, and reposes directly upon the granite, near Carlow, is shown in one of the sections above mentioned. The sections also exhibit the distances to which the sedimentary deposits have been altered or metamorphosed in consequence of the intrusion of the granite amid them. A large plan of the mining district of the Ovoca has also been published, and the maps of the counties of Carlow and Kildare will shortly appear. Portions of the Queen's county and county Kilkenny are completed, and the counties of Dublin and Wexford are in progress.

Museum of Practical Geology, London.

The donations to this establishment have been, as heretofore, both abundant and valuable. Great additions have been made to the collections illustrative of the applications of geology to the useful purposes of life, and of the mineral wealth of our country; and it should be borne in mind with respect to such establishments, that the applications of science by advancing civilization at the same time increase the opportunity of extending and advancing science itself. Thus the one aids the other, and both combined promote the general progress of mankind, as witness our railways, electrical telegraphs and steam navigation.

As connected with the objects of this Society, it may be mentioned that the investigation at the Museum for the Admiralty of the coals best suited to our steam navy has made great progress, that one report on this subject has been presented to Parliament and has been printed, and that a second report will soon appear. The waters of many of our streams and springs are under examination for the Board of Health. The chemical composition of fossil remains of different ages is under investigation, and already, as has been above mentioned, shells from the Silurian rocks have been found to retain animal matter. The new house for the Museum in Jermyn Street is now nearly completed; when finished, the collections of the Geological Survey, illustrative of the geology of our country, including its organic remains, and of our mineral wealth and its applications, will be there exhibited gratuitously to the public, as those collections which the limited space in the present provisional museum will permit being shown now are daily, and have been for several years past,—a gratuitous admission which has been marked by very slight damage, and that not chargeable upon the working classes.

A second volume, in two parts, of the Memoirs of the Geological Survey of Great Britain and of the Museum of Practical Geology has been published during the past year, and illustrations of British Fossils will shortly appear in connection with the publications of the Survey, each decade consisting of the same kind of fossils. The first decade will be devoted to fossil Star-fishes and Echinites, and the second to Trilobites.

Geological Society of France.

The communication to this Society which succeeded those we had an opportunity of noticing in the Address for the last year, was from M. Frapolli on facts illustrative of the deposits of gypsum, dolomite and rock-salt. He first mentions the gypseous deposits of the country surrounding the Hartz, found in all the secondary rocks, either in small isolated patches, as is generally the case in the Subhercynian Gulf, or in great deposits, as in Thuringia, where it appears on the limits of the muschelkalk and keuper, ranging like a great abrupt crescent-formed wall on the southern side of the Hartz. This gypsum is always stratified, the beds being parallel with those of the rocks amid which it is found, such as zechstein, grès bigarré, muschelkalk, variegated marls and chalk. A peculiar mineral aspect is stated to characterize the gypsum of each of these deposits. M. Frapolli considers certain of these gypsums, those of the muschelkalk, trias, Jura rocks and chalk, to have been of metamorphic origin, and that the sulphates of lime were originally carbonates of lime, the metamorphism having been effected in the dry way (*la voie sèche*), gaseous emanations having reached them from beneath. On this head he quotes a conversation with Berzelius, whose loss to our body we have this day had to record, who said, "Give me a substance containing sulphur,—admit the presence of the vapours of sulphur, or sulphurous or sulph-hydrous vapours,—let limestone be also present, and water on the surface or in the atmosphere, and we shall readily have gypsum." M. Frapolli adopts sulphurous acid as the principal agent of *gypsification*, and supposes that, evolved from beneath, it acted on the edges of recently fractured beds of limestone, replacing the carbonic acid of the latter, the sulphurous being converted into sulphuric acid under such a pressure that a portion of the oxygen of the carbonic was appropriated by the sulphurous acid, the remainder escaping as oxide of carbon.

The gypsum of the zechstein, regularly interstratified in lenticular masses with limestones and dolomite, is not thought to have been formed in the manner above noticed, but by the wet way (*la voie humide*), sulphurous acid gas being evolved through cracks at the bottom of the sea, which, forming gypsum with the lime it found, stopped up these cracks, others being however produced from time to time by new movements in the earth's crust, so that alternations of gypsum and limestone were effected. In like manner the dolomitic rocks of the district are inferred to have a metamorphic origin, the needful gaseous emanations having acted on limestones. With respect to the rock-salt, its occurrence in alternating lenticular portions amid the dolomite and gypsum of the zechstein, it is supposed, might arise from the presence, in the waters, of the carbonates of lime and soda, and the simultaneous emission of sulphurous and hydrochloric acids, or of chlorine with the chloride of magnesium from vents at the bottom of the sea, the abundance of each varying, sometimes the sulphurous acid being the most abundant, sometimes chlorine, and at others chloride of magnesium.

M. Elie de Beaumont communicated to the Society an extended note on the most ancient systems of European mountains, in which, after adverting to his well-known labours on the subject of the elevation of mountain systems, the first account of which was read before the Academy of Sciences of Paris in June 1829, he alludes to his continued researches in the same field, and describes four systems, succeeding each other in the order of geological time, to which he assigns the names of the Finisterre, the Longmynd, the Morbihan, and the Westmoreland or Hundsrück systems.

It would be impossible to give a correct view, in the limits to which we are necessarily restricted in an address of this kind, of the mass of matter connected with his subject which M. Elie de Beaumont has brought forward in this memoir. We must refer to the paper itself for tables and calculations which are essential to the right understanding of his communication, one which, moreover, is drawn up in a very condensed form, and therefore difficult of satisfactory abridgment.

M. Elie de Beaumont remarks that during the greater part of his labours on mountain systems he had used a graphic method of recording his observations, employing a stereographic projection on the horizon of Mont Blanc, which he had calculated and had engraved at the commencement of his researches, and of which he availed himself in his lectures. He points to the advantages which the graphic and trigonometrical methods each possess, observing that though the former so well addresses itself to the eye, the latter more correctly gives the mean of numerous observations.

"The fundamental problem," observes M. Élie de Beaumont, after alluding to the systems of small arcs of great circles, "presented by a like system of small arcs observed on the surface of the globe, where they are marked by the crests of mountains or by the outcrop of beds, consists in determining the great circle of comparison, to one of the elements of which each of the small arcs observed is parallel.

"The small arcs determined by observation may be generally considered as being themselves infinitely small secants, or tangents to so many small circles resulting from the intersection of the surface of the sphere with planes parallel to the great circle of comparison, forming the equator of the whole system. Each of these small circles is a parallel with respect to the equator of the system; it has the same poles as it, and these poles are the two points where all the great circles perpendicular to the small arcs, constituting the system of parallel traces determined by observation, intersect.

"The problem arising from such a system of parallel traces observed on the surface of the globe consists in determining these two poles, or, what amounts to the same thing, its equator; *i. e.* the great circle of comparison to which each of the small arcs observed may be considered as parallel. This determination, M. Élie de Beaumont observes, would be easy, and might be made after two, or at least a few observations, if the condition of parallelism was rigorously satisfied: since, however, this in general is but approximatively accomplished, the determination of the great circle of comparison can only follow from the means of numerous observations, well-combined with each other; and thus, while the observations are not very multiplied or spread over a wide space, we can only advance towards this determination by successive approximations."

M. Élie de Beaumont then points out the mode of arriving at the results proposed,—one which requires to be studied in the memoir itself, on account of the necessary formulæ and tables. Employing the method adopted, he enters into great detail respecting the evidences of the systems treated of.

With respect to the Westmoreland and Hundsrück system, one referred to a geological date posterior to the Silurian rocks, including the tilestone, but anterior to the old red sandstone or Devonian rocks, M. Élie de Beaumont passes in review the different localities in Europe which he includes in it, commencing in the north, and taking a mean for the direction of the small arc of the great circle traversing the centre of the locality. This gives for Lapland a direction of E. 22° 30′ N.; for Esthonia, E. 17° N.; for Wisby, in the Isle of Gothland, E. 22° 30′ N.; for the Grampians, E. 38° N.; Keswick, Westmoreland, E. 37° 30′ N.; Church Stretton, Shropshire, E. 42° N.; Falmouth, Cornwall, E. 45° N.; Freiberg, Erzgebirge, E. 27° 55′ N.; Hof, Frankenwald, E. 28° N.; Prague, Bohemia, E. 28° 40′ N.;

Ardenne, E. 25° N.; Condros, E. 35° N.; Taunus, E. 33° 13′ N.; Binger Loch, direction of the quartz rocks and green slates, E. 43° 50′ N.; Hundsrück-Taunus (chain), E. 27° 30′ N.; St. Malo, Brittany, E. 42° 15′ N. and E. 47° N.; Schirmeck, E. 30° N.; Saint-Dié, Vosges, E. 35° N.; Montagne Noire, E. 34° N.; Hyères, E. 22° 30′ N.; and for Ajaccio, Corsica, E. 22° 30′ N.

From these twenty-two local mean directions M. Élie de Beaumont proceeds to determine, trigonometrically, the direction of the great circle of comparison of this system considered as passing through the Binger Loch, and states the result to be the "supposition that the great circle passing the Binger Loch, with a direction E. 31½° N., is the great circle of comparison, or the equator of the Westmoreland and Hundsrück system."

M. Élie de Beaumont, adopting the same methods, next examines the evidence respecting the direction of the Longmynd system, one formed anterior to the Caradoc sandstone. The mean local directions are considered to be, for Church Stretton (Longmynd district), N. 25° E.; Morlaix, Brittany, N. 21° E.; Saint-James, Normandy, N. 22° 30′ E.; Limousin, N. 26° E.; Freiberg, Erzgebirge, N. 33° 57′ 30″ E.; Zlabings (for Moravia and the adjoining portions of Bohemia and Austria), N. 32° 30′ E.; middle distance between Gotheborg and Gefle, Sweden, N. 38° E.; Uleaborg, north-west of Finland, N. 42½° E.; Viborg, south of Finland, N. 50° E.; and for Saint-Tropez, Montagnes des Maures and the Esterel, N. 35° 45′ 46″ E. Proceeding with these means, as with those for the Westmoreland and Hundsrück system, our colleague finds that the Longmynd system, referred to the Binger Loch, has a direction of N. 31° 15′ E., differing from the former system by 27° 15′. M. Élie de Beaumont supposes that, provisionally, the great circle passing by the Binger Loch and making an angle of 30° 15′ towards the N.E., is the equator or great circle of comparison for the Longmynd system.

Adverting to his former researches respecting the direction of mountain chains, inserted in the French edition of the 'Geological Manual' and the 'Traité de Géognosie' of M. Daubuisson, in which he notices it, M. Élie de Beaumont next considers the Finisterre system, one formed anterior to the Silurian rocks. The direction of this system at Brest is stated to be E. 21° 45′ N., and he infers that it can be found in Sweden and Finland, and that it may be possible to recognise it in the fundamental rocks of the Pyrenees and Catalonia. The Finisterre system referred to the Binger Loch, becomes E. 11° 35′ N., differing by 20° from the Westmoreland and Hundsrück system, and more than 47° from that of the Longmynd.

Under the name of the Morbihan system, a direction of beds in Brittany is noticed, and considered to be due to an elevation different from those described previously. This direction is taken for Vannes at E. 38° 15′ S., and the system itself, it is thought, may be widely extended. Certain directions of beds in the departments of La Corrèze, La Dordogne and La Charente are thought referable to it, as also the direction of the crystalline rocks in the environs of Messina, and of certain rocks in the Böhmerwald and Erzgebirge, and in the Ukraine.

The Morbihan system is also inferred to be indicated in Labrador and Canada.

Respecting the relative geological ages of the four systems noticed, they are considered to be in the following order, the first being the most ancient, and the third formed anterior to all the Silurian accumulations:—

1. System of Finisterre.
2. System of the Longmynd.
3. System of Morbihan.
4. System of Westmoreland and the Hundsrück.

Treating of the old slates of Brittany, whether taking the direction of the Finisterre, Longmynd or Morbihan systems, M. Élie de Beaumont notices their envelopment, in an unconformable manner, by a great deposit of sandstones and conglomerates referred by him to the age of the Caradoc sandstone. M. Élie de Beaumont points to the greater extension of the sea at the time of the Caradoc sandstone than at the period when the previous fossiliferous beds were deposited, a sea covering portions of Brittany, Scandinavia and northern America, so that the first Silurian beds in those countries were contemporaneously formed, and are referable to the Caradoc sandstone, a great absence of accumulations being observable in the same regions, this absence in Brittany corresponding with the double period of tranquillity existing between the elevation of the Finisterre and Morbihan systems. He then inquires respecting the evidence of a geological horizon of the date of the Caradoc sandstone in Wales, one which has been ascertained from independent observations, during the progress of the Geological Survey, and of which a notice was communicated to you by Professor Ramsay and Mr. Aveline in a memoir previously noticed. Taking into account the system of La Vendée proposed by M. Rivière, which M. Élie de Beaumont considers not unfounded on facts, though he is not personally acquainted with them, the following is his view of the deposits of rocks and of systems of elevation formed in western Europe during the earlier times of the palæozoic period.

1. *Green satiny slates of Belle-Isle.*
   1. System of La Vendée.
      (Direction, N.N.W. and S.S.E.)
2. *Cumbrian rocks of Brittany.*
   2. System of Finisterre.
      (Direction, at Brest, W. 21° 45′ S. and E. 21° 45′ N.)
3. *Green slates of Wales and felspar rocks.*
   3. System of the Longmynd.
      (Direction, at the Binger Loch, N. 31° 15′ E. and S. 31° 15′ W.)
4. *Fossiliferous series of the Bala limestone.*
   4. System of Morbihan.
      (Direction, at Vannes, W. 38° 15′ N. and E. 38° 15′ S.)

5. *Silurian series, including the Tilestone.*

5. System of Westmoreland and the Hundsrück.

(Direction, at the Binger Loch, W. 31° 30′ S. and E. 31° 30′ N.)

6. *Devonian series.*

An additional note is appended respecting the prolongation of the systems of the Ballons, of Westmoreland and the Hundsrück, and of the Côte d'Or into distant countries, especially into North America, the Russian dominions and China.

M. Favre communicated observations on the relative positions of the rocks in the western Alps of Switzerland and of Savoy, in which he noticed,—1. the crystalline rocks; 2. the metamorphic rocks; 3. the Vallorsine conglomerate; 4. the Jurassic series; 5. the cretaceous deposits, divided into (*a*) Neocomian, (*b*) first rudiste zone, (*c*) Albian rocks, gault and greensand, and (*d*) the Seeven limestone of M. Studer; and, 6. the nummulitic limestone. The cretaceous deposits are stated to rest unconformably on the Jurassic series, and at the Diablerets the nummulitic limestone reposes on the green sand, the fossils of the two rocks being mingled. M. Favre notices a bed of coal in the nummulitic deposits sufficiently thick to be worked in the chain of the Titlis and other localities, and considers that the nummulitic rocks are independent of the cretaceous series on which they rest. The Macigno is then noticed, and it is inferred that both it and the nummulitic limestone are alike independent of each other and of the cretaceous series.

M. d'Archiac read an extract of a memoir on the fossils of the nummulitic rocks of the environs of Bayonne and Dax, in which he refers to the fossils from Biaritz sent to him by Mr. Pratt, and those from the arrondissement of Dax by M. Delbos. Of the 209 species determined and obtained from the departments of the Landes and Basses-Pyrénées, 128 are only yet known as local, 10 are found in the nummulitic beds of Corbières and the Montagne Noire, 12 in other parts of Europe, 48 in lower tertiary deposits, 22 in the middle tertiaries, and 4 species in the chalk, 3 oysters among these last being found in the lower group of the nummulitic rocks which rests directly on the chalk of the district.

In his researches on the crystallization of the granitic rocks, M. Durocher refers to the remarks of M. Scheerer on his previous labours on the same subject, and supposes that a mass containing in combination silica, alumina, alkaline and earthy bases, potash, soda, sometimes lithia, with a little lime, magnesia, the oxides of iron and manganese, as also minute quantities of hydrofluoric acid and even of boracic acid, would separate into quartz, mica and felspar when sufficiently cooled. The solidification taking place according to the relative tendency of the minerals to crystallize, the felspar would crystallize sooner than the quartz. The solidification of the silica he considers would not be instantaneous, the substance behaving like the vitreous bodies, and remaining long in a viscous state. Thus the crystallization of the granite would not be in the order of fusibility of the component minerals.

With respect to granites, M. Durocher considers that in the greater number of cases the solidification of the different constituent elements of the rock took place at nearly the same time, but not so with the porphyries. With respect to the view of water forming an essential part of granites, he infers that, *à priori*, the quantity must be very small, less than one per cent. By experiment he did not find so much as five thousand-parts of water in granites, felspathic rocks and quartziferous porphyries which were not decomposed. The small quantity of water found in ordinary granites (always excepting those containing talc or chlorite) appears to him to be due to percolation subsequent to their original consolidation, while he admits that many igneous rocks, such as serpentine, diallage rock and others, may have originally contained water as an essential component part.

During his experiments on the igneous rocks, M. Durocher found carbonate of lime and dolomite in many, these substances being invisible by means of a lens. With respect to dolomite, he found ·0092 of it in a granite from Stockholm, ·005 in a protogyne from the Vallée de l'Agly (Pyrénées Orientales), ·0043 in a petrosilex from Sala (Sweden), ·013 from a euphotide of Savoy, ·0024 from a basalt of Saint-Flour (Cantal), and ·0062 in an olivine lava of Auvergne. From ·001 to ·018 of carbonate of lime, either pure or slightly magnesiferous, was in twenty-five specimens of granitic and other igneous rocks considered original and not due to infiltration.

M. Pilla, whose loss to science amid the late political events in Italy we have to deplore, communicated a notice on the red ammonitiferous limestone of Italy. Having noticed the rocks of the districts of the Lago di Como, of La Spezia and of the mountains of Tuscany, referring to the previous writings of geologists, he infers that the true position of the red ammonitiferous limestone is in the Liassic Jura series, quoting the observations of Von Buch as to the liassic or inferior oolitic character of the contained ammonites as showing the age of the beds of the Lago di Como, where, from their mode of occurrence, they might otherwise be referred to the higher part of the Jurassic series. At La Spezia and in the mountains of Tuscany the red ammonitiferous limestone rests immediately on a dolomite and black limestone, rocks which, by their position and fossils, are considered identical with the dolomite and brown limestone of the valley of Esino, lake of Como, which geologists view as forming part of the lias. The exact equivalent M. Pilla supposes may be the lower part of the oolitic series.

M. Pomel described a new fossil pachyderm from the basin of the Gironde, named *Elotherium magnum*, considered to bear the same relation to the hippopotamus that the tapirs and rhinoceros do to the lophiodon and palæotherium.

In a memoir on the nummulitic rocks of the departments of the Aude and of the Pyrenees, M. Tallavignes proposes to describe these deposits with reference to the localities named, and not with regard to general classifications. He finds two formations, distinct both in their geological and palæontological characters. The first contains either new or known tertiary fossils, and the beds are commonly horizontal. To this formation M. Tallavignes assigns the name of

Iberian system. The other deposit he names the Alarician system. Its fauna is stated to present more of a cretaceous than tertiary character, and it has no apparent connection with the other system. Its beds have been disturbed, and in the Aude the strata of the former system rest unconformably upon them. The nummulitic rocks of the Central Pyrenees exclusively belong, he infers, to the Alarician system. The upper or Iberian nummulitic rocks constitute two distinct basins on the north side of the Pyrenees, that of the Aude on the east, and that of the Basses-Pyrénées on the west.

In a letter to M. Frapolli on the polished and striated rocks of Denmark, M. Forchhammer, after noticing many facts observed, calls attention to the action of ice on the present coasts of that country. He remarks that although the coast ice envelopes the blocks of rock and pebbles, to enable these to be borne away from the shore it is necessary that the thaw or rupture of the ice should coincide with a rise of the waters. In the winter of 1844 the ice surrounded a block of from sixty to eighty cubic feet (about four to five tons and a half). In the following spring this was carried out to sea, leaving as it quitted the coast a deep furrow in the sandy clay of the shore, not quite obliterated six months afterwards.

In the middle of February 1844, a sudden frost covered the Sound with ice, particularly towards the coast of Seeland, and this ice, driven by a heavy gale, was dashed on shore. Fears were entertained for the fishing village at the bottom of Täarbeijk bay. The masses of ice suddenly rose to the height of sixteen feet, breaking in upon the houses. The furrows and scratches made by this rush of ice extended beneath the sea-level. With regard to the transport of blocks of rock now taking place, M. Forchhammer mentions that in 1844 a diver in search of the remains of an English cutter which blew up, at anchor, during the bombardment of Copenhagen in 1807, found part of this vessel entire, but covered by blocks, some of which may have measured six to eight cubic feet. The same diver affirmed that all the wrecks he had visited in the roadstead were more or less covered by blocks. These blocks M. Forchhammer considers to be brought by the masses of ice borne out from the Baltic by the current setting through the Kattegat in the spring.

In a geological description of the northern part of the empire of Morocco, Dr. Coquard, after remarking on the physical aspect of the country, notices the occurrence of transition rocks (*terrain de transition*), which he separates into four divisions. The first, or the lowest, is formed of crystalline slates, in which various modifications are observed, from gneiss to argillaceous slate; the second composed of black grauwacke, quartzose conglomerates and grey quartz rocks; the third of satiny slates, thick beds of limestone and calcareous slates, containing orthoceræ, orthides, encrinites and trilobites; and the fourth of sandstones and conglomerates. The second of these divisions is referred to the Lower Silurian, and the third to the Upper Silurian series, while the fourth is considered equivalent to the Devonian series, fossils being, however, absent in it. The thickness of these deposits is estimated at 2850 feet. These accumulations are succeeded by a vast assemblage of limestones and dolomites, referred to the Jurassic series, resting unconformably on the rocks beneath. Above the Jurassic the cretaceous series reposes. It is divided by Dr. Coquard into three parts : *a*. a limestone with *Chama ammonia* ; *b*. nummulitic limestone (these being conformable to each other) ; and *c*. fucoid sandstone, unconformable. The first he refers to the Neocomian rocks, the second to the greensand, and the third to the upper chalk. The tertiary rocks are considered to be represented by a freshwater and by a marine deposit, both miocene and conformable to each other, and by an argillaceous and horizontal formation. To these succeed modern travertines, osseous breccias, bog iron, and dunes. There is much detail given in the memoir : the direction of the lines of elevation is noticed in accordance with the views of M. Élie de Beaumont, and the paper is accompanied by several sections.

In a letter from Boston (7th Nov. 1847), M. Desor gave an account of his discovery of fragments of *Venus mercenaria* in the drift of Brooklyn, near New York, and stated that in consequence much search had been made by Mr. Redfield, whose labours had been rewarded by fine collections of shells from the drift around New York, consisting of *Venus mercenaria, Ostrea canadensis, Nassa trivittata, Mya arenaria, Purpura floridana,* &c., all molluscs now found living on the coasts near that city, with the exception of one species, the living representatives of which are found more southward, on the coast of Carolina. Details are given respecting the drift of North America, and of the heights at which it is found. Pleistocene clay is also noticed. M. Desor observes that the shells obtained from the clay of the different localities are of littoral species, and hence, to account for the different levels at which they occur, he considers it not improbable that during the emergence of the land above the sea, there was time sufficient for these species to multiply and form beds at different altitudes above the present ocean level. Mention is made of the probable distribution of land and water in later geological times in North America, and of its consequences.

M. d'Archiac gave a summary of the observations made on the quaternary or diluvial rocks, which he defined to consist of accumulations effected between the close of the Subapennine deposits and the commencement of the modern period. It may, he observes, be considered, that no one cause yet assigned for these accumulations is of itself sufficient for the effects observed, while many of them have concurred either simultaneously or successively, in different degrees and under different circumstances, to produce the results seen. M. d'Archiac refers to the first part of the second volume of his *Histoire des Progrès de la Géologie* for the proofs of his opinions.

M. Frapolli, in a summary of the first part of a work on the *Terrains meubles* of Europe (subhercynian type), observes, after remarking on the varied production of detrital rocks, that the accumulation of boulders and blocks, gravels, sands and clays, commonly termed *terrains meubles,* is not, as a whole, single and posterior to deposits in beds, as has been sometimes supposed, but that there have been similar accumulations during all geological periods, formed on the land as well as in the sea. Taking the view of sudden marked elevations of land at distinct times, succeeded by periods of repose, he considers that there would result from the sudden action various irregular deposits due to geological currents thus produced, some of these deposits having never been subsequently submerged, while others have been so during one or more geological periods; and that during the succeeding periods of tranquillity there would be formed a variety of irregular deposits, marine, fluvio-marine, and terrestrial, such as beaches, banks and bars, deltas, alluvions of rivers and torrents, glacial accumulations, the sand-hills of coasts and deserts, the fallen fragments from mountains and inland cliffs, &c.

M. Frapolli then describes the subhercynian rocks of this class, dividing them into the accumulations of four different and successive epochs. The first he refers to a great elevation subsequent to the deposit of the cretaceous series, and which he supposes may coincide with that preceding the deposit of the eocene rocks. To the denudation and debacle attending this elevation he attributes the dispersion of the angular blocks of quartz rock in the district. The second is thought due to an elevation corresponding with that by which the western Alps were thrown up, and from it resulted deposits of which pebbles from the Hartz form a large portion. During the period following this elevation, the Hartz is inferred to have remained above water, deposits from terrestrial and marine causes, acting upon the land, being then effected, and the climate differing little from its present state. The next is referred to the Arctic epoch. A rupture on the north-west of Europe is inferred, followed by the dispersion of the third of these accumulations. The subhercynian district was then, it is supposed, invaded by detritus from the north, this detritus thrown especially upon the northern and north-western flanks of the hills, and covering previous deposits. During the period which followed, an arctic climate is considered to have prevailed, and the *lehm* of the district to have been accumulated. A fourth dispersion is supposed to have then been effected by a movement which produced the final emergence of the subhercynian district. The period following this is the present or modern, in which the accumulations of the class noticed have been effected and are now taking place.

In a communication on the environs of Chamonix, Savoy, M. Favre remarks that the pot-stone (*pierre ollaire*) and the granite veins occur in bands parallel to the contact of the crystalline slates and protogyne, and that along the whole of the line, on the north-west flank of the chain of Mont Blanc, the same phænomena are presented, and in the same manner. He affirms that on this flank there are several parallel bands of serpentine and potstone. With respect to the Vallorsine conglomerate, he observes, that with associated sandstones and slates it constitutes the anthraxiferous formation of the Alps, by which term he does not mean to refer it to any particular geological age, but simply to state that in this group the Alpine anthracite is found. M. Favre says, that while in the district noticed this group occurs beneath the belemnitic limestone, it nevertheless passes into it geologically, at the junction of the deposits, by alternation of beds. He gives some very interesting details respecting the structure of localities, some rarely, others never previously visited by geological observers,—details which require to be studied in the memoir itself and with the aid of a map. An outlying portion of the anthraxiferous rocks, a part of a great curved mass once connecting these rocks in the Buet with those in the valley of Chamonix, was found upon the Aiguilles Rouges, there resting unconformably and horizontally upon vertical beds of crystalline rocks. A section of this curve, one very interesting as regards the movements of the Alps, and the mode of accumulation of certain of the deposits in them, is given.

Dr. Boué read a note on the existence in the northern hemisphere of isothermal curves, such as they now are, at a period at least as remote as the close of the Jurassic series. In this communication he noticed the observations connected with the distribution of the erratic blocks in Europe and America, showing that they reached more southerly latitudes in the latter than the former; that identical fossils of the ancient alluvions and the tertiary deposits of the two continents bear out the same view; and that the same also happens with the cretaceous series. Dr. Boué observes that the northern limit of the nummulitic rocks, extending from Europe, by the Himalaya, into China, describes a curve according with the present isothermal lines; thus, he remarks, if the whole earth once possessed a higher temperature than at present, the same relation of climate existed in the regions noticed as at present, at least back to the commencement of the cretaceous series.

Upon communicating a notice of the fossils of the German zechstein by M. Geinitz, M. de Verneuil adverted to the labours of Sir Roderick Murchison, Count Keyserling and himself on the Permian system, as established in Russia, and remarked that several of the species of shells discovered by them in that country had been noticed for the first time in the German zechstein, such as *Murchisonia subangulata, Solemya Biarmica, Modiola Pallasi, Arca Kingiana, Avicula Kazanensis, Terebratula Geinitziana, T. superstes, Productus Leplayi*, and *P. Cancrini*.

Notice is taken of the *Orthotrix* of M. Geinitz, which the author considers should be separated from *Productus*, and which M. de Verneuil refers (in part at least) to the *Stropholosia* of Mr. King, who also observed sufficient differences in the so-called *Producti* of the magnesian limestone of England to lead him to this view. M. de Verneuil considers that the *Orthotrix Goldfussi* and *O. excavatus* of M. Geinitz are the *Stropholosia Morrisiana* and *S. Sedgwicki* of Mr. King.

M. de Verneuil also read a communication by Prof. Naumann of Leipsic on the deposits of Oschatz, which he assigns to the Permian series, to the same effect as that brought before our Society, and previously noticed, and at the same time adverted to the labours of Sir Roderick Murchison in Thuringia, Saxony and Silesia in the establishment of the Permian system.

Relating to this subject M. Delahaye communicated a note on the schists of Muse and Buxière-la-Grue, which form, he considers, a new subdivision of the Permian series. After quoting the Abbé Landriot, as believing them to constitute a passage from the zechstein into the coal-measures, M. Delahaye remarks, that in the basin of Autun the upper beds of the schists contain an abundance of *Psarolithes* identical with those of the new red sandstone (*grès rouge*), and that in parts of the basin, at Ygornay, at Chambois, and other places, and reposing conformably on the schists, there is a grey rock sometimes containing bituminous veins, at others presenting a dirty olive-coloured aspect from a more general dissemination of bituminous matter, offering the normal characters of zechstein, and upon analysis affording the carbonates of lime and magnesia. He also calls attention to the opinion of M. Agassiz, that the fish-scales found in all the upper beds of the basin of Autun and the fossil fish of the lower parts of the schists of Muse bear the greatest resemblance to the remains of Palæoniscus discovered by M. von Dechen in the limestones subordinate to the new red sandstone (*grès rouge*) of Bohemia. M. Delahaye refers the fish-scales above noticed to the *Palæoniscus magnus*, thought by M. Agassiz to be exclusively contained in the zechstein of Mansfeld. A general view is taken of the fossil plants found in the environs of Autun.

At a subsequent meeting of the Society, while MM. Virlet and Boubée supported the view that the bituminous schist of Autun was independent of the coal-measures, M. Élie de Beaumont combated this opinion, stating that analogous bituminous schists were found in many other of the coal basins of France and foreign countries.

Mr. Davidson communicated a detailed memoir on the Brachiopods of the Upper Silurian system of England, the result of his labours in the districts where these rocks are found and among local collections. He considers it as now recognized that many species have lived through the times of deposit of several stages of the Silurian system, and have been even perpetuated beyond it. He is also of opinion that the divisions proposed by Sir Roderick Murchison are characterized by certain species more abundant in or proper to them, so that these divisions may be usefully preserved, without at the same time attaching more importance to them than is their due.

Respecting generic divisions, Mr. Davidson observes as probable, that as we advance and *lacunes* are filled up, distinctions will become more and more arbitrary. "Thus," he continues, "confining ourselves to the Brachiopods, do we not daily find the great differences disappearing which once served to characterise the genera *Productus, Chonetes, Orthis, Leptæna, Spirifer, Terebratula*, &c.? Do we not find these genera more and more approximating to each other by a multitude of intermediary species, some possessing the external forms of one genus with certain internal characters of another, so that there is much difficulty in assigning them their true place? We may cite as examples the *Orthis biloba* and the *Orthis biforata* or *lynx*, which possess the internal characters of an *Orthis* and the external forms of a *Spirifer*. The genus *Aulosteges* of M. Helmersen comes between the *Productus* and the *Orthis*." After observing that a great number of examples might be adduced of the little value to be attached to the distinction of certain genera, he admits the necessity of forming generic divisions, founded on an assemblage of well-observed characters, often taken from internal structure, in order to classify the multitude of species presented by nature.

Mr. Davidson refers to the new classification of brachiopods by M. d'Orbigny*, and to an examination of his Silurian brachiopods with him. Mr. Davidson provisionally arranges the brachiopods of the Upper Silurian series and described by him under the genera *Productus, Chonetes, Leptæna, Orthis, Spirifer, Terebratula, Pentamerus, Lingula, Crania,* and *Orbicula.* He notices 78 species, and figures 48 of them, and a table is given of the 78 species, the names being those adopted by M. de Verneuil and himself. The synonyms are appended, and reference, in connexion with them, is made to the genera adopted by M. d'Orbigny. The particular stages of the Silurian system and the localities are mentioned, and other places where the species are found, either in Europe or America, are added.

M. de Verneuil communicated a note on some brachiopods of the Isle of Gothland, in which he refers to the labours of Mr. Davidson on the brachiopods of England and to the work of M. Barrande on those of Bohemia, and describes, with figures, seven new species of brachiopods under the names of *Leptæna Loveni, L. enigma, Orthis Davidsoni, O. punctata, Spirifer Marklini, Sp. Barrandi,* and *Terebratula bicarinata,* adding the *Orthis biloba* of Linnæus. A list is given of the brachiopods of the Upper Silurian system of the Isle of Gothland. In this are enumerated seventeen species of *Terebratula,* two of *Pentamerus,* eleven of *Spirifer,* nine of *Orthis,* nine of *Leptæna,* and one of *Chonetes.*

M. de Verneuil also read a note on certain species of *Leptæna,* having a perforated beak, noticing *Leptæna alternata* (Conrad, De Verneuil and Keyserling), *L. planoconvexa* (Hall), *L. sulcata* (De Vern.), *L. Loveni* (De Vern.), *L. antiquata* and *scabrosa* (Davidson), *L. analoga* and *depressa* (on the authority of Dr. King and Mr. Davidson), *L. tenuistriata* (Sowerby), and *L. planumbona* (Hall).

M. Fauverge communicated observations on the opinion of Dr. Boué respecting the coincidence of the isothermal lines of previous geological times with the present, remarking, as regards the coal-measures, on identical species of the plants found fossil in them being discovered under very different latitudes, and referring to central heat as the cause, at that period, of the surface-temperature of the globe. We may remark on this subject (one on which we have elsewhere entered), that as exact geological investigations progress, with reference to the varied distribution of land and water, and all the conditions of relief of the land and form of the sea-bottom, we may anticipate very important information as to the distribution of temperature over our planet's surface at different geological times. A better insight will also be obtained into the value which has to be attributed to the internal heat of the earth, up to the period when, from the loss of heat by radiation into planetary space having been sufficiently advanced,

* Comptes Rendus de l'Académie des Sciences, tom. xxv.

the earth's surface-temperature became materially influenced by the sun.

In a letter to M. Élie de Beaumont, Professor Angelo Sismonda mentions, that in a descent from the Col des Encombres, towards the Tarentaise, he had found numerous fossils in the schistose black limestone of that locality. He considers this limestone as a little above the schists of Petit-Cœur (remarkable for the mixture of organic remains in them, as above noticed). The fossils found are considered by M. Sismonda to prove the correctness of the opinion given by M. Élie de Beaumont, that the belemnite beds of the Tarentaise are referable to the lias*.

M. Talavignes, referring to the memoir of M. Élie de Beaumont on the most ancient systems of European mountains, and to the recent classification of the nummulitic rocks in the eocene series, considers that he was the first to show that the received opinion as to the date of the elevation of the Pyrenees should be modified, there being two distinct deposits of nummulitic rocks (as above noticed), one named by him the Iberian system, the other the Alarician system. In reply, M. Élie de Beaumont saw no objection to the nummulitic rocks of the Mediterranean being viewed as eocene. He considered that the fossil molluscs of the Mediterranean nummulitic limestone are divisible into three groups, of which the first only is found in the nummulitic limestone of Soissons (above the plastic clay, and forming the base of the *calcaire grossier* of the Paris basin), while the second is confined to the Mediterranean deposit, and the third, composed of at least fifteen or twenty species, is found in the cretaceous rocks, properly so called.

In addition to these communications there were notices and papers on floating ice, by M. Desor; on the snows of the Vosges, by M. Ed. Collomb; on new analyses of Predazzite and the products resulting from its decomposition, by M. Damour; on an estimate of certain emanations caused by natural and artificial heat, by M. H. Daubrée; on the occurrence of stratified diallage rock (*gabbro*) between serpentine and granite, resting on the latter, in the mountains of the Zobten, Silesia, by M. Gustave Rose; on the mountain of Cetona, by M. Ezio de'Vecchi, in which the red ammonitiferous limestone is mentioned, and the author agrees in its geological position with M. Pilla; on the lacustrine formation of La Bresse, by Dr. J. Canat; on the geological structure of the low part of Guadaloupe, named Grande-Terre, by Dr. Pierre Duchassaing; on the stratified rocks of the Venetian Alps, by M. de Zigno; on the folding of the tertiary rocks in the valley of the Dronne, and on the beds traversed by the railway between Libourne and Angoulême, by M. d'Archiac. There were also communications on the causes which appear to influence the growth of certain plants

* Part of these fossils were determined by M. Bayle, at the École des Mines at Paris. Those added to the others noticed are, *Ammonites fimbriatus* (Sow.), *A. amaltheus* (Schlot,), *A. planicostatus* (Sow.), *A. radians* (Schlot.), *Pholadomya liasina* (Sow.), *Avicula inæquivalvis* (Sow.), *A. costata* (Sow.), *Lima decorata* (Munster), *Cardinia concinna* (Agassiz), *Terebratula inæquivalvis* (Sow.), *T. variabilis* (Sow.), *Arca*, *Pecten*, and *Belemnites* (abundant).

under known conditions, by M. Charles Desmoulins; on the transport of certain erratic blocks of Scandinavia and North America by floating ice, considered as a consequence of the ancient extension of glaciers and the changed level of those countries, by M. Ch. Martins; on the fossils in certain flints found in the Perigord, by M. Ch. Desmoulins; on the ancient glacier of Wesserling, by M. Ed. Collomb. Also papers by M. Blanche on part of the Lebanon; on the Dôle (Jura), by MM. Lory and Pidancet; on an artesian well, sunk 433 feet, at Venice, with an interesting and detailed section, by M. de Challaye; on Elba, by M. de Collegno; on the Jurassic rocks of the southern part of the basin of the Rhone, by M. Victor Thiollière; on the geological structure of the Isthmus of Panama, by Mr. Evan Hopkins; on human fossils found in the volcanic mountain of Denize, the mammiferous remains noticed in the different deposits of the Haute-Loire, and the probable age of their entombment, by M. Aymard; on the different species of the Mastodonts of the Velay, by M. Aymard; on the ancient glaciers of the Jura, by M. Favre; on the more recent geological memoirs read before the Friends of Natural Science of Vienna, by M. Boué,—a condensed and valuable notice. There were memoirs and notices on *dépôts blocailleux* (a name given to deposits containing a more or less large quantity of angular fragments), by M. Omalius d'Halloy; on the ridging of the earth's surface, on the nature of unconsolidated accumulations, and on the theory of floating ice, by M. Frapolli; on Tantaliferous Wolfram of the Haute-Vienne, by M. Damour; on facts and considerations in aid of a classification of the nummulitic rocks, by M. Victor Raulin; on the *Magas pumilus*, by Mr. Davidson and M. Bouchard-Chantereaux. These communications were followed by papers or notices, on the depression of Northern Africa beneath the level of the sea, by M. Angelot; on the siliceous incrustation of the Geysers, and on different natural hydrates of silica, by M. Damour; on the upper tertiary deposit of Sundgau (Upper Rhine), and on the transformation of the felspathic pebbles of this deposit into kaolin, by M. Daubrée; on the mines of the environs of Bone and Philippeville (Algeria), by M. Paul Benoist. To these succeed a reply to MM. Martins and Desor respecting the theory of floating ice, and analysis of a MS. notice of M. Paul Weibye of Krageroe on that of waves, with a notice of the recent observations of M. Forchhammer on the polished and striated surfaces of Denmark, by M. Frapolli; and remarks on this reply by M. Ch. Martins.

M. Ed. Collomb gave an account of fossil plants found in Devonian or Silurian rocks near Wesseiling; and there were papers on dolomitization by De Morlot; on a geological survey of the basin of La Comté, by M. Leprieur; on the classification of the ungulated mammifers, by M. Pomel; on a temporary glacier (January and February 1848) in the Vosges, by M. Ed. Collomb; on agricultural geology, more especially of a domain near Nancy, by M. Nérée Boubée; on the fossil bones of the environs of Alais, by M. d'Hombres-Firmas; on the nature of the rocks of the domain of Gastilitza, near St. Petersburg, and on the fossils found in them, by Prince Emmanuel Galitzin; on the deposits between the white chalk and the *calcaire* *grossier* of the Paris basin, by M. E. Hébert; on the Fahluns of the south-west of France, by M. Delbos; on the freshwater *Physa* limestone of Montolieu (Department of the Aude), by M. Victor Raulin. There were also rectifications of his classification of the nummulitic rocks by M. Victor Raulin, and a paper on a classification of the tertiary rocks of Aquitain by the same author.

Connected with the publications of the Geological Society of France, M. d'Archiac has produced the second volume of his 'History of the Progress of Geology,' one, like the first, replete with valuable matter. It treats of the deposits known as quaternary or diluvial. Itself a condensation of a mass of information, illustrated by concise original remarks, it would be impossible to afford you a just idea of its contents in the brief notice which this address will permit. It may, however, be desirable to mention, that in this second volume M. d'Archiac gives an account of the raised beaches and superficial deposits, with fossil marine remains, and of the erratic blocks of the north of Europe and of the British Islands, of the effects due to glacial action in these islands, of their bone-caves and osseous breccias, and of their palæontology of this date. The quaternary deposits of Holland, Belgium and of France are mentioned in detail, the latter under the heads of basin of the Seine, chain of the Vosges and the valleys descending from it, basin of the Rhine, basin of the Loire and central plateau of France, north flank of the Pyrenees, basin of the Rhone, and osseous breccia and bone-caves. The quaternary deposits of the Alps follow, first considering those of the plains and valleys around the Alps, and then those amid the mountains themselves. The accumulations of this date are then treated of as regards Southern Europe, Central Europe, Eastern Europe, and Asia, including under the latter head those of the Ural, of Siberia, and of the north flank of the Altai. Then follow the accumulations of Western Asia and of Southern Asia. M. d'Archiac afterwards proceeds with the quaternary deposits of Africa and of North America, first treating, as respects the latter, of the marine and lacustrine deposits of the southern of the United States, then of those in the Northern States, and afterwards of the erratic blocks of North America. He next describes the deposits supposed to be of this age in Southern and Central America (including the West Indian Islands with a description of the Pampas and of the raised beaches of the western coast), and in Australia. M. d'Archiac concludes with a general summary, read also before the Geological Society of France, and with theoretical considerations respecting the former extension of glaciers.

Geological Notices.

This address has so far extended beyond the limits originally contemplated, and which may indeed be considered desirable, that we would venture to trespass little further upon your indulgence. At the same time it becomes matter of congratulation, as regards the still increasing cultivation of our science, that even a sketch of the progress of this Society, and mention of papers read before other geological societies of our land, with notices of those communicated to the Geological Society of France, and a statement of the advance of our Geological Survey, could so long have occupied our attention. The political events of the past year have, no doubt, interrupted geological investigations in many parts of Europe, yet even under this disadvantage it is gratifying to find how much has been accomplished in European geology, while steady advances have been made in our knowledge of America, especially of its northern portions, and of various other parts of the world.

We cannot omit to call your attention to the publication, during the year, of a second volume of the 'Explication de la Carte Géologique de la France,' by MM. Dufrénoy and Élie de Beaumont *; an important work, more especially as regards a right knowledge of the geological structure of France. It is remarked in the introduction to this volume that the study of the relations existing between the topography and the nature of the rocks had induced the authors to give detailed descriptions of the successive zones forming the outcrop of the different divisions of the Trias and the Jurassic limestone. They therefore have made known the regular course of these divisions in the basin of the north of France by examples taken at short distances from each other, and they have adopted the same method for the south of France in order to show the differences presented by the same deposits either in their lithological characters or in the nature of the fossils disseminated among them. These details also enabled them to render full justice to the labours which have either preceded or followed the publication of the geological map of France. The work is accompanied by 105 illustrative diagrams, and, in addition to the scientific detail, notices are given of the useful mineral substances found in, or forming part of, the rocks described. It is announced that the third volume will contain an account of the remainder of the sedimentary rocks which have been only slightly disturbed since their deposit, and that there will be a volume dedicated to the description and figures of shells characteristic of the different fossiliferous deposits of France.

The trias, consisting of the *grès bigarré*, the *muschelkalk*, and the *marnes irisées*, is described as occurring (1) around the Vosges, particularly on the plains of the ancient Lorraine; (2) on the flanks of the mountains of the Charollais, in the departments of the Côte d'Or, of the Saône and Loire, and of the Rhône; (3) on the northern foot of the mountains of Central France, in the departments of the Nièvre, of the Allier, of the Cher, and of the Indre; (4) on the slope of the hills of the Bocage, in the departments of Calvados and La Manche; (5) on the southern side of the central mass of France, in the departments of the Lot, the Aveyron, the Tarn and Garonne, the Tarn, and the Hérault; and (6) on the flanks of the Montagnes des Maures, in the department of the Var. Some other localities in disturbed districts, such as the Pyrenees and Jura, are to be separately noticed.

A small map is given, showing the outcrop-course of the Jurassic rocks, the divisions of which, it is remarked, present the great advantage of being nearly continuously traceable from one end to the

* A thick quarto volume containing 813 pages.

other of France. The divisions noticed are the lias, the inferior oolite, the middle oolite and the upper oolite; and it is mentioned that the beds are so similar both in the south and north of France, that specimens collected between the Sables-d'Olonne and Rochefort, on the borders of the Ocean, are exactly analogous with those of the same series of deposits on the shores of the Channel between Caen and Honfleur. The base of the Jurassic series is mentioned as marked by sands and other accumulations showing an absence of repose, such as the gravels and sands (*diluvium*) at the base of the Jurassic series in the environs of Moutiers, near Bayeux, and the quartzose sandstones, rich in altered felspar, to which the name *arkose* has been assigned. From their position they have been termed in the geological map of France the *infraliassic sandstones*. They are, however, sometimes associated with the inferior oolite, and perhaps even with the middle oolite. In each case they contain fossils analogous to those of the limestones which repose upon them, thus determining their age. These sandstones are remarkable for containing crystalline minerals, which are not commonly found in the calcareous beds. Sulphate of baryta is abundant, and even sometimes, as in the environs of Alençon, the shells of fossils are replaced by it in a crystalline form. The sandstone of the lias in many places contains galena, blende, and oxide of manganese.

It is announced that the government geological survey of Belgium is completed. And respecting maps we would wish to call your attention to the palæontological map of the British Islands by Professor Edward Forbes (published during the year as part of the Physical Atlas by Johnston and Berghaus) as embodying a large amount of valuable information. With respect to the progress of palæontology, we should also call your attention to that important work, 'The Palæontology of New York,' by Mr. James Hall, containing descriptions of the organic remains of the lower division of the New York system, considered equivalent to the Lower Silurian rocks of Europe. This work contains descriptions, with numerous figures, of 95 genera and 381 species; 14 species being classed as Plantæ, 4 as uncertain, 50 as Zoophyta, 15 as Crinoidea, 77 as Brachiopoda, 49 as Acephala, 71 as Gasteropoda, 68 as Cephalopoda, and 33 as Crustacea.

Under the same branch of our science, Bronn's 'Index Palæontologicus' should be mentioned as extremely valuable, as also Geinitz and Gutbier's work on the fossils of the Saxon Permian, Richter's Palæontology of Thuringia, Searles Wood on the Univalves of the Crag (one of the publications of the Palæontographical Society), an important work. In the 'Annals of Natural History' will be found papers by Schomburgk on Barbadoes fossils (found in beds referred to the miocene deposits); M'Coy on carboniferous and old red sandstone fishes, on mesozoic radiata, and on palæozoic corals; Lycett's further observations on the conchology of the oolitic rocks, and Toulmin Smith on the Ventriculidæ; observations on some Belemnites and other fossil remains of Cephalopoda from the Oxford clay near Trowbridge, Wiltshire, in which Dr. Mantell concludes that the true character of the animal of the Belemnite remains to be ascertained, and that the Belemnoteuthis is generically distinct from the Belemnite, the opinion formerly given by Mr. Chaning Pearce and Mr. Cunnington.

We should not forget the second part of the papers of the Friends of Natural History in Vienna, collected and published by the indefatigable Haidinger, who, notwithstanding the political events of the last year, has been enabled to produce this volume, containing in connection with geology the following papers:—Reuss on the Fossil Polypiaria of the Vienna Tertiary Basin, accompanied by eleven plates; Czjzek on the Fossil Foraminifera of the Vienna Basin; Barrande on the Brachiopoda of the Silurian Rocks of Bohemia (the continuation of his former), with nine plates; Morlot on the Geology of Istria, with a geological map; and Reissacher on the Auriferous District of the Salzburg Central Alps.

The cause of the production of dolomite having of late been matter of much attention, perhaps it may not be out of place, before we conclude, to notice a few circumstances connected with this subject. From the time, now many years since, when our veteran and distinguished colleague, Von Buch, first advanced his views on the production of certain dolomites, there has been much difference of opinion as to the mode in which this compound of the carbonates of lime and magnesia could have been formed. Facts have been adduced to show that the dolomitic beds, commonly known as the magnesian limestones, ranging amid the new red sandstone series of parts of England, and considered equivalent to part of the Permian system of Sir Roderick Murchison, had been deposited from water, in the same manner as many limestones, and that the same had been the case with many dolomitic beds occurring in different parts of Great Britain and Ireland amid the more common calcareous accumulations of the carboniferous or mountain limestone. Other facts have been brought forward to sustain the opinion that many dolomitic masses, often of considerable volume, were not in the condition of the first formation of such masses, but were limestones changed by circumstances which had added the carbonate of magnesia, so that the resulting product was a dolomite. Like many questions involving the union of particles of matter constituting certain mineral bodies, we should carefully weigh the evidence adduced, so as to be sure we do not attribute to a single mode of production those things which may have resulted from two. The study of the manner in which minerals occur has shown us that some of the same kinds have been formed from the solution in water of the elementary body or bodies of which they are composed, and also amid masses which have evidently been in a state of igneous fusion. Take, for example, common rock crystals or quartz,—little doubt can exist that their component particles of silica have been gathered together as crystals in fissures and other cavities from liquid solutions, and we find as well-formed crystals of the same mineral in some porphyries, the igneous origin of which can scarcely be called in question, the particles in both cases having been under such conditions that they could approximate, and, under the influences producing crystallization, be arranged in a definite manner. The same with certain other minerals, such as some belonging to the felspar family and sulphuret of iron.

In the progress of the Geological Survey during the past year in Ireland, we had an opportunity of seeing a beautiful arrangement of dolomite crystals in ordinary limestone on the south of Carlow, near Bagenalstown. In that part of Ireland there is a dolomitic series of beds amid the accumulations of the carboniferous or mountain limestone, having a considerable range. In the higher parts where this series is surmounted by certain dark and black shales, the beds, which may, for convenience, be termed those of passage, show the cessation of the conditions under which the crystals of dolomite were so deposited as to form the whole or nearly the whole of the strata. There were alternations of circumstances, and little sheets of crystals of the carbonates of lime and magnesia, often of slight depth, alternate with the common dark carbonaceous limestone, the light colour of the one, in sections, strongly contrasting with the dark colour of the other. We here seem to have had times when these crystals of the carbonates of lime and magnesia were strewed over the bottom, at first so little mingled with other matter as to constitute whole beds, and then so mixed, as conditions changed, that they were only strewed about in patches, their production finally ceasing altogether.

Many other facts, as you are aware, upon the great scale, could be adduced to support the view that, at least, some of the dolomitic rocks have been the result of deposit from water, as indeed we might expect, and we would here recall to your attention that numerous limestones contain carbonate of magnesia, besides the rocks properly termed dolomites, and often far more abundantly than would be supposed. We should also not feel surprised that when a deposit was effecting from solution in water, and the carbonates of lime and magnesia were being thrown down in certain definite proportions (and the proportions those of bitter spar or dolomite), that crystals were the result (supposing the needful time for the definite arrangement of the component particles), their arrangement in beds or thin laminæ, intermingled with ordinary limestone, being dependent on circumstances.

Satisfied as we may happen to be, however, with such a view as affording an explanation of the mode of occurrence of dolomitic rocks in certain districts, it by no means follows that it will suffice for all dolomites wherever found. Other views have been taken and ably supported. You are familiar with the opinions and facts adduced by Von Buch, respecting the occurrence of dolomite in certain districts, as also with the writings of others entertaining the same views. During the past year some highly interesting experiments have been made by M. de Morlot, the results of which are considered by him to support the metamorphic character of dolomites, more particularly in the manner advocated by M. Haidinger.

A notice of these experiments and conclusions is contained in a letter of M. de Morlot to M. Élie de Beaumont, in which he refers to the calculations of this distinguished geologist* respecting the

* Bulletin de la Société Géologique de France, 1837, pp. 174–177.

volume which a cube metre of limestone would occupy if converted into dolomite, by the substitution of one atom of carbonate of magnesia for one atom of carbonate of lime in each double atom of carbonate of lime, which show that hollows or pores would result equal to 12 per cent. of the total volume of the rock, explaining the cavernous structure of many dolomites. M. de Morlot, desirous of ascertaining how far the theoretical view of M. de Beaumont was borne out by fact, carefully chose a piece of the dolomite of the Prédiel, believed to represent its mean cavernous state, and with many precautions, ascertained the relation of the pores or hollows to the volume of the rock. This he found to be 12·9 per cent., a remarkable coincidence he infers, all the circumstances being taken into consideration, and a result confirming the views of M. Élie de Beaumont. M. de Morlot however regards the metamorphic character of dolomite, with M. Élie de Beaumont, as placed beyond doubt by the fact, that part of the Silurian corals of Gerolstein were formed of crystallized dolomite, and are cavernous, without having lost their organic form. He also notices, and gives a figure of, a coral from the Seisser Alp, from the structure of which he infers that there has been metamorphic action, and that the atom of lime thus displaced has been removed.

The frequent association of dolomite with gypsum in many places, and a careful examination of specimens collected near Vienna, induced Haidinger to suspect that the magnesia had been introduced in the form of a sulphate, and that this salt, so commonly existing in nature, had so reacted upon the limestone to which it was conveyed in solution in water, that the double carbonate of lime and magnesia, and gypsum were the results. A solution of sulphate of lime was, however, known, if filtrated sufficiently long through pulverized dolomite, to transform the latter into carbonate of lime, sulphate of magnesia being formed. From reasoning upon some circumstances observed, in connexion with this subject, Haidinger concluded, that though at a low temperature and solely under ordinary atmospheric pressure, a solution of sulphate of magnesia decomposes dolomite, under a high pressure and heat the reverse would take place. Estimating the increase of temperature from the surface of the earth downwards, and the probable pressure beneath a certain amount of mineral accumulations, M. Haidinger inferred, that at a temperature of 200° Centigrade, and under a pressure equal to 15 atmospheres, this would happen. The experiment was made; a mixture in atomic proportion of sulphate of magnesia and carbonate of lime was subjected, in a tube of glass, hermetically closed at both ends, and exposed in a modification of Sir James Hall's gun-barrel apparatus, to the pressure and heat calculated. The experiment was perfectly successful; there was complete double decomposition, and the formation of the double carbonate of lime and magnesia and of sulphate of lime was the result. Although, to make this experiment applicable to the occurrence of mixed masses of dolomite and gypsum in nature, we have to suppose like conditions on the great scale, and a very large proportion of that soluble salt, sulphate of magnesia, intermingled with carbonate of lime, it is one of considerable value, as showing what would happen

h 2

under a given heat and certain pressure; the latter very moderate, even 80 fathoms of water giving it, and therefore a very slight thickness of rock. The new arrangements of the particles of mineral matter from heat and pressure, under conditions for the free motion of at least a portion of the component parts of rocks, and the development of the forces governing the arrangement of the particles when free, are daily gaining increased attention. It is no doubt an investigation requiring extreme care and caution, but it is one from the skilful pursuit of which the geologist may expect a considerable increase of knowledge. While, however, we by no means neglect the changes and modifications mineral masses may suffer from such agencies, let us not forget the causes of difference in original accumulations, and those other changes and modifications which the simple infiltration of new substances in solution among the particles of rocks and the removal of others may effect during the lapse of time, not neglecting the relative position of mineral masses at different periods, a consideration of great geological importance.

My duties as your President now terminate. I should, however, be unworthy of the uniform kindness and effective co-operation experienced from you throughout the two years during which you have honoured me with your confidence, were I to retire without expressing, in all sincerity, my most unfeigned thanks for that assistance in the performance of my duties without which your President could but ill discharge them. After an experience of thirty-two years of the kind brotherly feeling which prevails among us, perhaps there was little reason to expect that the indulgence and forbearance enjoyed by my predecessors should not be extended to me. It nevertheless has been peculiarly gratifying, pressed as I have been by public duties, to find my endeavours to maintain our old effectiveness so indulgently viewed, and I trust that whatever may have been my faults, want of anxiety for your prosperity and of an earnest desire for the advance of our science will not be found among them. I now resign this chair to one who has previously occupied it, whose contributions to our Society have been numerous and important, and whose writings have so materially advanced the science of geology, feeling confident that in Sir Charles Lyell you will have a President in every way fitted for the office, and one who can, and will, devote his time and attention to the welfare of our Society and to the means it possesses of promoting the progress of that branch of knowledge for the cultivation of which we are here associated.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 3, 1848.

John Dorrington, Esq., was elected a Fellow of the Society.

The following communications were then read:—

1. *On the Development of the Permian System in* Saxony, *as communicated by* Professor Naumann *to* Sir Roderick Murchison, G.C.S., F.R.S. &c.

Those geologists who have attended to the recent progress in the classification of the palæozoic rocks may well suppose that I was highly gratified by receiving the letter from Professor Naumann of Leipsic, of which I now send a translation. The reasons for the adoption of the term Permian were so thoroughly explained, first in a letter addressed by me to Dr. Fischer of Moscow*, next in communications to the Geological Society of London, and lastly in the work on Russia and the Ural Mountains, that I have now only to refer to those documents. But I would specially call attention to the first pages in the tenth chapter of the last-mentioned work, because they were written after a visit to Thuringia, Saxony and Silesia, which confirmed and extended the view I had adopted from the survey of Russia; viz. that the Zechstein and Kupferschiefer were mere subordinate members of a great red sandstone group, of which the

* Phil. Mag., Dec. 1841.

Roth-liegende was the base, and in which the Zechstein was covered conformably by another red sandstone which had previously been erroneously united with the Trias. My colleagues, De Verneuil and Keyserling, having cooperated with me in establishing the independence of this group as developed upon so large a scale in the eastern regions (Permia) of European Russia, in showing that by its fauna and flora it must be viewed as the uppermost of the palæozoic systems, it was indeed evident that some single name must be applied to it, and hence Permian was adhered to, the word being derived from a vast region (twice as large as France) where the strata of this age are copiously exhibited. No other general term had been applied to the group in question; for although my excellent friend M. d'Omalius d'Halloy had used the term Pénéen, that word having been applied by him to characterize a "sterile" conglomerate only which overlies the coal-measures of Belgium, it was evident from its very import that the name could not be extended to a compound group of sandstone, limestone, schists and conglomerates, which instead of being sterile was clearly characterized by its organic contents. It is in this comprehensive sense that I have employed the word Permian in the small Geological Map of England and Wales published by the Society for the Diffusion of Useful Knowledge. The country of all others, however, in which the new term seemed least likely to be received was Germany, where my eminent contemporary, Leopold von Buch, was most anxious that the group should be named from the Zechstein so long known, and whose fossils had mainly contributed to prove the character of the system. Feeling the force of this appeal, I endeavoured, in deference to my friend, to alter the name Permian which had been announced; but finding it to be impracticable to elicit from "Zechstein" a term which could have passed current in the French, English and Italian languages, the euphonious synonym Permian was continued. I need not remind English geologists of the desirableness of having some general name for their "lower new red sandstone" and "magnesian limestone;" and as I now find that a distinguished German professor, whose geological maps are an honour to our age, has spontaneously come to the same conclusion for his own country, I have the best hopes that the Permian System will henceforward be recognized as founded on researches which proved it to be the uppermost member of the palæozoic series over an area of enormous magnitude.

The following is the letter of Professor Naumann:—

RODERICK I. MURCHISON.

Rome, February 19, 1848.

"Leipsic, January 6, 1848.

"I hasten to inform you that the sandstones and schistose clays of the environs of Oschatz, which are so loaded with impressions of Lycopodites or Walchia, and which at first I considered to be of the carboniferous age, develope more and more the characters of your Permian formation. The discovery of the *Calamites gigas* and of a fern closely allied to *Sphenopteris erosa*, together with the difference of most of the species of plants from those of the coal (*terrain houiller*), particularly induce me to make this assertion. Further, many of the ichthyolites are similar to the Palæoniscus or Amblypteris and to the Xenacanthus of Beyrich. The tract of country which furnishes the data I now communicate is almost entirely covered by drift (diluvium), and it is through trials for coal that my knowledge has been obtained. In addition to the sandstones and argillaceous schists, there occurs a very bituminous combustible schist which is charged with Cypris, and forms beds from 2 to 16 feet thick, wherein the fossil fishes are contained. After having in vain examined by means of a draining adit (*a a*) the upper stage of the sandstone and schistose clay, which is 500

5 Red sandstone*. 4 Zechstein. 3 Red sandstone.
2 Porphyry. 1 Sandstone and schistose clay.

feet thick, a shaft was sunk (*b b*) in order to explore the lower stage by a gallery (*b c*). A number of fossil plants were found in this shaft, viz. Calamites 3 species, Sphenopteris 4 or 5 sp., Odontopteris 2 sp., Pecopteris 1 sp., Neuropteris 1 sp., Lycopodites or Walchia 1 sp. The bituminous schist, it may be observed, was passed through between *b* and *c*.

"Now all these strata so resemble those of the coal-fields that they might well indeed be mistaken for them. But such an interpretation would, I am convinced, be erroneous; and I conceive that all the lower strata, which consist of white sandstone and greyish schists, and which attain a thickness of more than 800 feet, cannot be anything else than the lower stage of the Roth-liegende (lower new red of England). From that stage, or No. 1, the following then is the ascending order: 2. Quartziferous porphyry. 3. Red sandstones. 4. Zechstein (magnesian limestone of England). 5. Red and mottled sandstones and clays.

"The last-mentioned band does not belong to the Trias, but to the same formation as the Roth-liegende. That name is, however, no longer applicable to a formation, the greatest part of which is of white and grey colours; and as to the Zechstein, it is here reduced to a band which varies from 30 to 60 feet in thickness only. Hence it is that I prefer the denomination of Permian as proposed by you, Sir; and this term is the more applicable to the strata of Oschatz, inasmuch as by all their relations they approach much more to the Russian than to the Thuringian formation of the same age.

"Generally speaking, the lower member of our Roth-liegende is represented by white or grey sandstones and grits, as at Rohrlitz for example, where they attain a thickness of 200 feet; and again, the

* The upper red sandstone (5) does not occur in Professor Naumann's diagram, probably because it is not seen at Oschatz; but I have added it in order that the figure may agree with his table of superposition. This upper sandstone is indeed seen in that relation in many other places in Saxony, Thuringia, &c., and has been so classified by me. (See Russia and Ural Mountains, vol. i. p. 199–203.)

beds at Zwickau, which M. Gutbier has distinguished by the name of 'graues conglomerat,' are nothing more than the base of the Roth-liegende of Germany."

In a second letter to Sir Roderick Murchison, dated November 25, 1848, Professor Naumann says, "In reply to your letter of the 20th I hasten to inform you that I agree entirely with your idea, that the Roth-liegende and the Zechstein together constitute but one and the same formation, although in Germany these two members are very often distinctly separated from each other. It is for this reason that I shall always preserve this distinction in any description of the Permian system, such as it presents itself in our country. In reference to my assertion, that the coal-beds of Oschatz are separated from the Roth-liegende by porphyry, the term Roth-liegende was there used in a purely petrographical sense, as signifying a sandstone coloured red, and to indicate that the beds whose characters truly represent what may be called Roth-liegende commence in this section above the porphyry only. At all events, these red beds are only part of the same whole which includes the grey beds below the porphyry, the latter rock being intercalated in the middle of the Permian sandstone. This takes place both near Oschatz and Rohrlitz, though the phenomenon is more clearly seen near the last-mentioned town, as is exhibited in the 14th sheet (Grimma) of our geological map. Political troubles have interfered with the working researches near Oschatz, but tranquillity being restored, they will be renewed in the spring. In the mean time, M. Gutbier will give a description of the Permian flora of Saxony, the Saxon fauna of the same system having been already published by M. Geinitz."

December 26, 1848.

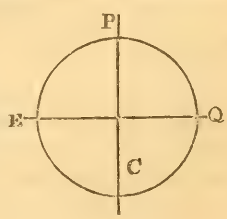
---

2. *On Change of Climate resulting from a Change in the Earth's Axis of Rotation.* By Sir JOHN LUBBOCK, Bart., F.R.S.

[Communicated in a letter to Charles Lyell, Esq., V.P.G.S.]

I HAVE thought a good deal upon phænomena indicative of a change in the climate of places on the earth's surface and of changes in the relative position of land and water, and as this is a subject to which you have devoted so much attention, I wish to know whether you think the following speculations of any value, or whether you think they have already been anticipated by any mathematician.

It follows from the theory of rotation of a solid body, as is well known, that, 1. If a body revolves about certain axes which are called principal, and no extraneous force acts upon the body, it will continue to do so for ever.

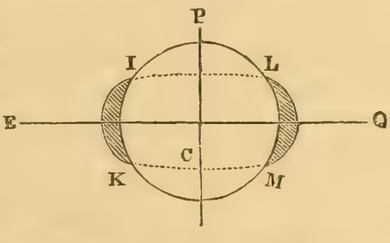


So in the case of the earth: if EQ is the equator and P the pole, if the earth, as is supposed, revolves at present about CP the axis of figure, as this is a principal axis, it will continue to do so for ever, and has done so since the origin. Hence the geographical latitude of any place on the earth's surface remains unchanged; no change of climate can obtain except from a change in the internal temperature, or in the sun, the source of heat.

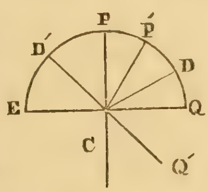
But a change in climate alone is not sufficient to account for geological changes, which indicate that water now covers land formerly dry, and *vice versâ*.

The preceding conclusions are not modified by the attraction of the moon, or by those causes which produce the precession of the equinoxes, so that at Greenwich for example the latitude remains, as Mr. Airy informs me, absolutely unchanged within those limits of which the errors of the observations are susceptible. If however we go back to the origin, it is unlikely that when the earth was first set spinning, the axis of rotation should exactly coincide with the axis of figure, unless indeed it were all perfectly fluid. We may however go back to some time less remote, and suppose the axis of rotation not coinciding with the axis of figure, and the earth in a semi-fluid state, or rather, in consequence of the different degrees of fusibility of different substances, partly solid in irregular masses and partly fluid. We then advance to another period more recent in which the earth consisted of land and water, and was suited for the support of animal life. We may if we please consider this as the original state. The only hypothesis I wish to insist upon as essential is, that the axis of rotation had not the same geographical position as at present.

In order to take the simplest case of the effect which a displacement of the axis supposed possible may have had upon the relative positions of land and water, suppose the solid part of the earth to consist of a spheroidal nucleus revolving about the axis CP. The effect of this would be to throw the water into the position IKML about the equator, the greater or less protuberance being caused by the greater or less velocity of angular rotation. It is evident that if the body after any length of time moved about any other axis of rotation, the water would occupy a position about the new equator, land would become sea and sea land, &c. &c.



Now suppose a point situated at D with latitude QCD, revolving about the axis CP and submerged, were after a lapse of time to revolve about an axis CP′ and having latitude DCQ′, it would cease to be submerged, but at the same time would be in a colder climate, which is consistent with what you find takes place in Europe (vol. i. p. 155); but if we consider what takes place at the point D′ situated at a distance of 180° longitude from D, we find precisely the reverse: primitively dry the point D will become covered by sea, and will acquire a hotter climate. The countries differing in longitude from us by 180° are at present submerged by the Pacific.



The solid nucleus of the earth is not a sphere, but a spheroid; and if we suppose the axis of rotation at any time to have occupied a different place from that which it occupies at the present time, and not identical with the axis of figure, if any resistance exists, it would cause the pole of the axis of rotation to describe a spiral round the pole of the axis of figure, and finally it would become, as it is at present, identical with it. Moreover you would necessarily have a change in the relative positions of sea and land.

If the axis of rotation could suffer such a displacement by reason of the causes which produce the precession of the equinoxes, you would have another and a more natural way of accounting for the existing phænomena; but this has been held to be impossible.

If we admit the rotation of the earth to take place under such conditions that the surface experiences any friction (i. e. resistance, which Laplace did not consider), then the invariability of geographical latitude which exists otherwise, noticed by Laplace (vol. v. Méc. Cél. p. 268), is not a necessary consequence.

Great obstacles interfere, so as to prevent a complete elucidation of this question. Putting aside the great difficulty of an exact and finished solution of the problem of the rotation of a body in a resisting medium, we have no numerical data which would assist in determining the amount of such resistance. Still less do we know the structure of the strata underneath the earth's surface, or the history of the changes which have taken place during the process of cooling, which might enable us to trace the position of the axis of rotation in remote times. So that I think the utmost that can be accomplished by mathematics is to explain under what hypothesis a change of the position of the axis of rotation is possible or not.

In the Méc. Cél. vol. v. p. 14, Laplace lays it down, that it is impossible to account for the changes which have taken place on the surface of the earth, and in the relative positions of land and water, by a change in the position of the axis of rotation. But this dictum is founded upon the absence of two considerations, both of which appear to me to be essential:

1. The dislocation of strata by cooling;
2. The friction of the surface.

If the earth were at any remote epoch a homogeneous spheroid, formed for example of any one pure metal in a state of fusion, then, in the process of cooling, I doubt not that the mass would always be made up of concentric spheroids, so that it would always revolve about the same principal axis of rotation, which would never deviate from the axis of figure. But the condition of the earth which really obtains is so very far, as we know, from being that of homogeneity, that it seems to me quite within the limits of possibility, that in cooling the position of the axis of rotation may have changed, apart from the influence of friction at the surface.

With regard to the second consideration, although not alluded to in p. 14 of the Méc. Cél. vol. v., it is expressly referred to by Laplace at p. 254 of the same volume. The inequalities to which Laplace there alludes, and which he supposes and admits may have existed and may have become obliterated by friction at the surface, are proportional in amount to the sine of the co-latitude of the pole of the axis of rotation, and could not exist if the axis coincided, as it does now, with the axis of figure.

---

3. *An Elucidation of the successive Changes of Temperature and the Levels of the Oceanic Waters upon the Earth's Surface, in harmony with Geological Evidences. By* WILLIAM DEVONSHIRE SAULL, Esq., F.R.S.A., &c.

THIS paper commences with an investigation of matter in its various forms, and proposes a new view of the nature of heat and light. The author next states that the poles of the earth are not fixed and invariable in position, as astronomers generally suppose, but are in continual motion. From these various causes combined he then deduces a new theory to account for the alternations of climate and the changes in the relative level of sea and land observed by geologists.

MAY 17, 1848.

J. R. Logan, Esq., Singapore, and the Rev. John Thornton, B.A., Kimbolton, were elected Fellows of the Society.

The following communications were read:—

1. *On some Fossiliferous Beds in the Silurian Rocks of* WIGTOWNSHIRE *and* AYRSHIRE. By J. CARRICK MOORE, Esq., Sec. G.S.

THE difficulty of assigning to the great chain of rocks of the south of Scotland their true place in the geological series, arises from the rarity of fossil remains, and from the want of beds with such well-marked mineral character, as to enable the observer to determine their superposition. Part of this obscurity has been lately removed by Mr. Nicol's description of fossiliferous beds in the valley of the Tweed (Geol. Journ. vol. iv. p. 195); and as any additional information, however scanty, may be interesting, I shall briefly describe the localities in Wigtownshire and the south of Ayrshire where I have found fossils, commencing with some account of the general structure of the country.

The description given by Mr. Nicol of the physical structure of Peeblesshire applies in the main to Wigtownshire and the south of Ayrshire. There is the same prevalent strike in an E.N.E. direction, a system of valleys running parallel to the strike formed by the convolutions of the rocks, with another transverse system of valleys at right angles to the former, remarkably equidistant, and through which the principal drainage of the country is effected. The rivers Stincher and Finnart are instances of the former system; the Cree, the Bladenoch and the Tarf, the Luce, and the Piltanton of the latter. The bays of Loch Ryan and Glenluce form another instance of this transverse system. They are shallow bays, nowhere exceeding seven fathoms in depth, separated by an isthmus about nine miles broad of low land, consisting entirely of boulder clay, loose sands, and peat bogs. The whole country, as we proceed from the highest mountains of Kirkcudbrightshire towards the west, becomes less and less elevated above the sea; so that an amount of depression, which in the more eastern part of the chain would form a valley with a river flowing through it, becomes an arm of the sea as we advance to the west.

That this transverse system of valleys or fissures is of high geological antiquity, seems indicated by the fact, that the most western of these depressions, the bay of Loch Ryan, is partly occupied by unconformable strata of clay, sandstone, and conglomerate about 400 feet thick, the lowest bed of which contains *Stigmaria ficoides* and Calamites. A fracture therefore had occurred across the greywacke range, and a valley had been scooped out in it prior to the deposition of these secondary rocks: and as this bay appears to be one of a system, it would follow that all these parallel fissures took place previous to the deposition of the coal-measures.

The rocks consist of the usual varieties of coarse and thin-bedded greywacke, and clay-slate in which true slaty cleavage can never be detected, with occasional intervening beds of plutonic rock, which in Wigtownshire is usually felspathic, varying from a nearly pure felspar rock to a syenite.

These plutonic rocks appear to follow the direction of the sedimentary beds, and to be interstratified with them; yet I am persuaded they are most frequently, if not always, of an intrusive character. The great extent of coast in Wigtownshire, washed by a boisterous sea, affords favourable opportunities for observing: near the Corswall Lighthouse, for example, an extent of many acres is washed bare by the Irish Sea. In such situations (and they are numerous), whenever a bed of plutonic rock is traced far, it will be found to cut transversely across the greywacke beds, which are thus seen to abut against it. The plutonic rock generally resumes its direction between the beds; so that if the point where it traverses them were not exposed, it might lead to false conclusions. The sedimentary beds are usually altered near their contact; they become more or less porphyritic, quartz veins are frequent in the vicinity of the trap, dark shales become white and sometimes red; and these effects are seen on both sides, and to the same distance from the dyke.

I shall now describe briefly the section exhibited along the Irish Channel from the Mull of Galloway to Corswall Point.

At the Mull of Galloway and for some distance to the north, the beds are nearly vertical. From the hill called Dunman to a point half-way between Portencorkrie Bay and Clanyard Bay, the coast for about two miles consists of granite, which covers a rectangular surface, extending about two miles inland to the eastward: it is a quadruple granite of quartz, felspar, mica, and hornblende, sometimes pink, but principally grey; it is distinctly columnar, dividing into prisms about a foot square, and is too subject to decomposition to be

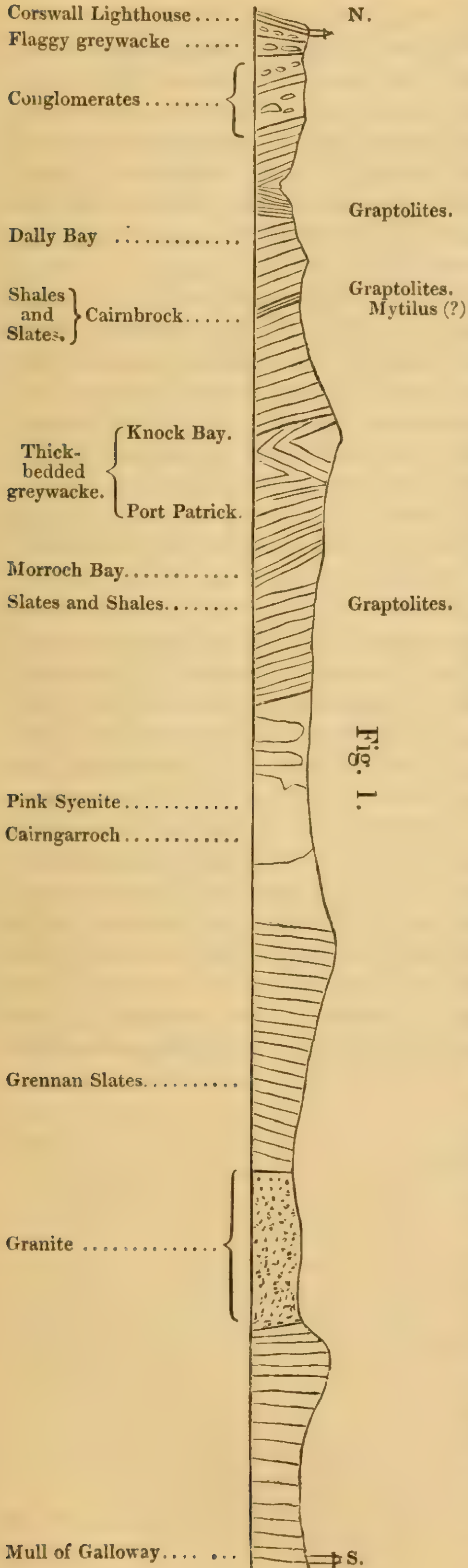
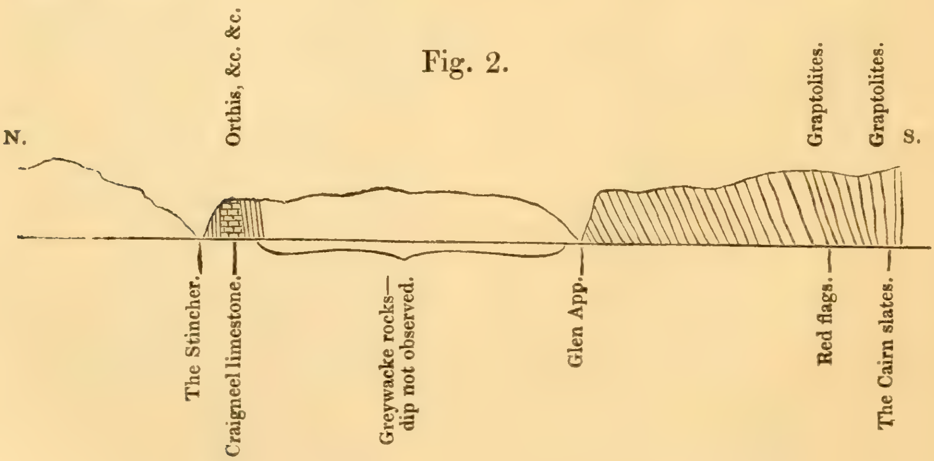


Fig. 1.

used for any but the poorer farm-houses. I have thought this granite worth mentioning, as I am not aware that any has been described as occurring between that of Cairnsmuir on the Cree in Kirkcudbrightshire, and that of the Morne Mountains in County Down.

From the bay of Drumore to the Grennan, a distance of one mile and a half, a mass of slates which have been used for roofing purposes dips to the north at a high angle; and after passing a great mass of syenite at Cairngarroch, which has altered the neighbouring rocks and invaded them in the form of dykes, we arrive at the Morroch Bay, one mile and a half south from Port Patrick; here a thick mass of shales, black, red and grey, in a vertical position, occurs interstratified with syenite and red earthy trap: the black shales are in some places full of graptolites; they are remarkably fissile, splitting readily as thin as a card, and their surfaces are marked by minute specks of iron pyrites. The red shales are similar to them in every respect, except in colour, and in not containing fossils,—differences probably due to their greater proximity to the trap. Proceeding thence to the north beyond Port Patrick, after passing much greywacke, so interfered with by a dark serpentinous trap, as scarce to present a trace of stratification, we arrive at the bay of Porto Bello near Cairnbrock, where there is a considerable thickness of slaty shales and flags, containing graptolites, and what appears to be the cast of a Mytilus. These beds dip to the south at a high angle. About a mile and a half further north, (the beds still uninterruptedly dipping south,) at the Dally Bay, graptolites again occur in a red flag or tilestone. Still further north, the beds for about a mile have a reversed dip to the north, after which they recover their southerly dip, then gradually become vertical, and at the extreme north point of the peninsula they plunge into the sea at a very high angle to the north. These vertical and highly inclined beds near the Corswall Lighthouse are very remarkable from their containing beds of conglomerate of a coarser nature than any I have ever seen described as occurring in so old a formation, with the exception of those of the Potsdam sandstone, described by Mr. Lyell as old Silurian. The fragments generally vary from the size of one inch to a foot in diameter; but in some of the beds, boulders of three, four, and even five feet diameter occur. They are well-rounded, and principally consist of red quartziferous porphyry and a large-grained grey syenite; but serpentine, red jasper, and other rocks occur; and I have found one or two instances of large angular fragments of greywacke. There are no rocks in the neighbourhood, as far as I know, from whence any of these rounded fragments could have been derived: serpentine, it is true, occurs in great quantity at the Bennan Head, two miles and a half north of Ballantrae; but it can be proved that that serpentine is of a considerably newer date, since it has penetrated and altered sandstones newer than the coal-measures. The matrix of this conglomerate is sometimes a green, trappean-looking sandstone of exceeding toughness, and sometimes an indurated sandstone indistinguishable from many common varieties of greywacke. The beds are well-exposed for a great extent; they are cut across in many places at right angles to their strike by deep fissures, resembling those in Arran and elsewhere occasioned by the decomposition of a trap dyke. These fissures afford abundant evidence that these conglomerates are vertical beds, in every respect conformable to the flaggy greywacke which is found to the north, to the south, and sometimes interstratified with them. Their vertical position is independently shown by the smaller pebbles being arranged in perpendicular layers, and by the greater diameters of the larger boulders being vertical.

Fig. 2.

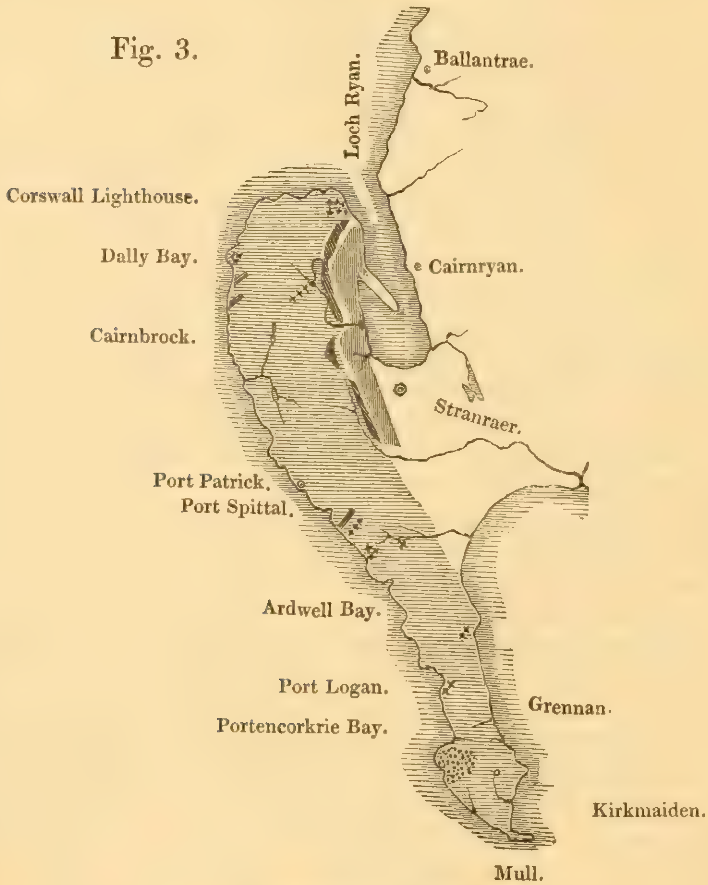


Crossing from the peninsula to the mainland at the Cairn, a great thickness of slates occurs, containing graptolites in abundance; and rather more than a mile to the north, red flaggy beds exactly like those at the Dally Bay contain the same fossil. I conceive these two sets of beds to be the prolongation of those before mentioned at Cairnbrock and Dally Bay; my reasons being, that the beds are nearly in the line of strike; the distance between the two across the line of strike is about the same, while their inclination in both cases is at a high angle, and to the same point of the compass; and the two beds on the Irish Sea in mineral character are respectively similar to the two on the east side of Loch Ryan. Moreover, on the west shore of Loch Ryan, at a spot called Sloughnagarry, in a line between the two most northern fossiliferous deposits, I have found the same graptolites in exactly similar red flags; and these are the only localities in the neighbourhood where, after much searching, I have found fossils. If it be objected, that in this view the Cairn slates ought to be found on the west shore of Loch Ryan, to the south of Sloughnagarry, I answer, that the older rocks are covered on that side of the bay for some miles by newer formations.

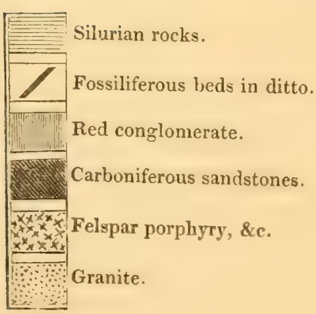
From the Cairn to the entrance of Glen App, a distance of about three miles, the rock has always a south dip. I am unable to state what the dip is from thence for about three miles across the strike; till on reaching the valley of the Stincher, we find a limestone which I have traced along that river in five distinct localities: in all of these it is highly inclined with a dip to the south. Its most western appearance is at a quarry near the mountain of Knockdolian, distant about three miles from Ballantrae. It bears about N.E. by E. and is much interfered with by serpentine, of which, judging from a hasty examination, the hill of Knockdolian seems to consist. The limestone shows itself again by the road-side with the same strike about half a mile further up the river, where it is not worked; again at Craigneel near the village of Colmonell, bearing N.E. by N., where it has been extensively worked; next at a place on the road-side, about one mile and a half above Colmonell; and lastly near Daljerrick. Although four of these localities occur on the north and one (Craigneel) on the south side of the river, whose course runs parallel to the bearing of the beds, yet I suspect that this arises from dislocation, and not from there being more than one bed. Craigneel, which is the greatest deviation from the line of bearing, contains the same fossils as Knockdolian; in short traverses which I made, I was unable to find a second bed; and the farmers have no knowledge of any other locality than those mentioned; testimony not to be neglected in a country which derives almost all its lime for agricultural purposes from Ireland. The limestone is only worked at Knockdolian and Craigneel, and at this last place the works seem suspended for fear of undermining the old castle of Craigneel, which singularly enough has been built upon the only bed of limestone in all Galloway. The bed is about thirty feet thick, dipping south at a high angle, which dip I ascertained to continue for some hundred yards to the southward. In the centre it is a dark grey compact limestone, degenerating into a clayey shale at the outside.

The fossils which I extracted from it have been submitted to Mr. Salter, who has had the kindness to examine and minutely describe them. For the most part they were ill-preserved, and not numerous; with the exception of the Orthides, which were very perfect, and at Knockdolian were in tolerable abundance. I hope at another visit to increase the list, and add something to this imperfect sketch.

Fig. 3.



Explanation of Map.



2. *Note on the Fossils from the Limestone on the* STINCHER RIVER, *and from the Slates of* LOCH RYAN. By J. W. SALTER, Esq., F.G.S.

THE fossils from the limestone are decidedly Lower Silurian; and I would identify them at once as belonging to the same epoch—probably the same bed—as those which Mr. Nicol brought from Peeblesshire; although, with the exception of an Orthis and a Trilobite, there are no fossils common to the two collections. In the Peeblesshire locality, Trilobites in plenty, with Cephalopods and Brachiopods, were the characteristic fossils; in this case we have only spiral shells, an Orthis and a Trilobite. As however they were all in both cases obtained from a very limited area, such a difference does not make it less probable that they belonged to the same strata; it is merely a local peculiarity, and may perhaps in the present case indicate a less depth of water.

The list is as follows:—

Pleurotomaria Moorei, new species.
————————, another species, much depressed.
———————— *latifasciata*, Portlock?
Murchisonia scalaris, new species. Common in the Bala limestone.
Euomphalus. A large species that may be *E. qualteriatus*, Schloth. (imperfect).
Euomphalus? Large reversed species; rather common, but imperfect; its shape reminds us of the large *Maclurea*, Hall, from America.
Orthis confinis, new species.
Illænus Davisii, Salter.

The last two species are those found also in Peeblesshire; the fragment referred to *Illænus Davisii* in Mr. Nicol's paper being probably this species; it has narrow body-rings.

None of the species brought by Prof. Sedgwick and Mr. Moore from the sandstone of Girvan Water appear to occur in this limestone.

The fossils of the red slate on Loch Ryan are *Graptolites*, and *Euomphalus furcatus*, M'Coy, a species also found in the black Llandeilo flags of Wexford and Cardiganshire. The same Graptolite occurs in the black slates of Loch Ryan and the black shales of Wexford and S. Wales; one in the red slate is identical with *G. pristis*, Portlock, from Tyrone. Taking the two bands of slate together, we have—

Euomphalus furcatus, M'Coy.
Graptolites folium, Hisinger.
———————— *pristis*, Hisinger [as figured by Portlock*.]
———————— *tenuis*, Portlock.
———————— *ramosus*, Hall.
———————— *sextans*, Hall.
———————— *tænia*, new species.

* The species so named by Portlock is possibly not that of Hisinger; some specimens appear identical with *G. mucronatus*, Hall.

In these localities we do not as yet find the *G. Sedgwickii*, so abundant in Peeblesshire and also in Tyrone; other species take its place.

Description of the Species.

Pleurotomaria Moorei, n. sp. Plate I. fig. 1.

Turbinate, conical, transversely ribbed; last whorl longer than the spire of four or five whorls, which are somewhat flattened; it has three ribs above the band, and an angle a little below it, from thence the base is smooth and flattened; umbilicus none?; band a little prominent, narrow, placed a little above the suture, which is hardly channeled; mouth rounded, and a little produced below; shell rather thick.

This is presumed to be a Pleurotomaria, from general analogy and the appearance of a band, but the lines of growth are not visible on our specimen, which is much worn, and has part of the last whorl broken away; the shell when perfect must have been 2 inches long. In general shape and proportion exceedingly like an undescribed Ludlow species, but with the band narrower and not close to the suture, and the ribs less numerous.

Loc. Lower Silurian limestone, Stincher River, Ayrshire.

Pleurotomaria latifasciata, Portlock?

Syn. *Schizostoma latifasciatum*, Portl. Geol. Rep. Pl. XXX. fig. 4.

Our specimen is only a cast, and may be the same as Portlock's species; the shape of the whorls is very similar.

Loc. Limestone of the Stincher River, Ayrshire.

Murchisonia scalaris, n. sp. Plate I. fig. 2.

Only internal casts, supposed to be the same as a common Bala species; the regular sharp angle in the middle of each whorl, and the elongate shape enable us easily to recognise it.

Loc. Limestone, Stincher River, Ayrshire.

N.B. The exterior of perfect specimens shows the band of the genus along the angle, and the fine striæ curve back to it and return again. Hall in the 'Palæontology of New York' has figured many species of this group of shells, and our shell may possibly be one of them; it can only be named provisionally.

Euomphalus? ———, reversed species. Plate I. fig. 3.

Sections and fragments of this curious shell, badly preserved, are not uncommon in the impure limestone. We have only the internal cast; the shell must have been thick, from the interval between the much-depressed whorls, which are flattened above, abruptly rounded or even squarish on the edge; and the base, as far as we can see, is again flat, so that the shell is nearly discoid. There are no traces of septa, nor are the whorls really free. It has some resemblance to *Maclurea magna*, Hall, Palæontology of New York.

Loc. Greenish muddy limestone, Stincher River.

ORTHIS CONFINIS, n. sp. Plate I. fig. 4.

Rectangular, transverse, flattened, irregularly and coarsely striated; dorsal valve a little more convex, slightly channeled or depressed down the central line; area narrow, vertical; ventral valve with a slight angular ridge down the middle; area moderate, oblique; beak scarcely projecting; ribs in both valves numerous, irregularly increasing in number at a short distance from the beak, and often fasciculate in twos or threes, *narrower than the interstices, which are smooth* and not crossed by any lines of growth.

The slight depth of the central channel, sometimes hardly visible, readily distinguishes our shell from *O. vespertilio*, which in the fasciculation of the striæ and general form it resembles; but the ribs in that are more numerous, closer, and broader than the interstices. We have no specimens to show internal structure.

Loc. Limestone of the Stincher River, Ayrshire.

ILLÆNUS DAVISII (Salt. in Sedgwick *ined.*).

Although pretty certain that the few segments of the body we possess belong to the species common in the Bala limestone, it would be out of place to give its characters here. Possibly the fragments may be *I. Bowmanni*, Mem. Geol. Survey, vol. ii. pt. 1, but the segments appear narrower, and therefore more like the Bala species.

Loc. Limestone of Stincher River, Ayrshire.

Fossils of the Slates of LOCH RYAN *and Coast of* WIGTOWNSHIRE.

EUOMPHALUS? FURCATUS, M'Coy.

SYN. *E. furcatus*, M'Coy, Sil. Foss. Ireland, pl. 1. fig. 11 (icon. mala).

An impression of the upper side of the last whorl of a species characteristic of the Lower Silurian shales of S. Wales and Wexford; it differs a little however, for the lines of growth are not sharply raised as in the Welsh fossil, a difference possibly due to the greater compression of the slate, or perhaps to this being a cast of the upper side. The Welsh specimens show only the base of the shell.

Loc. In reddish slate with Graptolites, Loch Ryan.

GRAPTOLITES FOLIŬM, Hisinger. Plate I. fig. 5.

Lower portion or stem linear, strongly dentate below, with teeth as broad as they are prominent; upper portion much broader, obtuse, serrated, with close narrow teeth projecting forwards, [the whole flat, with no projection at the midrib, and very thin and membranous?].

Although Hisinger's figure is so short, it is probably a fragment of the above-described fossil, very common in Lower Silurian shales. The state of preservation in which it is found, on the faces of fine slates, makes it unlikely we shall be able to get at the thickness, texture, or minute structure; indeed it was probably rather membranous than corneous.

Loc. Black slate, Loch Ryan; red slate, Loch Ryan.

G. PRISTIS, Hisinger ?, Plate I. fig. 6.

SYN. *G. pristis*, Portlock, Geol. Rep. pl. 19. figs. 10 & 11.

Our specimen is the base of the stem, and has not yet the serratures distinctly marked; this is also the case with some of Portlock's specimens.

Loc. Red slate, Loch Ryan.

G. PRISTIS var. FOLIACEUS, Portlock.

SYN. *G. pristis*, var. *foliaceus*, Portlock, Geol. Rep. pl. 19. fig. 9 *a*.

Loc. Black slate, Wigtownshire.

G. RAMOSUS, Hall, Plate I. fig. 7.

SYN. *G. ramosus*, Hall, Paleont. New York, pl. 73. fig. 3.

Axis cleft, the branches divergent and bearing polype-cells on the outer edge only. I should be disposed to refer this to *G. pristis*, for the unbranched portion is much like it, and such a monstrosity does not seem unlikely in so thin a plate, with a double series of cells. We have two specimens affected in this way, and another species mentioned afterwards.

Loc. Red slate, Loch Ryan.

G. TÆNIA, Sowerby and Salter, n. sp. Plate I. fig. 8.

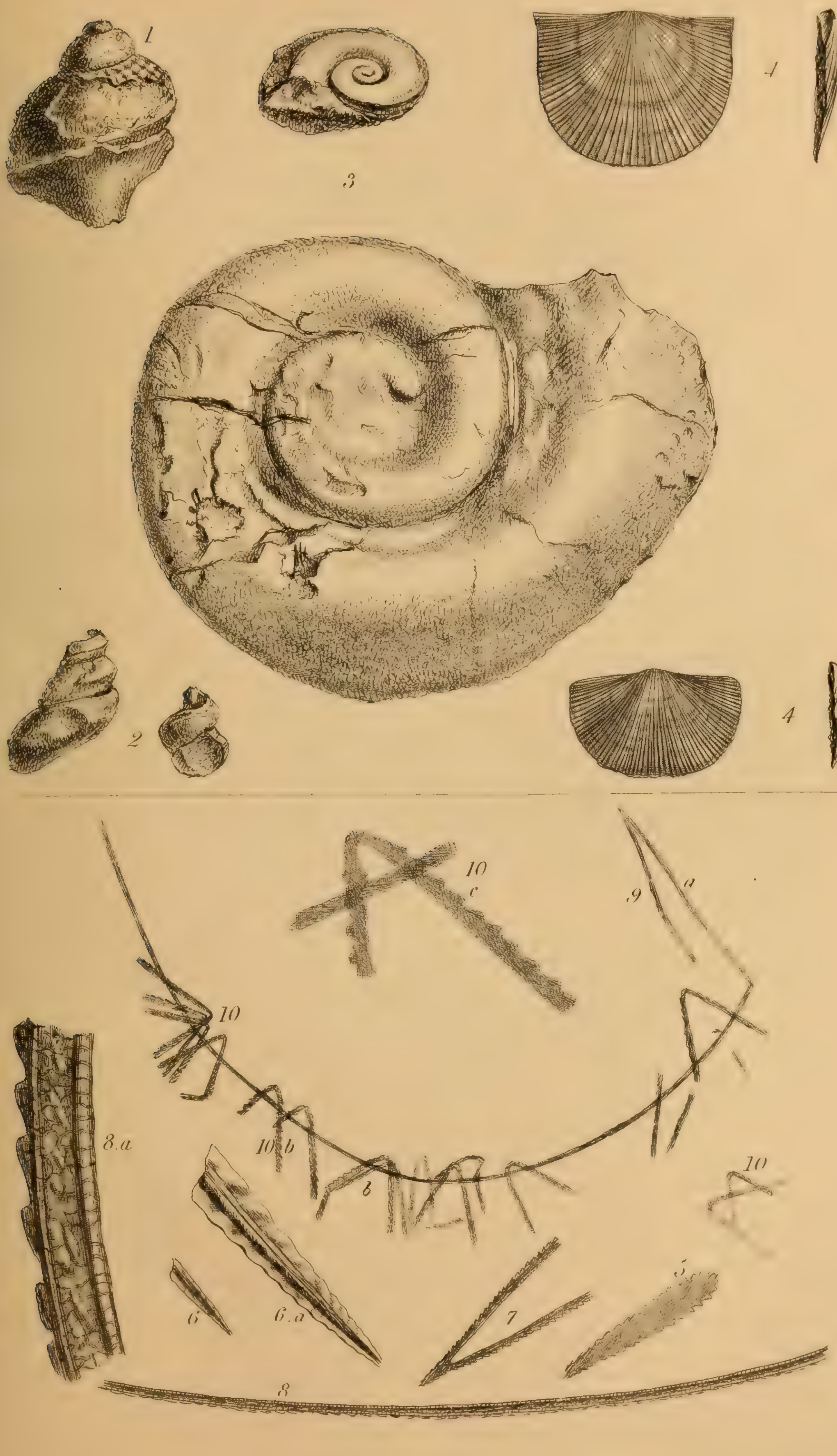
Linear, very long; axis lateral, slightly thickened; a thickened rib runs along the opposite edge, and the teeth or polype-cells project very little beyond it; they are appressed along the edge, probably on one of the flat sides, the teeth scarcely projecting; two cells together longer than the stem is broad; stem reticulate, the axis crossed by sharp close striæ; a short rib descends obliquely from the top of each cell to the middle of the stem opposite the next cell.

The last-mentioned ridge may mark the inner boundary of the polype-cell, which projects so little in this pretty species, and is therefore very likely seated upon the flat side. Our specimen, if this be the case, shows the barren side: the longitudinal thickening along the polype-bearing edge is very curious; it may be occasioned by the superior strength of the cells resisting pressure.

Loc. Black slate, Wigtownshire.

G. TENUIS, Portlock? Plate I. fig. 9—*a*.

A specimen supposed to belong to this species, 6 inches long, is bent and broken; the entire part, 4 inches long, is bent into a strong curve; and upon the belly of the curve are hooked eighteen specimens of a small two-branched Graptolite, with teeth outside; they were evidently caught on each other while drifting. At first sight these small Graptolites appear as if they were straight ones caught upon the long stem, and folded or bent double by the current, but a closer examination shows they are forked at the same or nearly the same angle of 50°, and one or two lying by themselves on the same slab are of the same form; those which do show the teeth distinctly have them on the outer edges. The species appears to be the same as that described by Hall as *G. sextans*.



J. De C. Sowerby. fecit.

G. SEXTANS, Hall, Plate I. fig. 10, *b*, *c*, magnified.
SYN. *G. sextans*, Hall, Paleont. New York, pl. 74. fig. 3.

Small, thin, rounded at the base, and branched directly from it at an angle of 45° or 50°, and with broad teeth outside; the depth of the teeth almost as great as the width of the shaft.

Nineteen or twenty specimens on one slab present the same characters.

This is a new form, and it is a more simple variation of the two-edged Graptolites than those with teeth on the inner sides, in which the splitting of the axis does not seem so intelligible. Our specimens are very ill-preserved, and were probably very thin.

Loc. Black slate, west of Wigtownshire.

---

3. *On Scratched Boulders.*

By JAMES SMITH, Esq., F.R.S.L.&E., F.G.S.

PART I.

[Read April 19, 1848.]

THERE are two modes by which we may suppose that boulders have been scratched; they may have been held fast in a fixed position whilst some hard substance passed over them, or they may have been entangled in the under surface of a moving body, such as an iceberg or glacier, and dragged over rocks, which would thus also be scratched.

I cannot doubt but that both these causes have contributed to the production of the phænomena in question. The instances to which I mean at present to call the attention of the Society belong to the former class—the boulders have been stationary whilst the scratching body, whatever it was, passed over them.

In a former communication* I stated, that I had observed, on the shores of the Gare Loch in Dunbartonshire, two boulders half imbedded in the till or diluvial covering, both of them grooved in the same direction, from N.N.W. to S.S.E., and concluded that it was not probable that the parallelism was accidental: subsequent observations have fully confirmed this conjecture. In the following year Mr. Maclaren of Edinburgh discovered rocks on both sides of the Gare Loch, which were grooved in the same direction as the above-mentioned boulders: I have since had an opportunity of confirming his observations and of discovering additional instances, some of them in the immediate vicinity of the two boulders. I have also discovered several additional scratched boulders, and in every case the direction of the scratches is the same. As this is also the direction of the axis of the valley which forms the trough of the Gare Loch, Mr. Maclaren concludes that they have been caused by a glacier, which formerly filled it.

Whatever was the cause, it must have been subsequent to the deposition of the till at least in this locality. We must be careful therefore not to confound the two phænomena, and conclude that these

* Read June 4, 1845.

boulders were transported by the moving body which produced the scratches.

From the difficulty, if not impossibility, of accounting for these furrows except by glacial agency, and from the marked resemblance which the till bears to the moraines left by ancient glaciers in Switzerland, it has been concluded that the cause of both deposits was the same. A careful examination of the Swiss moraines, however, satisfied me that they are essentially different. We have in both cases a confused assemblage of fragments of rock and earthy matter thrown together without regard to gravity, and in both cases the erratic blocks are found to have come in a certain direction ; so far the resemblance is complete : but in Scotland we find that the blocks become rounded, and diminish in size as they recede from the parent rock : in ancient moraines they do neither : there is nothing in fact, either in glaciers or in icebergs, to round the blocks they bear along with them, or to reduce them in size. The conditions therefore required, before we can admit that blocks have been transported by glaciers, are, angularity, a given direction, and no apparent diminution in size. Those which have fallen from icebergs ought to have the same characters, except as to definite direction; they ought also to be superficial. It appears to me, that the phænomena presented by the till could only be produced by the tumultuary and transient action of water.

Supposing this to be the case, could blocks impelled by a sudden rush, such as an earthquake-wave, produce the scratches? Without denying the possibility of their doing so in any case, I do not consider it possible in the present one—the striæ are too regular. A rock in the immediate neighbourhood of the above-mentioned boulders may truly be called a "*roche polie* ;" and in one place there is a furrow eighteen inches broad and six inches deep, which could not possibly be caused by a rolling mass.

The scratched rocks pass under the sea ; I do not however consider this as a proof of the recentness of the scratching process, but of a recent subsidence of the land.

Part II.

[Read May 17, 1848.]

Although I have not attempted to explain the particular phænomena described in the former part of this paper, I think it must be admitted, that the scratches and furrows on rocks and boulders must in many instances be ascribed to glacial action either in the shape of icebergs or glaciers.

If we suppose that the temperature of Great Britain was as low at the period to which we must ascribe them, as it is in other quarters of the globe at present, under correspondent latitudes,—and there is no antecedent improbability in the supposition,—then ice under both forms must have been in action. Let us inquire what would be the effects of such a state of things? In a period of geological repose, glaciers would scratch the rocks on the sides and bottoms of their valleys, moraines would be deposited, and fragments of rocks, detached from the shores and resting upon, or entangled in the coast ice, would be carried out to sea and dropt on its bottom at different depths ; but in this case the blocks would be found at lower levels than the rocks from which they were detached.

Mr. Darwin in a late paper has however shown, that boulders frequently occur at a level considerably higher than their parent rocks, and has accounted for it by supposing that they were floated to their present position by ice during a movement of depression of the land.

Now we have, in the superficial beds in the basin of the Clyde, evidences of such a movement which must have taken place in the period when the climate was colder than at present, and which if not paroxysmal was sufficiently rapid to have entombed alive the testaceous inhabitants of the sea, and to have covered them up to a considerable depth with beds of finely laminated clay, which could only have been formed at the bottom of the sea. It is obvious that such a movement must have had the effects ascribed to it by Mr. Darwin.

In former communications I have shown, that the elevated marine deposits in the superficial beds in this locality belong to two distinct epochs, namely the newer pliocene or pleistocene, in which there is a perceptible change in the fauna, and the post-pliocene, in which the marine remains agree with those of our present seas.

In the newer pliocene beds, the shells which are recent, but unknown in the British seas, have all been found in the Arctic seas ; here then we have evidence of a colder climate, and can thus account for the presence of ice upon our shores. Now it is in these beds that the proofs of depression occur. Beds of littoral and sublittoral shells, such as the *Mytilus edulis*, are found to underlie beds of laminated clay totally destitute of organic remains, which are sometimes thirty feet in thickness, and seldom less than ten, except in cases where they have been removed by the subsequent wasting action of the sea.

In the shelly beds, the shells are generally speaking *in situ* ; the bivalves with both valves adherent, still covered with epidermis, and the borers in their vertical position. As there is no gradation from beds in which the animals must have been alive when they were covered up, to others totally destitute of organic remains, we cannot ascribe their absence in the latter to the gradual process of decay, but to an entire change of conditions, and that change must have taken place with a certain degree of rapidity; otherwise the shells would have exhibited some evidences of the lapse of time which occurred between the time when the animals were alive, and that in which they were covered up.

Under these circumstances, the ice upon the shores must have been floated to a higher level, and with it the fragments of rock resting upon it.

I am satisfied therefore that Mr. Darwin has solved one of the numerous difficulties which we encounter, when we attempt to explain the phænomena of the erratic block beds.

The same cause would also account for the position of the superficial boulders, which must in many cases have been brought into their present situations subsequently to the deposition of the till.

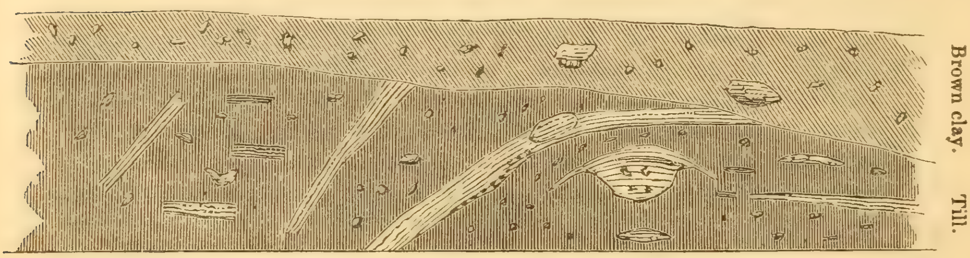
---

4. *Observations on the Recent Formations in the Vicinity of* EDINBURGH. By JAMES NICOL, F.R.S.E., Ass. Sec. Geol. Soc.

THE late discussions relative to the transportal of erratic blocks and the formation of the connected deposits having induced me to believe that the following observations may not be without interest, I now venture to bring them before the Society. They do not pretend to give any general view of the district, which has already been very ably done by Mr. Milne, in a memoir in the Transactions of the Royal Society of Edinburgh, but merely describe a few facts and sections which I have observed at different times.

The lowest of the recent formations in the immediate neighbourhood of Edinburgh is the blue or blackish coloured boulder clay, known under the name of the 'Till.' In some other places the till rests on beds of stratified sand seldom more than five or six feet thick; but in one place, where exposed in a cutting on the Hawick railway, about twelve miles south of Edinburgh, more than ten times that depth. The till is usually regarded as showing no marks of stratification, and hence has been described as originating in some violent and sudden action, unlike any now apparent on the globe. The following sections (figs. 1, 2, 3), which were exposed during the

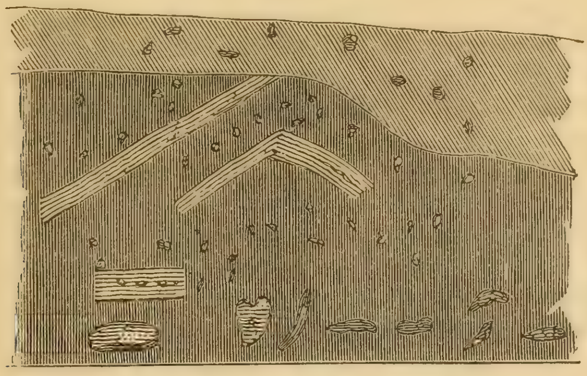
Fig. 1.



formation of the railway from Edinburgh to Leith, show that this view of the nature of the deposits is only partially true, and consequently that the above theory of its mode of origin cannot be maintained. In these sections it will be seen that the blue clay or till contains beds of yellow sand deposited in layers. These beds of sand are very irregular in their extent and in the direction of their lamination. In one section (fig. 2) a portion of the sand is bent over, forming an apparent anticlinal axis. This appearance however I regard as produced during deposition, and not as the result of any subsequent change. In other places the sand forms small nests, or detached masses in the clay, also proving its deposition by local and variable causes, and not by any general rush of waters, which would have mixed up the sand and clay in one confused mass.

In the clay many boulders occur, from a few ounces to several tons in weight, and generally derived from trap, sandstone, or limestone rocks, like those composing the coal-field on which it rests.

Fig. 2.



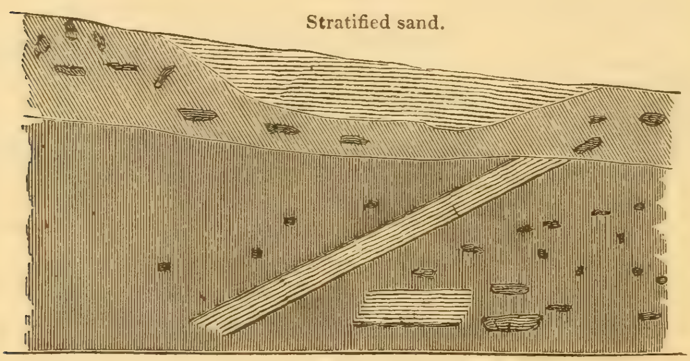
Some of these boulders however consist of granite, mica-slate or other primary strata, and must consequently have been carried a greater distance, as none of these rocks are found nearer than from forty-five to fifty miles, and granite in any quantity only at seventy miles' distance. These boulders are generally rounded and water-worn, but some on the contrary are angular. They are found in every part of the mass of blue clay, but, as it seemed to me, in more abundance in certain portions, and apparently arranged in horizontal lines.

These facts appear to prove that the deposition of this boulder clay or till was gradual,—the effect of long-continued and variable agents ; and not of a sudden rush of water, or debacle, as has been imagined. The whole phænomena seem more consistent with the supposition that the clay was formed by the continuous action of the sea on the various strata of the subjacent coal-field, than with any other theory. The blue clay forming the great bulk of the till may be regarded as merely the decomposed shales of the coal formation, and the sands as comminuted sandstones : even the relative position of the deposits, with the blue clay below, and a browner and more sandy clay resting upon it, as seen in the sections, favours this opinion. The soft shales when exposed to the action of the waves would be wasted away before the harder sandstones and trap rocks, and the deposit formed from their destruction would consequently occupy a lower position. The boulders may have been brought to the place where we now find them by ice, or entangled in the roots of floating trees, or in any other mode now in action for the transport of rock masses. Though mixed up irregularly with the mass of clay, it is by no means necessary that they should have been always transported along with it or by the same agent. Were a number of boulders at the present day dropped on a mass of soft semifluid clay at the bottom of the sea, they would not remain on the surface, but sink in it to various depths, and thus appear to have been deposited by the same agents, when in reality they were deposited by wholly different causes. Neither does the apparent want of stratification in the clay prove it to have been deposited simultaneously, or in a violent manner, as this is a common character in all mud formations.

In the sections now exhibited, the brown clay rests on a pretty even surface of the till. In some other places however there was proof that the till had been exposed to erosive action before the deposition of the immediately superior formation. In many places it was worn into hollows, as if part of it had been removed by the action of water: one of these hollows was very remarkable, being about five or six feet wide by three or four deep, and closely resembled the channel of a small stream. It was also filled with gravel and sand, in all respects like that found in such a stream at present. It was seen with the same characters on both sides of the cutting, but how far it continued beyond could not be known. I had no doubt that it had been formed by some stream of running water, which, if we suppose the till deposited in the sea, would imply that it had been elevated and again depressed for the deposit of the superior beds. This elevation of the till to the surface, permitting the action of the atmosphere on any shells or other remains contained in it, may perhaps account for the rarity or rather entire absence of fossils in this deposit.

The second subject which I should wish to notice has reference to the transport of erratic blocks. As already stated, this has begun even in the earliest period, during the deposition of the till, and has continued down to the most recent. They occur in the brown clay represented in the sections resting on the till, and in a higher deposit of gravel and boulders which often covers the deposit of fine stratified sand seen filling a hollow in the brown clay in section fig. 3.

Fig. 3.



They are frequently found lying completely exposed on the surface, and in this case may never have been buried in any of the subjacent deposits. Boulders of trap rocks are by far the most common, but with them are many fragments of sandstone, limestone, and even of coal, and a few also of primary rocks. I have found the latter over every part of the coal-field, and far up the sides of the transition mountains that bound it on the south: even in the centre of that chain, in the valley of the Tweed, boulders of primary rocks, though rare, occasionally occur. The most remarkable accumulation of them is however on the Pentland Hills, that range of mountains seeming to have stopped many of them in their journey to the south. Some of the boulders found on these hills are remarkable for their size. One angular block of mica-slate seen near Habbie's How, resting on the declivity of the hill, according to a measurement I made, would weigh six or eight tons. Further west I found another block, also angular, of the same rock, which would weigh about three-quarters of a ton. When it is considered that these masses must have been carried upwards of forty miles in a direct line, floating ice seems the only agent to which their transport can be ascribed. Blocks of a smaller size are very common, and of a great variety of kinds, some indeed of a mineralogical character, which is unlike any fixed rock I have ever observed or seen described in Scotland. On one hill 1500 to 1600 feet high, I found these travelled stones particularly abundant, and apparently increasing in numbers from below upwards. In some places they appeared to form as it were broad bands running nearly in straight lines from N.N.W. to S.S.E., and without any reference to the present declivity of the ground, except that they became more numerous towards the summit of the ridge. These blocks consisted chiefly of trap rocks, especially basalt, the hill on which they rested being a red felspar or claystone porphyry. Many were of sandstone, sometimes rounded, but more often in angular masses, one block measuring six feet long, five broad, and three feet thick, and consequently weighing about six tons. This mass was lying on the side of the hill facing the south, so that any current from the north, which had propelled it thus far, would in all probability have also rolled it to the bottom of the hill.

These sandstone and trap boulders lie at an elevation above the great mass of the similar rocks in the surrounding country. There may be a few points of sandstone and trap at nearly the same height, but only six or eight miles distant, and I do not believe that the great variety of trap rocks found on the top of this hill could be collected except from places now several hundred feet lower. This therefore forms a good instance of the class of facts which Mr. Darwin's theory, lately proposed to the Society*, was intended to explain. But it is also one of those cases in which that theory has particular difficulties to contend with. Were the surrounding country sunk in the ocean to the level of these blocks, the chain of hills on which they rest would form only a few widely scattered islands in the midst of a broad arm of the sea, extending from the Grampian mountains on the north to the Lammermuir range on the south. The blocks would thus be exposed to constant danger of being carried off from the land every time they were floated by the ice, and from the great declivity of the mountain sides, would, if dropped only fifty or a hundred yards from the shore, fall into water so deep that no iceberg could ever again pick them up. But there is another difficulty which the theory has in this case to contend with. On the flat summit of one of the transition mountains to the south, whose height is usually

* Since published in Quart. Journ. Geol. Soc. vol. iv. pp. 315–323.

stated at 2200 feet above the sea, I have found rolled quartz pebbles and other proofs of aqueous action. There seems thus no doubt that, supposing the land uniformly depressed, the whole range of the Pentlands, and the hill with these boulders on it, along with the others, must have been submerged. Now if coast-ice could carry the boulders up to the top of the hill during its gradual subsidence, it should also have lifted them off the top of the hill when it was finally submerged. There seems no reason why the ice should continue to raise the blocks just so far as the summit of the hill, and then cease to have this elevatory power.

The theory which I should substitute in place of this most ingenious one, is that of unequal elevation in different parts of the land. That this has taken place to a very considerable extent, the phænomena of the surrounding district most distinctly prove. We now find portions of strata, which there is every reason to believe were once continuous, separated by many hundred feet of vertical elevation: the workings in the surrounding coal-field prove this most emphatically. In the memoir on the Mid-Lothian coal-field already referred to, Mr. Milne enumerates fifty-two slips raising the strata to the south 5169 feet, and thirty-seven others which raise them 2412 feet in the opposite direction; the most extensive slip having thrown the strata 400 to 500 feet down to the north. In the coal-fields on the north of the Firth of Forth slips are no less numerous, but there those elevating the strata to the north preponderate, producing a difference of 1164 feet in twelve miles. A single fault in the eastern part of Fife amounts to 600 feet, and in the Clackmannan coal-field two slips are known, one of 700, the other of 1230 feet; all of them raising the strata on the north. The difference of elevation indicated by these faults seems sufficient to account for boulders having been transported from what is now a lower to a higher level.

The strongest objection to this mode of explaining the transportal of boulders from lower to higher levels seems to be, that we see no traces of unequal elevation on the present surface of the ground. But this objection leaves out of view the important changes which must have taken place on the surface since the land was raised above the ocean, and especially those connected with that process. During these changes, many inequalities which once existed must have been smoothed down, covered over, and obliterated, so that scarce a trace of them now remains; the effect of the last change being always to destroy the marks of those that preceded it. But if we suppose that the elevation of our present continents resembled that which we know is now taking place in Scandinavia, where one end as it were of a lever is rising, whilst the other remains stationary or sinks, we may have a very great amount of unequal elevation without any break in the continuity of the strata, or any proof of its having occurred being left on the surface of the dry land. A difference of angular motion amounting to one degree, producing an inclination so small as to be imperceptible to the eye, would be sufficient to account for the whole phænomenon. Were the country between London and Anglesea subjected to such a twist, we should have that island sunk 20,000 feet below the ocean. To explain the phænomena, therefore, of the apparent transport of boulders from a lower to a higher level, it is only necessary to suppose that the land during its repeated elevations and depressions was subjected to a slight angular motion, and the whole difficulty is removed. Now, setting aside the case of Northern Europe, where we know from actual measurements that such a movement takes place, and the instances of earthquake elevation in which it has also been supposed to occur, such a kind of motion seems more probable than the elevation of whole continental masses in an exactly vertical direction. To produce the latter, the elevating power must act with equal intensity below every part of the surface, and everywhere experience a uniform resistance; or the one of these powers be everywhere exactly proportioned to the other; neither of them suppositions at all likely to be realized on a mass composed of such various materials as the crust of the earth.

May 31, 1848.

H. Wedgwood, Esq. and T. Brown, Esq. were elected Fellows.

The following communications were read:—

1. *On the Colouring Matter of Red Sandstones and of Greyish and White Beds associated with them.* By John William Dawson, Esq.

[Communicated by Sir Charles Lyell, V.P.G.S.]

The appearance at certain points of the series of stratified deposits of red sandstones and other rocks coloured by the peroxide of iron, in regions where the older formations contain comparatively few red beds, is a fact observed in many countries; and in some cases these red deposits are associated with rocks of more neutral tints, whose colours appear to be due to chemical changes which have affected portions of the red sediment. These phænomena, though often noticed, scarcely seem to be thoroughly understood either in reference to their causes or to the inferences which may be drawn from them. In the present paper I propose to state some facts in the geology of Nova Scotia which appear to be connected with the first appearance of red strata in that country, and which may perhaps admit of a more general application; and also to notice some changes now taking place in recent sedimentary deposits, which may explain the occurrence of occasional grey, greenish and white beds in formations whose prevailing colour is red.

In Nova Scotia, red conglomerates, sandstones and clays predominate for the first time in the lower part of the carboniferous system; and it is to this lower carboniferous series chiefly that the following remarks are intended to apply, though red beds continue to prevail in the newer carboniferous deposits and also in an overlying formation of red sandstone. The red colouring matter, which is the peroxide of iron, is in a very fine state of division, having indeed rather the aspect of a chemical precipitate than of a substance triturated mechanically. In the clays and shales it is usually very uniformly diffused through the mass; in the sandstones and conglomerates it is principally contained in the argillaceous matter which occupies the interstices of the sand and pebbles, and it also stains the surfaces of these fragments. In addition to the oxide of iron distributed through the beds, there is in the fissures traversing them, a considerable quantity of the same substance in the state of brown hæmatite and red ochre, as if the colouring matter had been superabundant, or had been in part removed and accumulated in these veins. Though the greater part of the thickness of the lower carboniferous series consists of reddish beds, there are many subordinate strata and minor groups of beds from which the red oxide of iron is entirely absent. These uncoloured beds are of three kinds. First, grey and dark sandstones and shales, consisting of detrital matter similar to that of the red beds. In some of these scarcely any ferruginous matter is present, in others there are small quantities of the carbonate and sulphuret of iron. Where these grey and dark beds appear in any considerable thickness, they always contain either fossil plants, bituminous matter or thin seams of coal, or all of these; and even in thin and isolated layers of this description, vegetable remains are often present. For reasons to be stated in the sequel, I believe that the presence of this organic matter is the cause of the absence of red colour in these cases, and I am also disposed to extend the same explanation to certain marly beds and blotched and variegated sandstones in which vegetable matter does not appear. The second class of uncoloured beds consists of limestones, of which there are several thick beds appearing in a great number of places. These beds are very rarely coloured by oxide of iron, and the few that are so contain also a little sand and other detrital matter. Many of the limestones are made up of unbroken shells and corals, others show under the microscope that they consist of shelly fragments, and a few are laminated and crystalline, and may have been deposited by water holding the bicarbonate of lime in solution. Limestones of all these three kinds occasionally contain bituminous matter. These beds of limestone certainly mark long intervals in the deposition of detrital matter in the localities where they occur; and though the absence of red oxide of iron may be in part due to the influence of putrefying organic matter, it also indicates that the causes which produced the red colour were connected with those which accumulated sand and other detritus, and were not in active operation during those intervals when shells and corals flourished. The third kind of beds destitute of red colour consist of gypsum, which in this formation forms thick and conformable strata. These are generally very pure and colourless; a few however are blackened by bituminous matter, and I have seen one containing sufficient red oxide of iron to give it a light flesh-colour. The comparative absence of detrital matter from the gypsum, its constant crystalline texture and its want of fossils, clearly indicate that it is a chemical deposit; and the same circumstances, in connection with its regular stratification and association with marine limestones, render it probable that it originated from the action of free sulphuric acid on the calcareous matter previously accumulated in the seas of the period. This view must also be extended to the anhydrite, which occurs in layers associated with the common gypsum, since its relations entirely preclude the suppositions that it can be gypsum altered by heat, or that it can have been produced by acid vapours passing through limestone; I am not however aware under what circumstances anhydrite could be chemically deposited from water. In the series of formations found in Nova Scotia, gypsum as well as red sandstone appears for the first time in the lower carboniferous series, and it will soon appear that this simultaneous development on a great scale of red oxide of iron and sulphuric acid may not be accidental.

We may next endeavour to ascertain the sources from which the materials of the rocks above-noticed have been derived. In the carboniferous period, the Silurian, metamorphic and hypogene rocks seem already in Nova Scotia to have formed ridges traversing and separating the basins in which the newer strata were deposited, and furnishing large quantities of detritus which can easily be recognised in the carboniferous conglomerates, sandstones and shales, and indeed constitutes the mass of these beds. The limestones have evidently resulted from the growth of shells and corals *in situ*; and the gypsum is also of local origin, since it can scarcely be supposed that, at the period of its formation, the sea was charged either with sulphuric acid or sulphate of lime, over wide areas, while it is highly probable that these substances, if brought from the land or the bottom of the sea, would produce beds of gypsum in the vicinity of the places whence they were derived. It thus appears that the materials of the lower carboniferous rocks have in general been obtained from the older formations the remains of which are still seen in their vicinity, and we may therefore expect to find, in the same older formations, the sources of the red colouring matter. If in accordance with this view we examine the Silurian and metamorphic rocks, it at once becomes apparent that the red oxide of iron cannot be attributed to the degradation of red-coloured rocks, since these form a very trifling proportion of the older formations. Neither can this colouring matter be attributed to the mechanical trituration of iron ores, since though large deposits of specular iron ore exist in the Silurian system, this mineral is too hard and intractable to have furnished the finely-divided colouring matter of the red sandstones and shales. It is also worthy of notice, in reference to this iron ore of the Silurian system, that the greater part of it occurs in the form of thick beds, abounding in fossil shells, and which seem to have been produced by the deposition of iron ore in the state of sand or scales derived from the waste of older deposits; it cannot therefore have been, at the time of the formation of the carboniferous strata, in a state very different from that in which it is at present found. The remainder of the peroxide of iron of the Silurian system occurs in irregular veins traversing altered rocks, and is generally crystalline, though in some places accompanied by earthy red ore capable of having acted as a colouring matter. The only other form in which large quantities of iron occur in the Silurian and metamorphic rocks, is that of the bisulphuret of iron or iron pyrites, which is very abundantly contained in these rocks, and to the decomposition of which I believe the red colours of the derived deposits should be mainly attributed.

It can scarcely be unfair to assume that the immense masses of the older formations which have been worn down to furnish the materials of the carboniferous beds, contained proportionally as large quantities of iron pyrites as those portions which remain. We may therefore proceed to inquire respecting the changes which this mineral probably suffered, before or during the degradation of these rocks. Under ordinary atmospheric influences, iron pyrites passes by oxidation into sulphate of iron and hydrous peroxide of iron, and much of it is now, and probably has been in all past periods, undergoing this change. Under the influence of heat, however, it is capable of undergoing other modifications, of more importance for our present purpose. The formations in which the pyrites in question is contained, have been greatly changed by igneous agents before the carboniferous period; and under such influences this mineral may have been changed in three ways. First, in the deeper parts of the deposits it may have remained chemically unaltered, but may have assumed a more crystalline structure or aggregated itself into grains, masses and veins, as it now appears in the remaining portions of the metamorphosed deposits. Secondly, in other circumstances, its sulphur might be sublimed, the iron remaining buried in the altered rocks, or, in low states of oxidation, entering into the composition of molten masses. We have no evidence of the occurrence of this change at the period in question, though it probably occurs in many modern volcanos. Thirdly, in the superficial parts of the deposits it would be converted into peroxide of iron and sulphuric acid, or in parts less near the surface, into oxides of iron and sulphuretted hydrogen, and the latter might be subsequently oxidized and converted into sulphuric acid, in passing through moist fissures*. Such processes, especially if carried on in the presence of water, would produce large quantities of the peroxide of iron, and would probably stain with it all the superficial parts of the deposits subjected to their influence. It is not always easy to understand the precise effects which may be produced in nature on the large scale by the application even of familiar chemical agents; but in this case, I think the results of the artificial oxidation of iron pyrites, by the combined influences of heat and water or heat and air, are sufficient to convince any person who can perform even a few simple experiments upon this mineral, or clays in which it is contained, that these processes are at least competent to produce the required effects.

It is evident that the oxide of iron produced in the manner above stated, would naturally accompany the detrital deposits of the period, and it is even possible that the chemical changes which produced it would be accompanied by mechanical disturbances tending to produce large quantities of fragmentary matter. It is also apparent that the sulphuric acid resulting from the decomposition of pyrites would

* This may be imitated by passing the gas through moist porous substances.

speedily find its way to the sea, or might even in some cases be produced in its bottom, and coming into contact with calcareous matter accumulated by shell-fish and madrepores, would be deposited, in combination with lime, in the form of gypsum. There might thus in the seas of the carboniferous period be alternations of organic accumulation and detrital and chemical deposition, producing a formation precisely corresponding with the lower carboniferous series of Nova Scotia, as described in the beginning of this paper.

I do not so far overrate the force of the above remarks, as to suppose that they prove that the oxidation of iron pyrites has been the sole cause of the red colours of sedimentary deposits. They may however lead geologists to inquire if any production of red oxide of iron attends the formation of sulphuric acid in modern volcanic regions,—if in other countries the first appearance of red sandstones and shales is attended with the presence of gypsum or other sulphates, and if the materials of the red beds have been derived from rocks containing iron pyrites. If these circumstances are of general occurrence, they may perhaps show that the cause above referred to is also general.

In the lower carboniferous series of Nova Scotia, there are, as before stated, grey, dark and white beds interstratified with red rocks forming the mass of the deposit; and though the sediment forming these has no doubt in many instances been originally uncoloured, there are other instances in which they appear to have consisted of red sediment deprived of its colour by chemical agents after its deposition. This may have been effected by the agency of organic matter in two ways, the first of which applies more especially to marine, the second to freshwater deposits.

The first consists in a reversal of the process above described, or in the conversion of oxide of iron into sulphuret of the metal. I shortly referred to this change in a paper sent to the Geological Society in 1845, but did not state the facts on which my views were founded. My attention was first directed to this process by observing it actually in progress in the harbour of Pictou. This harbour receives the waters of three rivers and several smaller streams, which in times of flood carry into it large quantities of reddish mud, which sometimes discolours the whole surface. This mud, with similar sediment from the shores of the harbour, is deposited in the bottom, and there undergoes a remarkable change of colour. A portion of old mud recently taken from the bottom is of a dark grey colour, and emits a strong smell of sulphuretted hydrogen. When dried it loses this odour, and its colour is a pure grey without any trace of red. If a piece of the dried mud be heated to incipient redness, it emits a sulphurous odour, and at once resumes the red colour which belonged to the sediment before it was deposited. It thus appears that the iron of the red clay has entered into combination with sulphur, and this is probably obtained from the sulphates contained in the sea-water, by the deoxidizing influence of decaying vegetable matter, the greater part of which seems to be furnished by the eel grass (*Zostera marina*), which grows abundantly on the mud flats. It is evident that this modern deposit is quite analogous to many grey beds of great antiquity, in which sulphuret of iron is mixed with organic matter, and there can be little danger in inferring that the causes in both cases are the same. I may mention, that in some parts of the deposit forming in Pictou harbour, the vegetable matter which has caused the change of colour is so completely decomposed that no visible fragments of it remain. I may also notice in passing, that this mud contains vast numbers of the siliceous coverings of infusoria.

Another modern cause of change of colour in red sands and clays, is the action of acids produced in the putrefaction and decay of moist vegetable matter. This is the usual cause of the whiteness of the subsoils of peat bogs and swamps, and in such places the oxide of iron is often redeposited at the outlet where surplus water escapes from the bog. This process also probably prevailed extensively in the freshwater deposits of former periods, and may have changed the colours of clays and sands, and have collected their colouring matter in bands and nodules of carbonate and hydrous peroxide of iron. Beds bleached in this way of course do not resume their colour when heated.

It is evident that the formation of red sediment and its partial decoloration may have frequently alternated in the same locality, or have occurred at the same time in neighbouring localities; and when viewed in this way, they possess some interest independently of the explanation of the colours of rocks. First, they satisfactorily account for the rarity of fossils in red beds; since both the red oxide of iron and sulphuric acid, when present in the waters, must have been unfavourable to aquatic life; and conversely, wherever organic matter either terrestrial or marine could accumulate, the red colour would be partially removed. Secondly, they show the cause of the almost constant association of large quantities of coal and other vegetable remains with the carbonate and sulphuret of iron. Thirdly, they may in some cases serve to distinguish marine from freshwater deposits; since on the above view, sulphurets would be formed in large quantity where sea water had access to the beds in which vegetable or animal matter was decaying, while carbonates would prevail where fresh water only was present. In some cases, however, the sulphates afforded by springs, or even by river water, might produce a sufficiency of sulphurets to invalidate such inferences. Fourthly, the occurrence of grey beds and patches in red formations may often indicate the former existence of fossils whose forms have perished; and the quantities of iron pyrites found in some ancient non-fossiliferous beds may possibly be an indication of the same kind.

---

2. *Remarks upon the Structure of the Calamite.* By JOHN S. DAWES, Esq., F.G.S., President of the Lit. & Phil. Soc. of Birmingham.

[SINCE this paper was read to the Society, Mr. Dawes has made some further observations upon the structure of this fossil, and its full publication is therefore deferred at his request.]

Mr. Dawes stated, that specimens he had obtained clearly showed that the Calamite as usually met with exhibits merely the interior shape of the woody part of the plant, the supposed leaf-scars at the articulations being the fractured portions of certain large rays of muriform tissue which pass through the ligneous system in a similar manner to what has been observed in the pseudo-vascular sheath of Stigmaria, these rays being connected with verticillate areolæ met with on the exterior of the fossil. The ligneous portion is found in some specimens to occupy about one-half of the diameter, although usually much less. It consists of tubular tissue, which although distinctly scalariform, has nevertheless in the transverse section a radiated structure together with the concentric rings of Exogens; and in addition to the leaf-cords already mentioned, there are numerous fine medullary rays which either alternate with, or intervene, every second or third row of the ligneous or scalariform tissue. He also mentioned, that occasionally the striæ upon these vessels become reticulated, so as to resemble in some respects the Pinites; and again, that there appears to be a further affinity with the latter fossils, and with the Coniferæ generally, for these peculiar markings are usually to be observed only in the direction of the ray. The phragmata at the joints, which have been considered by some writers as probably representing the thickness of the wood, he considers now prove to be merely thin lateral inward extensions of the ligneous system, the converging lines being a continuation of the perpendicular ribs, and having a similar origin; consequently the articulations will not be observed upon the exterior of the plant. With respect to the supposed fistular character of the stem, Mr. Dawes states that he is in possession of sufficient evidence to prove not only that such was not the case, but that, in addition to cellular tissue, there are also indications of vascular bundles within the central column. The specimens he has hitherto met with retaining these tissues are very imperfect, but there are appearances in the arrangement which he regards as showing an affinity with Endogens. This he says we might have been led to expect from certain external characters observed by Messrs. Lindley and Hutton; and thus in all probability these interesting plants of the carboniferous epoch will, he thinks, prove to be a link connecting in some measure the three great classes of the vegetable kingdom.

---

3. *Notice on the Discovery of a* Dragon-fly *and a new species of* Leptolepis *in the* Upper Lias *near* Cheltenham, *with a few remarks on that Formation in* Gloucestershire. By the Rev. P. B. Brodie, M.A., F.G.S.

As I have already described the position and structure of the upper lias and its organic contents in Gloucestershire*, my chief object in the present brief communication is to announce the occurrence of a

* History of the Fossil Insects in the Secondary Rocks of England, p. 55, *et seq.*

nearly perfect *Libellula* and a new species of *Leptolepis* in that deposit, for an account of which I am indebted to the kindness of Mr. Westwood and Sir Philip Egerton.

The upper lias in Gloucestershire is of considerable extent and thickness, and may be traced along the lower escarpments of the Cotswolds between the inferior oolite and the marlstone; owing however to the few sections exposed, the various fossils which it affords have been chiefly obtained from one particular locality. It also caps detached outliers a few miles from this range, and if a line be drawn from the summit of any one of them to a parallel point in the opposite hills, the strata will be found to correspond; and hence we may infer that they were formerly attached to the main chain, the intervening space having been subsequently denuded, though there are few traces of liassic boulders in the adjacent valley. In the two outliers at Churchdown and Robinswood Hill near Gloucester, the upper lias is comparatively thin, the shale resting conformably on the marlstone, scarcely averaging eight feet, and the loose pieces of the "*fish-bed*," not exceeding a few inches, but containing the usual and characteristic fossils*. I have not been able to detect any traces of this stratum further south; at least, its outcrop is not anywhere seen; although the marlstone is largely developed in the neighbourhood of Wotton-under-edge, and the lower lias, especially the "insect limestone," extends over a considerable portion of the vale, and contains some beautiful portions of insects, particularly wings allied apparently to *Phryganea*.

At Dumbleton, twelve miles north-east of Cheltenham, where another and larger outlier is exposed, the upper lias shales are about 150 feet thick, and include an irregular band of limestone, locally termed "the fish-bed," above alluded to, which varies from four to fifteen inches in thickness. It occurs near the lower part of the shale, running at irregular intervals, and here and there forming rounded blocks of some size. The outer surface is soft and of a yellow colour, but towards the interior it becomes hard and assumes a blue tinge. It has an irregular fracture when dry, and as it is readily acted upon by frost, it does not make a good building-stone, though it would burn into lime if required. The clay contains a great many casts of Ammonites and other shells, but the best-preserved and remarkable fossils are confined to this limestone. Of these the insects are perhaps most worthy of notice, though hitherto confined chiefly to single wings and elytra, to which the fine specimen about to be described forms at present a unique exception, and is, as far as I am aware, the first nearly perfect Neuropterous insect found in this country.

Mr. Westwood observes, that "it possesses an arrangement of the wing-veins differing from that of any English species, and also from any foreign species known to me; but it comes nearest to the small British *Libellulæ* forming the genus *Diplax*. The wings are broad and nearly equal. The third and fourth veins of the upper wings are curved towards the inner margin near the base. The stigmata are

* See Mr. Buckman's paper, Proc. Geol. Soc. vol. iv. part i. p. 211.

rhomboidal. The expansion of the fore-wings is about $2\frac{1}{2}$ inches, while the hind-wings have the anal area very slightly developed, much less so even than in our English and far less so than in many exotic species. The expanse of each wing is $7\frac{4}{32}$ inches; the breadth of the upper wings $\frac{11}{32}$ inch, the breadth of the under wings $\frac{9}{32}$ inch. The veins are most beautifully perfect, and are better displayed as the specimen is lying in the matrix with its four wings expanded, like those of the same family from Solenhofen, and must evidently have died under circumstances highly favourable to its preservation. But in order to understand the peculiarity of this fossil *Libellula*, it will be necessary to enter into a little detail as to the general distribution of the veining of the wings in the family to which it belongs; a point which has been hitherto almost entirely neglected.

"Taking *Æshna maculatissima* (Latr.) (*grandis*, Donovan), one of the largest and commonest species of *Libellulidæ*, as a good type, we perceive the arrangement of the chief veins of the FORE-WINGS (fig. B) to be as follows:—

"1. A *subcostal* vein extending from the base, nearly parallel with the fore-margin for half its length, where it joins the margin at an angle.

"2. A *median* vein (behind the subcostal) which extends from the base to the tip of the wing, a small portion of the space between it and the fore-margin being occupied, near the tip of the wing, with the oblong black stigma.

"3. A *submedian* vein, extending from the base to the hind-margin of the wing, about one-third of its length from the tip.

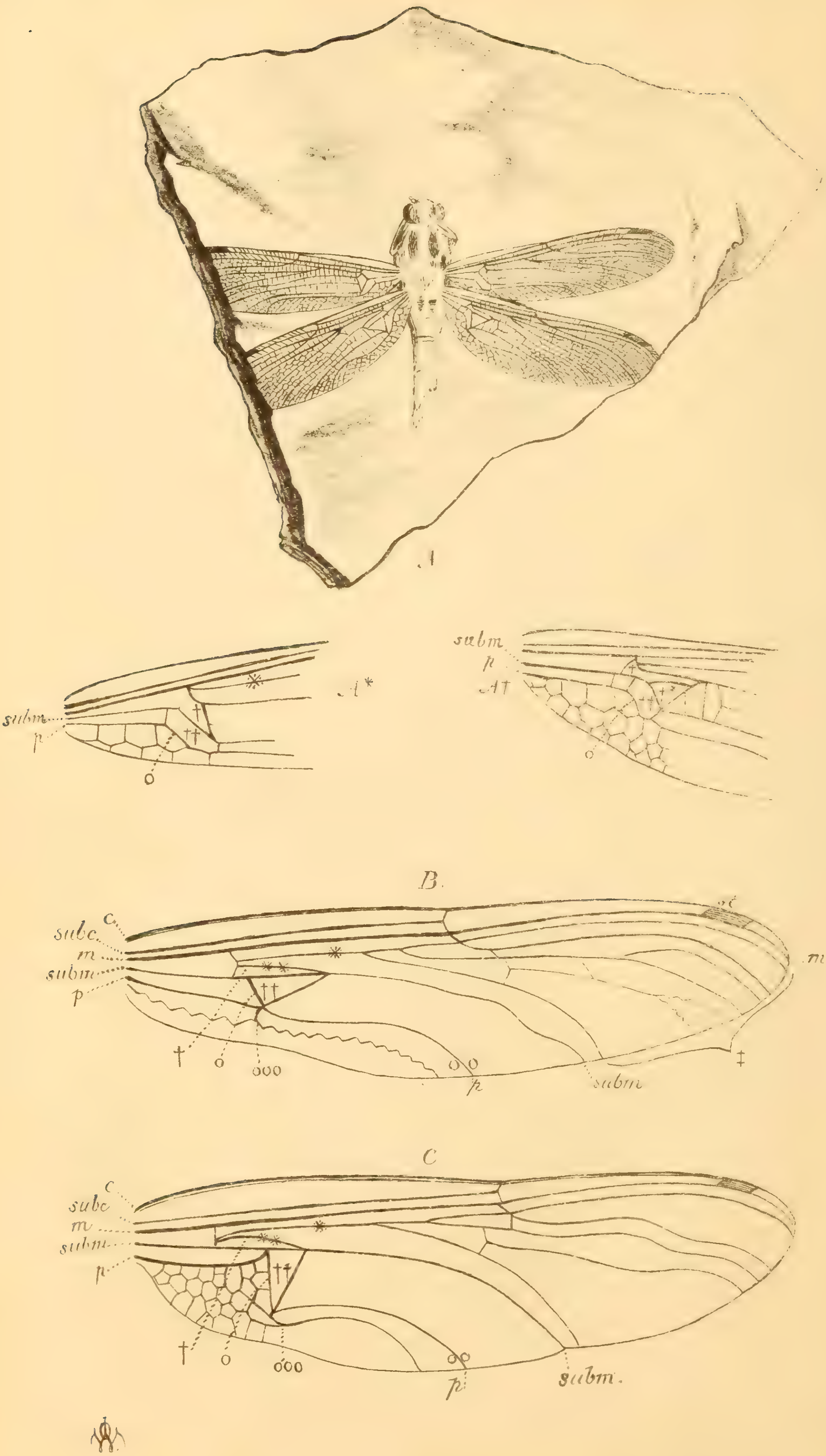
"4. A *posterior* vein which extends from the base to the hind-margin of the wing at about one-third of its length from the base.

"Between the median and submedian veins, there is a short connecting vein at about the distance of one-third of an inch from the base of the wing, and from the middle of this connecting vein a long vein (*) is emitted, the branches of which occupy all the space at the hinder extremity of the wing between the median and submedian veins. There is also emitted a short oblique vein (**) which soon again joins the submedian vein; the space between them forming a long narrow (characteristic) triangle (†).

"I will not here stop to inquire whether the veins emitted from this short transverse connecting vein are to be considered as branches of the median or of the submedian vein, but I believe them to belong to the former. At a distance of about half an inch from the base of the wing, we see another characteristic triangle (††) (extending between the submedian and posterior veins), the apex of this second triangle joining the apex of the former one, and pointing to the tip of the wing. The short base of this triangle is formed by an oblique vein (*o*) between the submedian and posterior veins. We also see a vein (*ooo*) branching off from that angle of the second triangle which is towards the hinder margin of the wing, and which extends almost parallel with the extremity of the posterior vein (*oo*). The hind-wing differs in no respect from the fore-wing in the arrangement of the veins, but the space between the posterior vein and the anal angle of the hind-wing is greatly enlarged.

"If the above description be compared with the veining of the *fore-wing* (fig. c) in the equally common *Libellula depressa*, we find the same general arrangement, as far as the subcostal, median and submedian veins, and the branches between the two latter are concerned. We also see the second characteristic triangle (††) behind the submedian vein, with one of its angles united to the extreme angle of the *first* elongated triangle (†), but here the second triangle is shortened, and its apex instead of pointing to the tip of the wing points to the hind-margin; arising from this apex we see the two curved veins (*oo* and *ooo*) which unite with the hind-margin of the wing about halfway between the tip of the submedian vein and the base. In *Æshna* I have regarded these two curved veins as the extremity of the posterior vein and a branch of it; but in *Libellula depressa* the posterior vein (*p*) is very short, and extends only to the basal angle of the second triangle; whilst if we regard the two curved veins above alluded to as portions of the same posterior vein, we might at first be led to believe that the middle part of this vein had become obsolete; whereas I believe we must from analogy look for it in some of the small veinlets (composing hexagonal cells) between the base of the wing and the transverse vein forming the side of the second triangle nearest to the base of the wing. This is I think rendered quite evident by tracing the veins of the *hind-wings* connected with these triangles in *L. depressa*, where we see precisely the same general arrangement as in *Æshna maculatissima*.

"Now the new fossil insect has an arrangement of the veins in connection with these characteristic triangles quite different from either of the arrangements above described, and which are found in the whole of our *Libellulidæ* (as separated from the *Agriones*, &c.). The subcostal and median veins are in their normal position, but in the fore-wings (A*) the submedian is greatly deflexed, at about one-sixth of an inch from the base, whereby the first elongated triangle (†), which I have above described as extending longitudinally from the little transverse vein, between the median and submedian vein, along the latter, is obliquely deflexed, so as almost exactly to represent the second triangle in *Libellula depressa*. The posterior vein is also deflexed, whereby the smaller veins in connection therewith are thrown so far out of their places that the second triangle (††) takes an oblong-quadrate form. The confusion is still greater in the hind-wings (A †), for here the first elongated triangle (†) occurs in its usual longitudinal form; but there is connected with it between its posterior apical half and the deflexed part of the submedian vein, a regular, nearly equal-sided triangle (†*), which, from being posteriorly bounded by the submedian vein, I consider only as analogically representing a portion of the ordinarily narrow elongated first triangle; whilst the second triangle, which typically occurs between the submedian and posterior veins, or is even sometimes apparent posterior to the posterior vein, here becomes an oblique oblong-quadrate cell (††), between which and



LIBELLULA (HETEROPHLEBIA) DISLOCATA.

the anal margin of the hind-wing are only three rows of cells in consequence of this part of the wing being comparatively so very narrow.

"As these tedious details can only be understood by figures, I have given enlarged outlines of the wings of the three species above described. See Pl. ii. figs. A*, A†, B and C."

The head unfortunately is so shattered that it does not furnish any distinctive characters, and hence, from the want of the more characteristic organs, it will be difficult to determine whether it strictly belongs to any of the numerous subgenera lately separated from *Libellula* by Rambun and Leach. As the extreme segments are not visible, it is impossible to discover the length of the abdomen or the form of the anal appendages. The specimen appears to be a female. The eyes are not seen, but the basal joints of one of the antennæ may be observed attached to the head. One leg is very perfect, even displaying the claws. Although this fossil appears to approach nearest to the genus *Diplax*, Mr. Westwood considers that it will be better to adopt *Libellula* as the generic title: while the peculiar veining of the wings will form the ground for a provisional subgeneric one, which he names *Heterophlebia*. Hence I propose, provisionally, to name it Libellula (Linn.) Heterophlebia dislocata (Brodie)*, Pl. ii.

According to Mr. Westwood, the wing figured in my work on 'Fossil Insects,' pl. 8. fig. 2, is not an *Agrion* as there supposed, but belongs to the same species as the one above described. He is also of opinion that fig. 8. pl. 10. is the base of the fore-wing of an allied species of gigantic size, measuring as much as seven inches in expanse. Fig. 4. pl. 8. may also probably belong to the same.

A few sepiæ, small crustacea and shells accompany these remains of insects, and imperfect specimens of *Leptolepis* are abundant, but they are rarely met with entire. Sir Philip Egerton has been good enough to favour me with the following description of this fish:—

"Leptolepis concentricus, Egerton.

"This distinct and well-marked species of *Leptolepis* was discovered by the Rev. P. B. Brodie† in the beds of the upper lias at Dumbleton in the county of Gloucester. The first specimens forwarded for examination contained a few scales, which, from their circular form and concentric ornament, were considered by some to have belonged to a fish of the Cycloid order; an error in which the zealous discoverer did not participate, as he attributed them to the proper genus. On comparing them with the scales of these fishes already known, it appeared impossible to refer them to any species hitherto described; I therefore proposed the specific designation *concentricus* (which Mr. Brodie has adopted) in reference to their most prominent character. This term is not altogether appropriate, for the scales of all the spe-

* Mr. Ingpen, Vice-President of the Entomological Society, has kindly given me several useful hints in the latter part of the description of this beautiful fossil.

† My friend the Rev. C. Murley was the first person who noticed the remains of fishes in the upper lias at Dumbleton, and he drew my attention to them some years ago.—P. B. B.

cies of *Leptolepis* present the same features. It must therefore be considered in reference only to degree, since in Mr. Brodie's species the sculpturing on the enamelled surface is visible to the unassisted eye, while in the other species a powerful magnifier is required to detect it. The comparative thickness of the scales is perhaps a more important character, for this at once eliminates them from every other species of *Leptolepis*, and even invalidates, to a certain extent, the generic title. The subsequent discovery of more perfect specimens (also submitted to me by Mr. Brodie) has enabled me to confirm the generic identity and specific differences founded on the former specimens, as also to complete in detail the characters of the species.

"The most perfect specimen shows the head and two-thirds of the body, with the position of the ventral and anal fins; another fortunately completes the subject by exhibiting the posterior half of the fish, with the dorsal, ventral and anal fins. This species is about the same length as its nearest ally, *Leptolepis Bronni*, viz. between three and four inches from the snout to the extremity of the tail. The head, however, is proportionally smaller, being less than a fourth, whereas in the former species it is more than a fourth of the entire length. The other dimensions of the head are also smaller, while the depth of the body immediately behind the thoracic cincture is greater; consequently the contour of the body is more regularly fusiform than in *Leptolepis Bronni*, or in any other species of the genus. The opercular and other bones of the head are smooth and lustrous, without any tracery or ornament except the lines of growth. The vertebral column is robust and composed of about thirty-six vertebræ. The hæmapophyses of the six terminal bones are strong and flattened for the support of the rays of the caudal fin. The pectoral fins are of mediocre size, the number of rays not being distinguishable. The ventrals are situate about midway, and are opposed to the dorsal fin, which contains about a dozen rays. The caudal fin is powerful and has this remarkable structure: the rays of the upper lobe are principally supported by the terminal vertebræ, a few short ones only being attached to the penultimate and antepenultimate apophyses; while in the inferior lobe the rays are supported by the processes of the six terminal bones of the column, which are thickened and compressed to give a firmer and broader attachment for this organ. This arrangement of the parts gives a somewhat heterocercal air to the caudal extremity, which also obtains in other species of this genus found in the lias, viz. *Leptolepis Bronni*, *caudalis*, *filipennis*, and an undescribed species I have from the lias of Courcy in France. The zeal of collectors and the progress of modern research have added so largely to the species of many of the genera of fossil fishes, that it will soon be found necessary to eliminate some of the aberrant forms under new generic or subgeneric characters. Should the genus *Leptolepis* come into this category, the form of tail above-described offers an easily appreciable and appropriate feature on which to found a subgeneric distinction . . ."

I have lately traced the upper lias in the south-eastern division of

Somersetshire, where it occupies the same relative position, retains the same mineralogical character, and yields identical fossils. As might be expected, however, in another and more distant portion of the series, there are some genera and several species which have not yet been found in Gloucestershire: these will, I hope, shortly be described by Mr. Moore of Ilminster, their discoverer, whose fine local collection and zealous labours have already brought to light many interesting palæontological and strategraphical facts of novelty and value.

June 14, 1848.

The following communications were read:—

1. *A brief Notice of Organic Remains recently discovered in the Wealden Formation.* By GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., F.L.S., Vice-President of the Geological Society.

As our knowledge of the zoology and botany of the islands and continents that flourished during the formation of the secondary strata, can only be extended by a diligent examination of the organic remains that may be discovered from time to time, it appears to me desirable occasionally to record, however briefly, the additions made to the fossil fauna and flora of the Wealden, in the hope of ultimately acquiring data that will afford a satisfactory elucidation of that remarkable geological epoch, "*The Age of Reptiles*;"—in which the vertebrated animals that inhabited the land, the air, and the waters, were, with the exception of fishes, almost exclusively of the reptilian type of organization. I therefore submit to the Society the following concise account of the Wealden fossils that have either come under my immediate notice, or of which I have received information from my correspondents, since my last communication on this subject.

Flora of the Wealden.—The additions to the Wealden flora from my own researches consist only of a few more instructive examples of *Clathraria* and *Endogenites* than any previously obtained. Specimens of the stem of *Clathraria Lyellii*, bearing the characteristic cicatrices formed by the attachment and subsequent separation of the petioles or leaf-stalks, have been found at Hastings, at Brook Point in the Isle of Wight, and in the Ridgway cutting near Weymouth. A water-worn fragment of a stem of *Clathraria*, which I picked up on the sea-shore at Brook Bay, was so much indurated as to render it probable that the internal organization of the original was preserved; but sliced and polished sections made in various directions, when examined under the microscope, only presented such a general indication of the structure as to enable our eminent botanist, Dr. Robert Brown, to pronounce that the essential characters of the *Cycadeaceæ* were present, but no close affinity to any known recent genera could be detected.

A specimen of the internal part of the stem of *Endogenites erosa*, collected from the same locality, appeared to be solid throughout, and therefore likely to retain the internal structure; but sections made by the lapidary, under Dr. Brown's direction, only showed that the general form and arrangement of the bundles of vascular tissue preserved by mineralization, were more analogous to those which characterize the *Cycadeaceæ* than to any other existing plants.

Five or six small cones, of the size of the juli of the larch, and apparently referable to the same species of *Abies* or *Pinus* as those found in the greensand of Kent*, have been obtained from the Wealden sands and limestones that emerge on the sea-shore at Hastings and St. Leonard's, and in Sandown Bay in the Isle of Wight; and in each of these localities these fossil fruits were collocated with bones of the Iguanodon and other reptiles.

But although the Wealden of England has proved so barren, that of the North of Germany has yielded a rich harvest to the industry and talents of my friend Dr. Wilhelm Dunker, of Hesse Cassel, who has added to its flora upwards of sixty species of plants; and he informs me that he has discovered several new ones since the publication of his beautiful work†. Of these, thirty species, belonging to seven genera, are Ferns, and twelve are referable to *Cycadeæ* or *Zamiæ*. The British Wealden plants, *Endogenites erosa*, *Sphenopteris Mantelli*, *Carpolithus Mantelli*, and some species of *Thuytes* or *Cupressites*, apparently identical with those from Heathfield in Sussex, occur in the same formation in Germany.

The beautiful figures and accurate descriptions of all these plants in Dr. Dunker's work render it unnecessary to particularize them; I will only remark, that the extensive coal-field of Hanover, which was long since identified with the Wealden by M. Roemer, and the numerous plants discovered by Dr. Dunker, prove that the countries of whose debris the Wealden deposits are composed, were clothed with a luxuriant and varied flora, of which arborescent ferns, cycadeæ, and coniferous trees, were the most characteristic and predominant forms.

Fauna of the Wealden.—Of the shells of mollusks, no new species have I believe been detected in England; but the Wealden of Germany has proved as rich in fossils of this class as in vegetables.

Dr. Dunker enumerates upwards of 100 species, comprising *Unio*‡, 5 species; *Cyrena*, 37 species; *Cyclas*, 4 species; *Corbula*, 4 species; *Melania*, 9 species; *Paludina*, 8 species; *Limnæa* and *Planorbis*, of each 1 species; and of *Ostrea*, *Exogyra*, *Avicula*, *Modiola*, *Mytilus*, *Turritella*, and *Neritina*, of each 1 species§.

Crustaceans.—These consist exclusively of the shields or cases of *Cyprides* and *Estheria*||, of which four new species have been

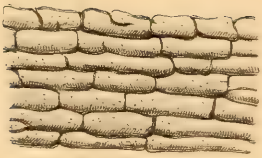
* Quarterly Journal of the Geological Society, vol. ii. p. 54.

† Monographie der Norddeutschen Wealdenbildung, 1846.

‡ It may be worthy of remark, that Mr. Barlow, C.E., has discovered specimens of *Unio Valdensis* (previously known only in the Isle of Wight), in the Wealden of Sussex and Kent.

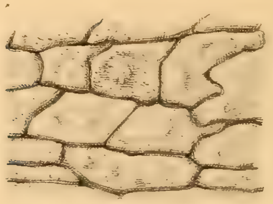
§ See Dr. Dunker's Monographie der Norddeutschen Wealdenbildung.

|| Of Rüppell, ibid. pl. 13. fig. 33, p. 59.



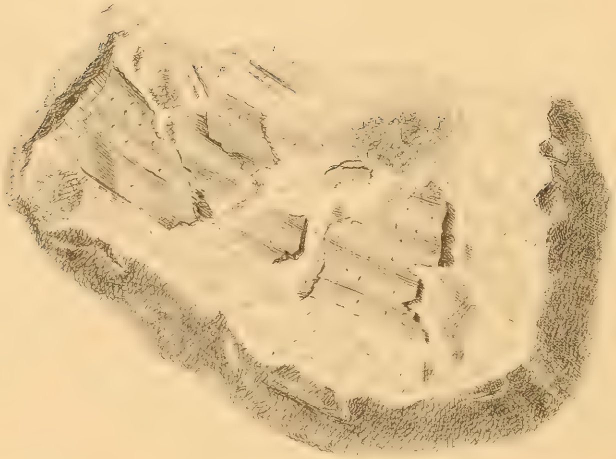
3

highly magnified

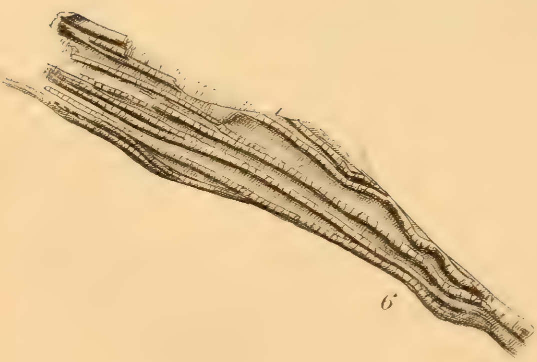


4

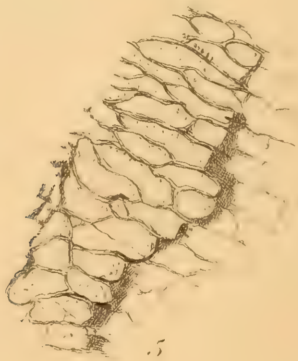
1
nat. size



2
× 5 *diameters*



6



5

C. A. Mantell del.   J. De C. Sowerby sc.

found in Germany. The British fossil *Cyprides,* first made known by Dr. Fitton, also occur in the Wealden of the North of Germany. The Isopodous crustaceans discovered by Mr. Brodie in the Vale of Wardour have not been found on the continent.

Insects.—To the list of Wealden insects given by the Rev. P. B. Brodie in his interesting work*, I can add no new species; but I am able to corroborate his account of the occurrence of insects in the freshwater strata above the oolite in Buckinghamshire; my friend the Rev. J. B. Reade, and myself, having collected a few specimens from the quarries between Stone and Hartwell. None of these are sufficiently perfect to require remark, with the exception of two fragments of wings, apparently of coleopterous insects, which appear to differ from any figured and described by Mr. Brodie; and as fossils of this kind are very rare, and difficult of detection, I am desirous of preserving faithful representations of these fragile relics. They are accurately figured in the annexed drawings.

PLATE III. fig. 1. Fragments of the membranous wing of a small Coleopterous (?) insect, natural size.

Fig. 2. The same, magnified.

Figs. 3, 4, 5. Portions of the same, highly magnified.

Fig. 6. Fragment of another wing, highly magnified.

A few fragments of the elytra of Coleoptera have been observed in the Wealden clays and shales laid bare by the railway-works between Tunbridge and Maidstone.

Fishes.—The Wealden of Germany has yielded one species of *Enchodus,* two new species of *Hybodus,* two of *Lepidotus,* one of *Sphærodus,* and one of *Gyrodus*†. The scales and teeth of the two well-known British species of *Lepidotus* (*L. Fittoni* and *L. Mantelli* of Agassiz) appear to be as abundant in Germany as in the S.E. of England. Several splendid examples of the last-named fishes have recently been collected from the rocks exposed along the shore at Hastings, some of which are in the possession of Dr. Harwood of St. Leonard's, and of Mr. Moore of the former place. The entire cranium covered with its plates, the jaws with teeth, and the body enveloped in its rich cuirass of scales, are preserved. Some portions I examined must have belonged to fishes ten or twelve feet in length.

The jaws with teeth, and the crania of *Hybodi,* as large as the *H. basanus* from the greensand of the Isle of Wight, described by Sir P. Egerton‡, have also been obtained. I have not been able to examine these Ichthyolites with the attention necessary to speak positively as to the species, but I have little doubt that some of them belong to the greensand *Hybodus*; and in fact, the occurrence of several Wealden plants and reptiles in that division of the cretaceous formation, renders it highly probable that similar fishes will be found in both series of deposits.

Reptiles.—Of the colossal terrestrial and aquatic Saurians, whose

* A History of the Fossil Insects of England.

† Mon. Nord. Wealden. p. 62.

‡ Geol. Journal, vol. i. p. 197.

remains are so abundant in some of the Wealden strata, numerous detached bones of enormous size have been found at Hastings and St. Leonard's, and in Sandown and Brook Bays in the Isle of Wight; some specimens have also been obtained from the Wealden at Ridgway, by Mr. Shipp of Blandford. The specimens I have examined are, with but very few exceptions, referable to the genera *Iguanodon, Hylæosaurus, Megalosaurus, Streptospondylus* (?), *Pœcilopleuron* (?), *Goniopholis*, and *Cetiosaurus* (?).

Numerous fragments of the bones and carapaces of Chelonians have also been obtained, especially of the remarkable Wealden Trionyx, the *T. Bakewelli*.

It would be irrelevant to my present object to offer a detailed account of the fossils thus briefly noticed, and I will simply enumerate some of them, as exemplifying the general character of the remains of this class to be met with, along those parts of the coasts of Sussex and the Isle of Wight above-mentioned.

Plesiosaurus: Vertebræ. Hastings, and Brook Bay.

Cetiosaurus (?): Caudal and sacral vertebræ. Hastings, and Brook Bay.

Pœcilopleuron (?): Vertebræ. Isle of Wight.

Streptospondylus (?): Cervical and dorsal vertebræ of large size. Isle of Wight, and Tilgate Forest.

Hylæosaurus: Vertebræ and dermal bones. Hastings, and Brook Bay.

Goniopholis: Teeth. Hastings, Isle of Wight, and N. of Germany.

————: Vertebræ, and a portion of the cranium (?).

Macrorhynchus: The cranium of a reptile of the gavial type, thus named by Dr. Dunker from its extremely elongated snout, has been found in the Wealden of Germany near Bückeberg*.

Iguanodon.—The remains of this genus of herbivorous terrestrial reptiles are more abundant in the Wealden strata of the south-east of England and of the Isle of Wight, than those of any of the other saurians. Among the specimens found last year in Brook Bay were two femora, each of which when entire must have been four feet in length; dorsal vertebræ five and a half inches in the antero-posterior diameter; several teeth; dermal tubercles or horns; ungueal bones of a more depressed form than those in the Maidstone specimen; fragments of the sacrum, and of ribs of large size, &c.

At Hastings numerous bones have been collected during the last two years, having for the most part been washed out of the ledges of rock by the action of the waves, the agency by which almost all the bones from this locality, and from the Isle of Wight, are brought to view. In the cabinets of Dr. Harwood, Mr. Moore, and other local collectors, I have seen bones of the Iguanodon of great magnitude. The lower extremity of a femur measures forty-one inches in circumference at the condyles, and exceeds in magnitude by nearly one-third

* Mon. Norddeutschen Wealden. tab. 20. Another genus of Saurians has also been proposed by Meyer, from part of a vertebral column with ribs from near Harrel, and named *Pholidosaurus*.—Ibid. p. 71, tab. 17, 18, 19.

the largest example in the British Museum. Teeth of this reptile are very rarely found at Hastings.

Upper and lower jaw of the Iguanodon.—But the specimen of the highest interest that has been lately discovered is a considerable portion of the lower jaw of an adult Iguanodon with three successional teeth in place, obtained from a quarry in Tilgate Forest by Capt. Lambart Brickenden, F.G.S., to whose liberality and ardent love of science I am indebted for it. This fossil consists of the right dentary and opercular bones; it is twenty-one inches long, and when perfect must have been two feet in length. According to the proportions of the maxillary elements in the Iguana, the entire length of the jaw to which this specimen belonged was four feet. Two successional teeth, and vestiges of a third, remain in their natural situation, within the internal alveolar parapet; and there are sockets, or rather excavations, for nineteen or twenty mature teeth in the outer wall of the alveolar process. The implantation of the teeth was intermediate between the pleurodont and thecodont types.

As this specimen is the first unequivocal example of the lower jaw of an Iguanodon hitherto known, it is of the highest interest in a palæontological point of view. A fragment of the upper jaw—the anterior part of the left maxillary bone—discovered by me, and now in the British Museum, interpreted by the aid afforded by this recent acquisition, has enabled me, with the valuable assistance of that eminent comparative anatomist, Dr. A. G. Melville, to obtain some important and very unexpected results. But as I have laid before the Royal Society, in whose Transactions my first memoir on the teeth of the Iguanodon was published in 1825, a full account of the anatomical characters of the maxillary and dental organs of this reptilian herbivore, and the physiological deductions resulting therefrom, I will only briefly notice a few of the most striking peculiarities.

In the Iguanodon, the true saurian type of structure is manifested in the mode of implantation and constant reproduction of the teeth, and in the composite construction of the lower jaw, each ramus consisting of six pieces. But the teeth of the upper and lower maxillæ are placed in a reversed position in relation to each other, as in the Ruminants; the enamelled coronal facets of the lower series facing the inside of the mouth, and those of the upper the outside. From the appearance of the abraded coronal portion of the used molars, it is evident that the teeth of the opposite jaws were arranged subalternately or intermediately, for the grinding surface of each tooth presents two facets, from the attrition of two antagonist teeth.

Another most extraordinary modification of structure is presented by the anterior part of the dentary bone; and it is one that could not have been predicated from any thing previously known as to the maxillary organization of reptiles. The symphysial portion, or front of the lower jaw, instead of being crested by the alveolar process beset with teeth, and continued uninterruptedly round the mouth, as in existing lizards, is edentulous, and contracted in a vertical direction, extending horizontally, and uniting by suture with the opposite side. Thus the two rami form by their union an expanded scoop-like process, which very closely resembles the corresponding part in the Sloths, and especially that of the extinct colossal Edentata—the Mylodons. The dental canal is very large, and the number and size of the vascular foramina sent off from it, and opening on the outer surface of the lower jaw, and along the symphysis, indicate the great development of the lower lip, and of the soft parts and integuments that invested the jaw.

The physiological inferences suggested by this configuration of the dentary bone are in perfect harmony with those derived from the structure of the teeth, and we have now unquestionable proof that the Iguanodon, like the colossal Edentata, possessed a large prehensile tongue and fleshy lips, capable of being protruded and retracted; these must have formed most efficient instruments for seizing and cropping the foliage and branches of the ferns, cycadeæ, and coniferous trees, which doubtless constituted the food of this saurian representative and predecessor of the great herbivorous mammalia.

The true characters of the maxillary organs of the Iguanodon being thus established, I have been able to determine with more precision the nature of several fragments of bones, which were temporarily referred to that animal. The portion of a lower jaw of a small lizard from Tilgate Forest, described by me in the Philosophical Transactions for 1841 as probably that of a young Iguanodon, is evidently subgenerically, if not generically, distinct, though clearly belonging to the same remarkable family. This saurian I therefore now propose to distinguish by the name of *Regnosaurus**, to indicate the district in which it was discovered; with the specific designation of *Northamptoni*, as a tribute of respect to the noble President of the Royal Society.

Summary.—The fauna of the Wealden, according to the present state of our knowledge, comprises the following Vertebrata:—

Fishes.—About 30 species; of which one belongs to the Cycloid order, 16 are Placoids, and 15 Ganoids.

Reptiles.—Twelve genera of Saurians; and there are indications of four or five not yet established.

One genus of flying reptiles—the Pterodactyle.

Four or five genera of Chelonians.

Of the warm-blooded Vertebrata, bones, supposed to belong to Birds (*Palæornithis*), are the only vestiges hitherto obtained.

In concluding this imperfect sketch of the fauna and flora of the Country of the Iguanodon, it is impossible not to indulge for an instant in a retrospective glance at the light shed by geological researches during the last quarter of a century, on the physical history of that *terra incognita* of my early years—the Wealden district of my native county; and I will venture to affirm, that notwithstanding the interest and importance of the organic remains that have been discovered, the palæontology of the fluviatile deposits of the South-east of England is as yet but very imperfectly explored, and that relics

* Sussex, the ancient kingdom of the Regni.

of the past, more precious than any hitherto obtained, remain to reward the labours of future observers. I would also remark, that the fact of so long a period as nearly thirty years having elapsed between the first discovery of detached teeth, and of a portion of the jaw of an Iguanodon with teeth in place, notwithstanding diligent and constant research, is worthy of especial consideration, as a striking proof of the little reliance that ought to be placed on what is termed negative evidence; and it suggests the salutary caution, that we should not hastily infer the non-existence of any forms of animated nature in the earlier ages revealed by geology, simply because no vestiges of their organic remains have been detected.

---

2. *On the Position and General Characters of the Strata exhibited in the Coast Section from* Christchurch Harbour *to* Poole Harbour. By Joseph Prestwich, Jun., Esq., F.G.S.

I have on former occasions described the eocene strata of Whitecliff Bay and of Alum Bay*. The sections of these two localities show in a remarkable manner the changes there undergone, in the comparatively short distance of twenty miles, by the series of sands and clays forming the Bracklesham Bay beds, and included between the London clay and the Barton clay. I also gave the commencement of the section of the Barton clays at Barton, to show their connection with the upper part of the section at Alum Bay. I have recently had the opportunity of further examining the coast-sections from Barton Cliff to Poole Harbour, with a view to continue the sequence of superposition lower in this more westward portion of the series. This part of the coast was described by Sir Charles Lyell in a paper read before this Society in March 1826. I need not therefore enter into a detailed description of the strata, but will confine myself to the question of the exact position which they bear with reference to the Barton clay, and to a few general observations on their physical conditions. The progress made by the sea in the destruction of the cliffs has also, I believe, brought to light some new features.

In the first place I have, I think, obtained evidence of the existence of the Barton clays to the westward of Christchurch Harbour; consequently the section downwards from them, which I had discontinued at Muddiford, can now be taken up and continued uninterruptedly to Poole Harbour.

Mr. Webster and Sir Charles Lyell have both noticed the sands which underlie the Barton clays at the end of the Barton Cliff near Muddiford. After leaving this cliff, Christchurch Harbour, with its dunes, intervenes for the space of a mile and a half before we reach the cliff at Hengistbury Head. The relation of the strata at this point to those of the Barton cliffs is thereby obscured, and the sequence rendered apparently incomplete.

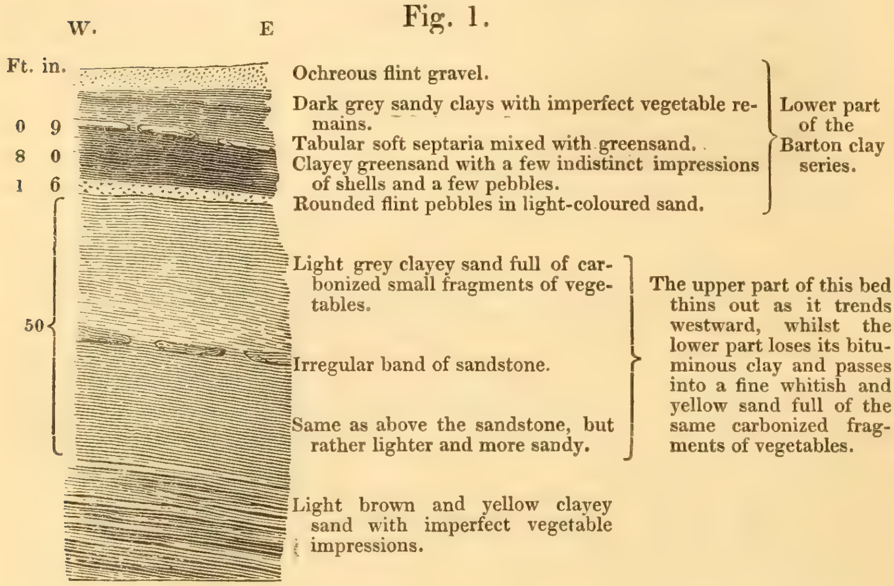
It may be necessary here again to mention briefly the general characters of the lower part of the Barton clays as exhibited in the cliff east of Muddiford. The extreme abundance of fossils in the upper

* Quart. Journ. Geol. Soc. vol. ii. p. 224, and vol. iii. p. 408.

part of the Barton clays near Hordwell is well known, but in descending lower in the strata they become much scarcer, and almost entirely disappear at the base of these clays. The strata also become generally more mixed with sand, much of which consists of greensand. At the end of the cliff near High-cliff House, nearly one mile east of Muddiford, we have the following section, fig. 1.

Section near the West end of Barton Cliff.

Fig. 1.

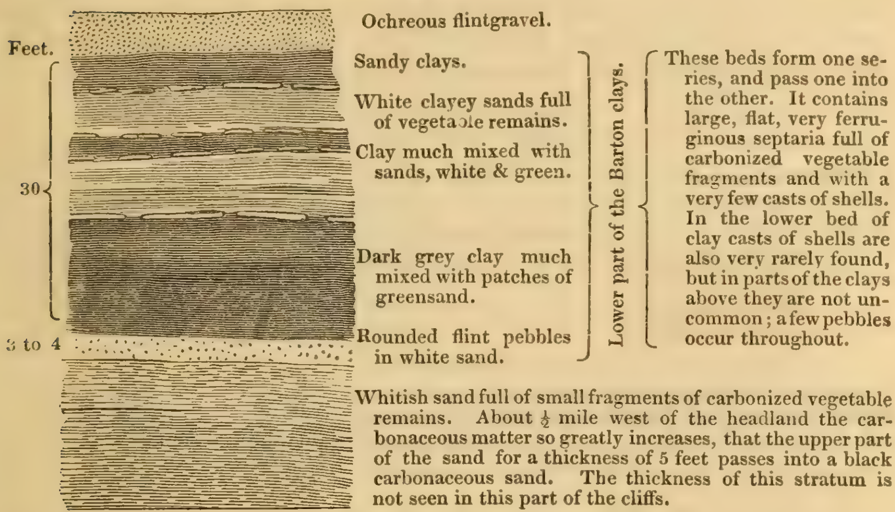


If the strata at the Barton cliffs and those at Hengistbury Head were on the same line of strike, and no fault intervened, we might expect to find at the latter place beds lower in the series than those we left at the former; but it will be perceived that Hengistbury Head projects south in advance of the general line of coast, and consequently is not in the same bearing of the strata as the Barton Cliffs. At Hengistbury Head the strata are more in the trough of the synclinal line of which the anticlinals of the Isle of Wight and Isle of Purbeck form the southern edge. This may, I think, account, without any disturbance, for the reappearance of the Barton clays on the other side of Christchurch Harbour at Hengistbury Head. I have little to add to Sir Charles Lyell's description of the cliffs at this place, and beg to refer to his paper for fuller details than I purpose entering into. I would venture however to introduce the grouping shown in the section fig. 2.

In examining this section we find a near lithological resemblance to the cliff east of Muddiford. The difference is no greater than is common at like distances in any beds of this varying series. The same general characters are preserved, but some slight details vary. The sands at the base of both sections are exactly alike in appearance, and present in both places the same peculiar fragmentary and carbonized appearance in their imbedded vegetable remains. Then we

Section of the Cliff at Hengistbury Head.

Fig. 2.

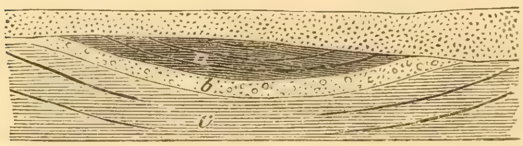


have the same well-marked bed of black flint pebbles, varying in size from a marble to a swan's egg, and imbedded in white and yellow sand and forming a perfect gravel-bed. Above these are the clays, rather more sandy, it is true, at Hengistbury Head than in Barton cliff and the septaria more ferruginous, but with no character of any value as indicating difference of origin. In further corroboration we have the evidence, scanty though it be, of organic remains. In the lower part of the clay at Hengistbury Head they are extremely scarce: I only found one cast of a small Modiola and some teeth of the *Lamna*. Rather higher in the section, and at a short distance west of the Head, I however found very friable, but abundant remains of Barton clay species of Panopæa, Solen, Cytherea, Pectunculus and Venericardia. Of themselves these few fossils would be insufficient to determine the age of these clays. Several of them equally mark the Bracklesham beds, though on the whole they probably more resemble those of the Barton clays; but this fact being supported by a superposition and by lithological characters, agreeing with the lower beds of the Barton clay at Barton, it follows that the weight of evidence is in favour of their belonging to this series. I had not time to work out more fully the organic remains of this bed, but a further search would, I am convinced, bring many more to light. There is a brick-pit recently opened immediately on the eastern side of the headland, at which I requested the men to collect any specimens they might meet with.

The septaria, although containing almost exclusively carbonized fragments of plants and imperfect vegetable impressions, also showed traces here and there of shells. The "*Teredo antenauta*" was far from uncommon in some of the large fossil stems of trees which are found both in the clays and in the septaria. I would also call attention to the occasional occurrence, in a tolerably perfect state, of the seeds of plants amongst the mass of fragmentary vegetable remains in the septaria.

The cliffs range westward about half a mile without any lower strata outcropping. For a distance of nearly a mile we then find nothing but low cliffs of sand and gravel, which interrupts the sequence of stratification. When the cliff rises again it consists of gravel underlaid by whitish and yellow sands regularly stratified, but with no characters sufficiently definite to indicate to what exact part of the series they belong. After a continuation, however, of this section for about half a mile, we luckily meet with a slight throw-in of an overlying stratum, which enables us to resume the plan of superposition in descending order. The section is as follows.

Fig. 3.



Here we evidently have in a small depression the base of the Barton clays. The peculiar appearance of the clays "*a*" and of the bed of pebbles "*b*" cannot, at this short distance from its last appearance, be mistaken, and this structure and order is peculiar to this part of the series.

After this slight reappearance the Barton clays are not seen again. As we proceed westward the cliffs rise in height, and range uninterruptedly to the entrance of Poole Harbour, a distance of six miles and a half; but, as observed by Sir Charles Lyell, the section is continued "so precisely in the line of bearing of the strata that no new beds rise up;" the whole consisting of the sands which immediately underlie the Barton clays.

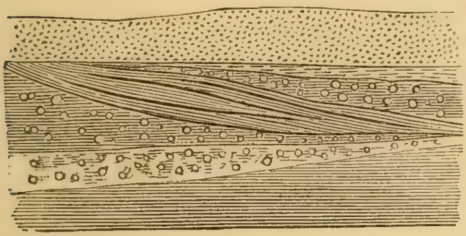
Notwithstanding, however, the want of fresh outcrops, there is much to interest in the illustration which these strata afford of rapid changes of condition within short distances.

To commence with the pebble bed "*b*." This at first sight might appear to thin out, whereas it in reality forms the upper part of the cliff for a considerable distance westward; but, from the circumstance of its immediately underlying the common surface-gravel in this part of its course, it may readily be confounded with it; a closer examination will, however, distinctly show the difference between the two. The one is a confused mass of angular, with a few round, flint pebbles in clayey ochreous sand; the other consists uniformly and solely of perfectly rounded smaller or larger flint pebbles, mixed with more or less sand, and always, when the latter predominates, showing distinct though rough stratification.

At Alum Bay we have seen this bed of pebbles about six inches thick (see Section of Alum Bay, stratum 28), and consisting of pebbles about the size of an egg.

At the end of Barton Cliff the pebbles are generally larger, and the bed is about a foot and a half thick. At Hengistbury Head its thickness has increased to about three feet; two miles westward of this headland it is four feet thick. Thus far it has increased in thickness very gradually, and its character has not materially changed, the proportion of pebbles and sand and the size of the former not varying much. At this point however it begins to be rapidly developed, as represented in fig. 4.

Fig. 4.



The pebbles now become larger; irregular and false stratification with beds of sand sets in, and in the range of fifty yards this stratum attains a thickness of fifteen feet. So rapidly does the change proceed, that by the time we have reached within two miles of Bournemouth, or three miles westward of Hengistbury Head, this conglomerate bed, which at the latter place we have seen to be only three feet thick, is developed to a thickness of about forty feet. This forms, for its limited extent, the most important conglomerate-bed in the English tertiaries.

Below this bed is a series of laminated and impure sands. Indications of the variations they present we have already perceived at Barton Cliff and at Hengistbury Head; there however their development is confined both as regards thickness and range, but in the Bournemouth cliffs they are exhibited, as we have before said, in perfect continuity for a range of six miles, and with a thickness of probably, as Sir Charles Lyell estimates, about 150 feet.

The sands are at one spot white, at another yellow, then light red, sometimes coarse, at other places very fine; the clays are here very carbonaceous and compact—there they are interlaminated with sand; elsewhere they consist of fine pipeclays; all these changes are not changes in different parts of a vertical section, but changes in the same bed and on the same levels, with incessant passages from one to the other state of things. In one part of the cliff, as near Boscombe for example, nothing can appear more tranquil and regular than the arrangement of the beds. The upper part of the cliff consists of well-marked, horizontal and uniform, fine white laminated sands, passing downwards into yellow sands, the whole having a ribboned appearance at a distance, and reposing upon horizontally-deposited and laminated fine dark grey clays.

At a short distance east from this we find these clays almost entirely replaced by sands; they then reappear again with strongly-marked false stratification. Further still they again disappear, and then they not only reappear as before, but the sands above and below them assume the same lithological characters, and the whole cliff presents a face of laminated clays. And thus it continues from beginning to end; clays replacing sands and sands clays, horizontal lamination giving way to oblique lamination, and then changing again, with extreme frequency. So great are the changes, that if the country were only exposed, here and there along the line of cliff, by pits, it would hardly be supposed that the sections were in one and the same stratum.

Westward of Bournemouth the division into layers of coarser sand and fine clays is more marked; pipeclays become more frequent. It was in one of the latter subordinate layers, a short distance west of Bournemouth, that the Rev. P. B. Brodie discovered the impressions of leaves*: they are beautifully preserved, and in one or two seams are most abundant, but the species are not numerous. At the end of the cliff, towards Poole Harbour, there are indications of the appearance of an underlying bed, consisting of a dark grey clay with numerous flat masses of iron pyrites; without seeing it, however, in greater extension, it would be difficult to say whether it is or is not subordinate to the sands of Bournemouth Cliff.

As a whole, this stratum may be considered to consist of whitish and yellow sands, occasionally very coarse, irregularly laminated with subordinate dark carbonaceous clays, which latter are however chiefly developed in the middle part of the stratum. It represents probably the strata Nos. 27 and 28 of the Section of Alum Bay Cliff, and consequently the fossil plants of Bournemouth occupy a higher position in the series by 300 to 400 feet than those of Alum Bay, which occur in stratum 17†. Compared with the strata around London, these beds would form part of the Upper Bagshot sands, or the upper part of the Bracklesham Bay series of Hampshire. The clays worked within a mile or two of Poole I believe also to belong to the same series, but I am not yet in possession of data sufficient to establish a continuance of the series downwards. The sections are numerous; but they are not connected, and the want of fossils, and the rapid changes which we know to take place in the same stratum on the same level, and of which I have further seen some interesting examples in the railway-cuttings between Poole and Wimbourne, together with the frequent repetition of very similar characters in the different vertical parts of this series, render it necessary to proceed in the study of the relative superposition of the strata in this part of the country with much caution.

As a study of a peculiar physical tertiary structure, this is a district of considerable interest. In the east of the Isle of Wight we observe the portion of the eocene series between the London clay and the Barton clay to consist of clays and fine sands repeated with but little variety and in considerable thickness. The absence of strong drifts is denoted by the abundant fossils and by the beds of shells in their normal position, uninjured as at the moment of their entombment, whilst vegetable remains are scarce. At Alum Bay, on the contrary, the remains of drifted vegetables are common; the strata are strongly marked,—fresher, as it were, from their source; exhibit

* Proc. Geol. Soc. vol. iii. p. 592.

† Journ. Geol. Soc. vol. iii. section p. 408.

the action of stronger drifts, and do not contain a single fossil to represent the 200 species abounding in the synchronous strata at so short a distance eastward. Continuing the examination still further westward, we see every indication of an approach to those waters which transported into the then seas the materials of which this series is formed. Extreme irregularity prevails; the coarser portions have here been left. In strong contrast with the coarse grits and sands are the fine white clays, the result probably of intermediate action so quiet as to carry but little of such sediment beyond this threshold; whilst, on the contrary, silt, which here under the stronger aqueous action remained in small proportion and with few subdivisions, became, as it were, by its longer transport, sorted and sifted. We thus have at Alum Bay a succession of clearly-defined and well-marked strata, the representatives of which from Christchurch to Dorchester, there is reason to believe, are fewer, less distinct, and much entangled. I here merely allude to these questions to show the interest which ground, apparently geologically barren and unattractive, may possess when viewed in its larger bearing of ancient physical conditions. To enter upon them fully would require a far more complete survey of this district.

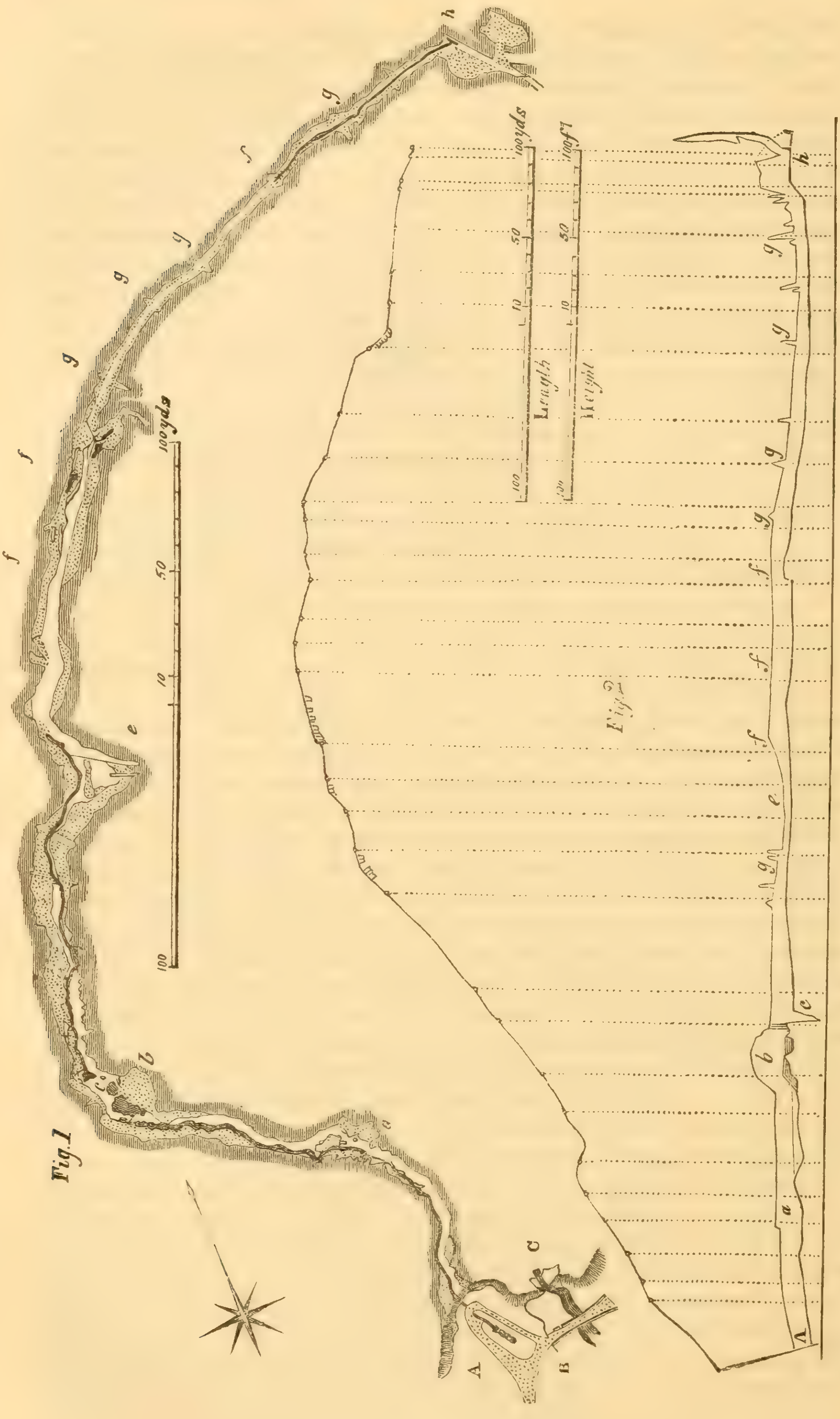
---

3. *On Ingleborough Cave.* By J. W. Farrer, Esq., F.G.S.

I venture to lay before the Society a plan of the Ingleborough Cave in Clapdale. In Mr. Phillips's paper "On a group of Slate Rocks, &c." published in the Transactions of the Geological Society, second series, vol. iii. part i. p. 12, under the title "Clapham-dale," the dale or valley, of which the cave forms a feature, is described. The "broad depressed cavern" mentioned by him is a little beyond the mouth (A) of the "Old Cave," immemorially known, the extent of which is shown upon the plan. At that time a curtain or barrier of stalactite (*a*), descending from the limestone roof, was supposed to be rock, but in September 1837, a passage being cut through it, the several galleries and chambers marked upon the plan (fig. 1) were discovered. This series of galleries and chambers has at some distant period been the course of the *beck* or stream which Mr. Phillips notices, but the great accumulation of stalagmite on the floor has diverted its course and forced it to work out another channel, and to issue generally through "the broad depressed cavern."

The rock in which these caves are situated is on the line of the Great Craven Fault, and is the Great Scar Limestone described by Prof. Sedgwick in a paper published in the same Transactions (second series, vol. iv. part i. p. 69). In floods, the "broad depressed cavern," called in the country "Little Beck-head," is not sufficiently large for the body of water, which rushes from the hills above through the fissures and hollow interior windings in the rock; and it then forces itself a passage through the larger (supposed to be the original) mouth. The cave described on the plan is in its extent wet. On its floor are numerous basins formed of stalagmite from one foot to four

Ingleborough Cave: Plan, Fig. 1.—Section, Fig. 2.



A. Cave mouth; B, Bridge; C, Cave; A—*a* Old Cave; *a*, Curtain; *b*, Pillar Hall; *c*, Pillar and abyss; *f*—*f*, Long gallery; *g*—*g*, cross arches; *h*, Giant's hall.

feet in depth; some of these remain full of water as when discovered; from others the water has been let off for the purpose of rendering the cave passable. In the narrower parts or galleries, in which these basins have not been formed, the bottom is covered with sand and gravel of limestone and millstone grit, pebbles of various sizes, cemented together in many places by carbonate of lime. It is unnecessary to add, that the curtain or barrier above referred to is formed of layers of carbonate of lime. The temperature of the cave varies very little; the highest between November 1846 and August 1847 was 50° of Fahrenheit, the lowest 48°. A register-thermometer was noted and left in the Pillar Hall (*b*) in the former month and again observed in the latter. The total length measured along the middle of the cave is 702 yards.

---

4. *A Sketch of the Geological Formation and Physical Structure of* WESTERN AUSTRALIA. By FERD. VON SOMMER, Dr. Med. and Phil.

[Communicated by the Secretary.]

DR. SOMMER states that he was charged by the Local Government of Western Australia to examine and to trace out a seam of coal found by accident about a year ago in the bed of a creek or temporary river called the "Irwin," at a distance of 200 miles northwards from Perth. He begins his description with Port Grey, or as the northern division of that diluvial segment is called, Champion Bay. Both divisions or bays are separated and in a great measure formed by a small peninsula of two miles in length and three-quarters of a mile in breadth, stretching nearly from east to west; composed of a peculiar kind of oolitic limestone of combined coral and shell formation and covered with sand. The older parts of the line of coast in this neighbourhood, as well as the islands of a corresponding age, rest on a more crystalline secondary limestone. The newer portions of the coast, with the long reefs which shelter the bay against north-west gales, and the numerous groups of low islands, called the Abrolhos, are composed of a softer oolite resting on compact, often crystalline coral. The same marine agent operates still, as well in forming new bays and islands as in shutting up old bays (converting them first into estuaries and then into diluvial soil), and in shutting up the rivers of Western Australia with bars.

These new diluvial formations are materially assisted by hills of quicksand driven by wind and waves over the reefs and bars often to the height of some hundred feet, as is to be seen at the estuary of the Hutt, Champion Bay, and Jurieu Bay. These sand-downs are then often cemented with a pasty solution of softer shells, and are soon covered with a saliferous vegetation forming the foundation of a new country.

These well-known contemporary modifications of the sea-boundary are perhaps nowhere more obviously manifested. The estuary of the Hutt, for instance, is, since the few years when it was first seen by Capt. Grey, already so much altered that Dr. Sommer could scarcely recognize his description; and at Jurieu Bay there is an extent of more than 150 square miles of grassy and wooded country elevated from forty to eighty feet above the level of the sea, of so recent a date that many of the shells still existing in great beds upon it have not even lost their colours.

About five miles eastward of Champion Bay, Moresby's flat-topped range (of which Mount Fairfax is the eastern outlier) consists of a ferruginous clay formation with prismatic escarpments, elevated 300 to 400 feet above the surrounding sandy plains, and from 500 to 600 feet above the sea, passing into sandstones, conglomerates and porphyritic rocks. Those iron-clay hills extend here from fifty to sixty miles to the east, and have the appearance of a table-land cut into pieces by a vehement ocean-current directed from south-east to north-west.

Eastward the high country begins to rise again, and consequently to form watersheds, directed against the valleys of the clay table-land. This new rise extends in the mean only from ten to twenty miles, with an additional altitude of 100 to 200 feet, and in a direction pointing nearly from Cape Riche on the south coast to the centre of Shark's Bay on the west coast. It is constituted entirely of the different strata of the coal formation, with the exception of the calcareous members, as in all that line neither carboniferous nor mountain limestone exists below the coal.

The clay of the table-land passes here, almost in a direction from west to east, into a fine-grained sandstone or a conglomerate amygdaloid or true porphyry; and eastward, where the country still rises, grauwacke appears in combination with hornblende rocks and micaceous gneiss.

From this place the country descends gradually farther to the east for a distance of about 150 miles, forming extensive plains of red decomposed iron-clay covered with a high and dense scrub of the Melaleuca, passing over into swamps or lakes covered with gypsum interstratified with new red sandstone and iron-conglomerate, indicating a second parallel coal-field.

Dr. Sommer traced the first or western coal-field down from the heads of the Irwin river to those of the Moore, a distance of about 160 miles, and has transmitted specimens of the coals, shales, sandstones, and petrifactions of these localities. The first stratum of coal is six feet, the second eight feet thick; both quite near to the surface, and bearing from N.N.W. to S.S.E., and dipping to the W.N.W. under an angle of about 72°.

A section of the country at the north branch of the Irwin gives the following series in descending order:—

	feet.
Alluvial soil	5
Yellowish and reddish clay	10
Soft white sandstone	10
Ferruginous sandstone	1
Micaceous soft white sandstone	15
Porphyritic iron-clay	4

	feet.
Stratified and unctuous clay	10
Yellow micaceous sandstone	8
Grey laminated shale	16
Yellow and red micaceous sandstone	7
Ferruginous new red sandstone	9
White micaceous clay	4
Shale	12
First seam of coal	5
Micaceous sandstone	3
Micaceous shale	4
Second seam of coal, thickness unknown.	

The iron-clay formation between Port Grey and Shark's Bay passes gradually into sandy grits, near Jurieu Bay, and then near the Moore River into a level clay country, covered with white and yellow sand, and but little elevated above the sea. The country rises again through a series of undulations; the higher hills being composed of iron-clay and granitel covered with different varieties of the Eucalyptus. About forty miles northwards from Perth a granitoidal table-land commences, which has received the name of the Darling Range, and runs at an elevation of 500 to 600 feet from thence to King George's Sound on the south coast.

In the district between the small rivers called the Canning and the Serpentine, veins of zinc ore containing traces of lead and copper are found and worked. These metalliferous veins run nearly from east to west and dip to the north, but as the flat diluvial land between the Darling Range and the sea-coast interrupts the granitel very abruptly, they will probably have a very short run, or lie very deep.

---

5. *Notes on the* Souffrière *of* St. Vincent. By Major Henry Davis, 52nd Light Infantry.

[Communicated by Sir Charles Lyell, V.P.G.S.]

In 1840, when quartered with the 52nd Regiment in the Island of St. Vincent, I visited the Souffrière volcano, and again repeated my visit the following year in company with a scientific friend, the Rev. T. Checkley, now rector of Kingston the capital of that island: we were fortunate enough to fall in with an engineer named Dixon, a most sensible, hard-working Scotchman, who had a property at the foot of the mountain, and was a resident in the island and eye-witness of the eruption in 1812: this gentleman accompanied our party and afforded us most valuable information as a guide, and witness of the events that left the traces of interest it was our object to visit. This gentleman I regret has died since that time, and the more especially so, as amongst the old people who saw the eruption so much ignorance prevailed, and so much terror, that little or no reliance can be placed on their report; and now the lapse of six-and-thirty years presents such a distorting medium, that everything they saw assumes dimensions beyond the boundary of truth. However, the traces of the event are indelibly engraven on the mountain itself, and I think there is enough to enable one to read the history of former commotions from the data still extant.

In the remarks made on that eruption of the St. Vincent Souffrière which took place in 1812, one fact seems to have been generally overlooked, namely, the many eruptions that preceded it in the same place. That something of the kind had formerly happened seems to be implied by the local acceptation of the word *Souffrière*, but no account of it, written or traditional, has travelled down to us. The fact of many previous eruptions is abundantly proved by the existence of vegetable mould now lying between the strata near the bottom of the last-made chasm; and we may in some instances conclude, that a long period of quiescence intervened between the convulsions from the great thickness of the vegetable layers, particularly that one which seems to separate the matter of the *second* last eruption from that which immediately preceded it. We should have been in utter ignorance of these data, were it not for the almost perpendicular sides of the *new* crater; but there the mountain exhibits the record laid up in its own bosom, and shows the lines by which nature has divided the times of its convulsions.

Many have wondered why a new opening was made almost in contact with that already yawning, and which seemed ample enough to discharge the contents of the mighty cauldron; but they forget that a greater mass was to be emitted than was contained in the outward cavity of the old crater, and that nature works by the simplest modes: when the boiling matter rushed furiously forward for escape, and found the already choked orifice too small for its volume, it sought a new opening in the quarter where it was likely to meet with the least resistance, and this was the side on which the new crater now gapes. The incumbent matter was more easily displaced from its want of coherence, and the lowness of the side next the Charaib country facilitated its exit. During the eruption of 1812 no lava issued from the mountain, but torrents of scoriæ and boiling water ran down its sides with a fury that defied all resistance. On comparing the layers that indicate the eruption of 1812 with the strata of eruption long antecedent, a correspondence is observed not only in the similarity of the matter of those layers, but in the order of their ejection.

In ascending the foot of the mountain on the east side, I visited the dry bed of a lake which was formed during the last eruption: the sides were about 80 feet deep, in some parts perpendicular, and formed of volcanic mud and pumice. The lake lasted only a few days; the water was arrested by the debris and other obstacles; it was supposed to have been upwards of 100 feet deep, but eventually burst its barrier, and overwhelmed some sugar-plantations. On the west side in descending the mountain, I crossed a dry bed of the old Rabaca river; it was nearly one mile wide, and one continued bed of immense boulders and sand and pumice-stones. I should consider the width of the old crater to be full a quarter of a mile, and the depth to the water about 700 or 800 feet. Before the eruption, a wooded cone of about 40 feet high was situated in the crater; this was dissipated in 1812, and since that time none has been visible; the depth of the water is not known; the walls of the crater are so steep, that it is very difficult and dangerous of access.

---

6. *Notes on* FOSSIL ZOOPHYTES *found in the Deposits described by* DR. FITTON *in his Memoir entitled* "A STRATIGRAPHICAL ACCOUNT *of the* SECTION *from* ATHERFIELD *to* ROCKEN END *." By WILLIAM LONSDALE, F.G.S.

See PLATES IV. and V.

THE fossil to be first noticed is apparently not included in the stratigraphical lists or table published in the Quarterly Journal of the Geological Society of London. It consists of small amorphous masses attached at the base, from which in one instance extended a thin layer (Pl. IV. fig. 1); and it is composed chiefly of irregularly arranged ridges with adjacent hollows, the whole surface being indented by small pits and furrows, some of which are shallow, but others penetrate to a greater depth (fig. 2); the intermediate apparently solid portions have also minute pores (fig. 2), the terminations, it is presumed, of similar openings detectable in transparent slices of the interior and even in opake sections, and which cannot be regarded either as distinct tubuli or as mouths of cells. Internally the fossil presents numerous lacunæ (fig. 3), the downwards extension of the surface-pits. Some of them are circular, but they are more often unequal in shape and size, and occasionally blended together; they have no direct boundary, and frequently exhibit a greater or less degree of cloudiness, due apparently to a structural substratum. In some portions of an intersection they abound, while in other parts they are few in number or wanting. The intervals consist of an opake-white matter, not reducible to any distinct texture by the powers used in the examination (a Codrington lens and a Hooker's microscope); but it occasionally incloses an irregular network, formed of very minute fibres, and not unlike in texture the reticulation of horny sponges (fig. 4). This structure is also exposed in some of the lacunæ. The opake intervals are penetrated by the microscopic pores before-mentioned. These leading component parts prove, that nothing strictly identical with the abdominal cavities of Anthozoa and Bryozoa is recognisable in the Atherfield fossil; while they justify its being assigned to the class Amorphozoa.

The materials of which the solid portions of recent sponges are constructed, and their modes of combination, are known to vary

* Read January 22, 1845. Published in the Quarterly Journal, August 1847, vol. iii. p. 289 *et seq.* At p. 318, a "Cellepora (same as at Farringdon)" is mentioned among the organic remains from "Sandown Bay and coast near Shanklin." No specimen of that fossil was included in the collections submitted to examination; and it is not possible that those about to be described could have been assigned to the genus Cellepora.

greatly. Many are stated to consist solely of a horny network*, but the detection by Mr. Bowerbank of siliceous spicula in corneous sponges† renders doubtful to what extent horny fibres may occur unaccompanied by earthy secretions. M. Milne-Edwards had previously announced the existence in *Sp. carbonaria* of a "réseau corné hérissé de petits spicules siliceux;" and in the *Alcyonium papillosum* of Lamarck, of a corneous network with calcareous spicula‡. Similar bodies had long claimed attention§; but their true nature was apparently not understood until Dr. Grant investigated the characters of the sponges of the Frith of Forth and other coasts||. In one great tribe he announced that "the axis is entirely calcareous, and soluble with effervescence in acids" (*op. cit.* vol. xiv. p. 336), and that in very many others "the fibres are composed of minute siliceous tubes" (p. 337). In addition, however, to these decidedly mineral structures, M. Milne-Edwards has shown that earthy constituents are combined in sponges in many other states: in *Sp. penicillosa,* the filaments "renferment dans leur substance un peu de carbonate de chaux¶;" also in *Sp. calyx* (p. 556); while in *Sp. pennatula* "ces filaments" corné "sont solidifiés par du carbonate de chaux. Parenchyme hérissé de petits spicules siliceux" (p. 560–561); and *Sp. juniperina,* he says, is composed of "un réseau corné, dont les filamens s'élargissent beaucoup dans leurs points de soudure, et sont entourés d'une multitude de petits spicules de silice et de quelques granulations calcaires" (p. 563–4); lastly, for the *Sp. fragilis* of Montagu**, Dr. Johnston has founded on his own and Mr. Bowerbank's observations the genus *Dyseidea*††, in consequence of the grains of sand, which Montagu had also noticed. The compiler of this notice is not aware whether the species just mentioned have been recently arranged under distinct names; but it is well known that Dr. Fleming‡‡ proposed the terms *Halichondria* and *Grantia* for sponges respectively composed of siliceous or calcareous spicula (*op. cit.* pp. 520, 524), while he retained the word *Spongia* for the species which have a decidedly corneous framework. These "genera," however, have been regarded by Dr. Grant as "orders§§," and

* Consult Lamarck, 2nd Ed. vol. ii. p. 543 *et seq.*, nos. 7, 9, 11, 12, 45, 46, 48, 54, 63, 73, 114.

† Annals Nat. Hist. vol. vii. p. 129, 1841; and Trans. Geol. Soc. 2nd ser. vol. vi. p. 182 *note.*

‡ Lamarck, 2nd Ed. vol. ii. p. 546, No. 20, p. 604–5, No. 23, 1836.

§ Consult Ellis, Nat. Hist. Corallines, 1754, Sponges, No. 2; Ellis and Solander, Zoophytes, 1786, tab. 58. fig. 4, or Lamouroux's Exp. Méthod. tab. 58. fig. 4: also Montagu, Essay on British Sponges, Wern. Trans. vol. ii. p. 93 *et seq.*, particularly pp. 93, 116, 88, 89, 95, 97 and 99.

|| Edin. Phil. Journ. vol. xiii. pp. 94, 333, and vol. xiv. pp. 113, 336, 1825–26.

¶ Lamarck, 2nd Ed. tome ii. p. 548; consult also p. 540.

** Wernerian Trans. vol. ii. p. 114. pl. 14. fig. 1, 2.

†† History of British Sponges, pp. 185, 187–190, pl. 13. fig. 6, pl. 14. fig. 4, 1842.

‡‡ History of British Animals, 1828. Dr. Grant has proposed Halina and Haliclona for siliceous sponges, as quoted by Dr. Johnston, *op. cit.* p. 88, and M. de Blainville, Halispongia, Man. d'Actinologie, p. 532, 1830, 1834: for Grantia, Dr. Grant has also proposed Leucalia, and Leuconia (apud Dr. Johnston, p. 172), while De Blainville has applied to the same bodies Calcispongia (*op. cit.* p. 530).

§§ Todd's British Annual for 1838, p. 268.

in an able article on Spongiadæ by another authority, they are considered as families*. It is also now admitted, that the composition of Amorphozoa is not a sufficient basis for genera; but that the arrangement of the skeleton, and the form and distribution of the orifices and pores, as well as the habitat, should be considered; likewise when possible, the nature of the gelatinous matter with the characters of the ova, and many other points, will be readily suggested to the mind of the experienced student. The freshwater body *Spongilla* has been by one authority united generically with marine Halichondria†, solely on account of its siliceous skeleton; a union, however, which has not been adopted. These remarks on the known component parts of sponges have been considered necessary in an attempt to approximate towards a knowledge of the Atherfield fossil.

A flake of that body dissolved completely in diluted muriatic acid, so far as the magnifying powers employed could be trusted; due care being also taken to discard adventitious particles; and it was not until a portion of the fluid had evaporated, that anything resembling spicula could be detected. The microscopic needles then visible were however regarded only as minute crystals of selenite, due to a slight impurity in the acid. This rough experiment, in conjunction with the detected structures, leads, therefore, to the inference, that the fossil was originally a calcareous sponge; and that among existing known Amorphozoa, it resembles most nearly the genus *Grantia,* if mineral composition were admitted a sufficient basis on which an agreement could be founded. In the dense nature of the opake portion, a similarity may be also noticed with *Grantia compressa,* especially when squeezed fragments of that species are examined conjointly with sections or transparent slices of the Atherfield organic remain, and each is viewed under the same low magnifier; but when the power is sufficiently increased and applied successively to the recent and extinct body, the former is shown to consist of very conspicuous trifid spicula, while the latter retains its minutely granular appearance; Grantia, moreover, is described as wholly destitute of a network‡, while in the Atherfield fossil such a structure was clearly observed, independent of the general calcareous composition, though its true nature is not presumed to have been ascertained. The characters of the large or excurrent canals in the greensand sponge differ markedly from the equivalent apertures in *Grantia compressa* and similarly formed species; but in others which are crustaceous, as *G. coriacea,* there is a seeming resemblance; nevertheless, the apparent nature of the calcareous matter, and the existence of a fibrous reticulation, forbid, it is conceived, a generic identification. The union of a corneous network and calcareous spicula in the *Alcyonium papillosum* of Lamarck has been already mentioned; but supposing that the fossil under consideration

* Penny Cyclopædia, vol. xxii. p. 376, col. 1, 1842.

† Hist. Brit. Animals, p. 524.

‡ Johnston, Brit. Sponges, p. 8; consult also Dr. Grant's original memoir, Edinb. Phil. Journ. vol. xiv. p. 339, 1826.

should prove when fully investigated to have such a composition, still it could not be regarded as a true *Alcyonium*, that term having been adopted by Pallas, and subsequently retained by Cuvier, M. Milne-Edwards and other great authorities for certain tentaculated Anthozoa*.

For certain fossil Amorphozoa, Prof. Goldfuss† adopted the terms *Achilleum*, *Manon* and *Tragos* from Schweigger‡, who had borrowed them from Pliny§. Schweigger apparently regarded the three genera as solely corneous, one of his characteristics for the whole group being "calx nulla" (*loc. cit.*). For his type of *Achilleum* he adopted with Pliny ("ex quo penicilli") the ordinary sponge of commerce; for that of *Manon*, the *Sp. oculata* of Esper‖, a European species, and identified by Dr. Johnston¶ with the *Halichondria palmata* of Dr. Fleming**; while for *Tragos* he gives *T. incrustans*, *Alcyonium incrustans* of Esper††, considered by Dr. Johnston to be the well-known "bread-sponge," or *Halichondria panicea*‡‡. Two out of the three genera have therefore, according to Schweigger's types, a mineral (siliceous) skeleton, and the other, the sponge of commerce, has an intermixture of earthy with corneous materials. M. Goldfuss's characters for *Achilleum* (*op. cit.* p. 1) agree with those given in the 'Beobachtungen,' as well as his notices of *Manon* and *Tragos*, embodying however in the permanent structures the large apertures alluded to by his predecessors in the superficial gelatinous or subgelatinous matter. From this statement it is plain that the Atherfield fossil, having a decidedly calcareous composition, cannot be generically identified with the *Achilleum*, *Manon* or *Tragos* of Schweigger; and Prof. Goldfuss not having alluded to the probable composition of the fossils assigned by him to those genera, though from his adopting the characters previously given, he possibly regarded the original constitution to have been corneous, it might be deemed justifiable to reject, in the present case, those names without farther inquiry. Moreover, the author of the article "Spongiadæ," before-mentioned, rightly observes, "Very few of the genera adopted from Schweigger, Goldfuss and others, can be considered at all sufficiently determined, because the constituent structures of the fossil

* Consult M. Milne-Edwards's Memoir "Sur les Alcyons proprement dits," Ann. des Sc. Nat. 2nd series, Zool., tome iv. 1835, or Recherches sur les Polypes, Mem. "sur les Alcyons," p. 1 *et seq.*, 1838; also 2nd Ed. Lamarck, ii. pp. 598, 631 *note*, 1836.

† Petrefacta, &c., pp. 1, 2, 12 *et seq.*, 1826–1833.

‡ Beobachtungen auf Naturhistorischen Reisen, 1819, Systematic Table VII.

§ "Spongiarum tria genera accepimus: spissum ac prædurum et asperum, tragos id vocatur: spissum et mollius, manon: tenue densumque, ex quo penicilli, Achilleum." (Hist. Nat. Ed. Harduini, fol. tom. i. p. 529, or lib. ix. cap. xlv. sec. 69, 1723.)

‖ Pflanzenthiere &c., 1791–1794, Zweyter Theil, s. 180, Spongia, pl. 1.

¶ Hist. Brit. Sponges, p. 92–93. pl. 2.

** Hist. Brit. Animals, p. 523.

†† *Op. cit.* Alcy. tab. 15 apud Schweigger. Consult also Lamarck, 2nd Ed. ii. p. 603, no. 16.

‡‡ Hist. Brit. Sp. p. 122; Hist. Brit. Anim. p. 520.

masses on which alone they can be justly founded, have, in most cases, been altogether left unexamined*." M. de Blainville having, however, adopted *Manon* and *Tragos*†, and M. Milne-Edwards‡, with hesitation, the three genera, solely for fossil Amorphozoa, as well as M. Roemer§ with certain modifications, and M. Geinitz‖, the terms *Achilleum*, *Manon* and *Tragos* have acquired a peculiar signification; and it is a duty to ascertain, so far as is possible, what are the essential structures of the bodies referred to them, and whether the Atherfield sponge can be identified generically or specifically with any of those fossils. It is advisable to begin with *Tragos*.

1. The characters of that group (Petrefact. p. 12) are dense fibres, and distinct, scattered, surface-openings; but M. Goldfuss in his Addenda (p. 243, 1833) considers *Tragos* to be equivalent with the *Chenendopora* of Lamouroux¶; and he identifies *T. acetabulum*** with *Ch. fungiformis*. This generic determination is proposed by M. de Blainville†† also for *T. pezizoides* (pl. 5. fig. 8) and *T. patella* (pl. 5. fig. 10); and by M. Milne-Edwards‡‡ for *T. radiatum* (pl. 35. fig. 3) and *T. rugosum* (pl. 35. fig. 4). *Chenendopora* is stated to be distinguished by a funnel-form, with pores or cellules on its internal surface, characters exhibited more or less distinctly by the fossils just mentioned, and by *T. reticulatum* (pl. 35. fig. 5) as well as by *T. verrucosum* (pl. 35. fig. 6). These structures are clearly insufficient, to the extent known, to be the basis of a genus; nevertheless they indicate a certain, uniform, physiological property in all the species enumerated, except perhaps in the body represented by fig. 1. pl. 35; and it is believed that those fossils should not be generically united to the others described under the term *Tragos*. Whether they are in part or wholly identifiable with *Chenendopora*, no evidence is at present accessible. It is sufficient for this inquiry to state, that the Atherfield fossil differs in every leading particular from those Amorphozoa, and from *Chenond. fungiformis*, so far as figures or descriptions can be trusted. Of the remaining eight species, Goldfuss himself refers *T. capitatum*, a Bensburg production, to *Stromatopora polymorpha*, which is found in the Eifel (pp. 13, 243 and 215) as well as at the former locality; *T. hippocastanum* he says is doubtful, being founded on imperfect casts (p. 13); and *T. pisiforme* (p. 12) he considers may be the young of *T. stellatum* (p. 14, where *Manon* is mentioned apparently by mistake; compare

* Penny Cyclop. vol. xxii. p. 376, col. 1, 1842.

† Man. d'Actinol. pp. 542, 543.

‡ 2nd Ed. Lamarck, ii. pp. 576, 587, 609.

§ Verst. Norddeutsch. Kreidegebirges, Erste Lieferung, p. 2–3, 1840.

‖ Charakteristik der Petrefacten des sächsisch-böhmischen Kreidegebirges, p. 96, 1839–1842. Refer also to Gäa von Sachsen, p. 132, 1843. The genera have probably been adopted by many other authorities, unknown to the compiler of this notice, or inaccessible to him, as Von Hagenow and Bronn, quoted by Roemer.

¶ Exposition Méthodique, p. 77. tab. 75. fig. 9–10, 1821.

** Petref. pp. 13, 243, pl. 5. fig. 9, and p. 95, pl. 35. fig. 1. The locality Eifel, given in p. 13, is stated in p. 95 to be an error; consult also Index, p. 252.

†† Man. d'Actinol. p. 543.

‡‡ 2nd Edit. Lamarck, ii. p. 611–612.

pl. 5. fig. 5, and pl. 30. fig. 1, with pl. 30. fig. 2); leaving but five species, and even this small group wants unity of characters*; also strict conformity with the leading definition of the genus. *T. deforme*† (pl. 5. fig. 3) and *T. rugosum* (fig. 4), not very dissimilar bodies, and both found in the same formation as well as at the same locality (p. 12), exhibit most nearly the required structures, which differ however from those of the Atherfield fossil; and the other species are still more unlike that body.

2. *Manon*, according to Goldfuss, consists of a lacunose fibrous mass, with large circumscribed openings on the surface (p. 2); and M. Roemer (*op. cit.* p. 2) describes the genus as composed of variously formed masses, consisting of a trellis-like web, or bent and anastomosed fibres, and having on the upper surface round or oval openings with projecting edges. He discards from his characteristics an external thick dense layer, conceiving that the generic separation between Manon and Achilleum should rather depend upon the nature of the network. Of the ten species described by Goldfuss (pp. 2, 94, 220), *M. favosum* (pl. 1. fig. 11) is removed by himself to *Cyathophyllum quadrigeminum* (p. 243); *M. cribrosum* (pl. 1. fig. 10) from the Eifel is possibly a fragment of M. Goldfuss's *Astræa porosa* (pl. 21. fig. 7), also from the same district; *M. stellatum* (pl. 1. fig. 9) is considered by M. de Blainville (*op. cit.* p. 543) and M. Milne-Edwards (Lamk. ii. p. 589) as referable to true Alcyonia or Lobulariæ, and consequently as not belonging to the class Amorphozoa, while *M. marginatum* and *M. impressum* (pl. 34. fig. 9, 10) are separated from the genus by M. Edwards (*op. cit.* p. 588–9) on account of their quadrangular network‡. Of the five remaining species, only *M. tubuliferum* (pl. 1. fig. 5) and *M. pulvinarium* (pl. 1. fig. 6, Maestricht; pl. 29. fig. 7, Essen), apparently possess the required generic structures, though under the latter term possibly two species have been included. Distinct circumscribed apertures moreover are not limited to Manon, and they do but characterise certain stages of growth among Amorphozoa generally§. If specimens exhibiting a different condition of development were alone examined, they might be excluded from the genus. Respecting the other three species, *M. capitatum* (pl. 1. fig. 4) is stated to have a few small openings (p. 2); while in the fossils included under the term *M. peziza*‖ and derived from three formations, the apertures present diversities of structure not referable to relative conditions, resembling

* Consult pl. 5. figs. 3, 4 and 11, pl. 30. fig. 2, also pl. 30. fig. 4.

† *Tragos deforme* has been accidentally misquoted for *T. tuberosum* in a notice on the Lymnorea of Lamouroux (Lamk. ii. p. 612; Goldfuss, pp. 16, 84 and 243).

‡ Consult also that author's observations on *Sp. bombycina*, &c. (*op. cit.* p. 540), and *Sp. calyx*, p. 556. Parkinson in his 'Organic Remains,' vol. ii. pl. 7. fig. 8, has delineated certain "cruciform spines," found on the surface of a Swiss fossil (p. 93–95) represented in fig. 9. A comparison with Goldfuss's figures 9 *e*, 10 *c*, (pl. 34) almost justifies the inference that the "spines" formed part of a similar network.

§ Consult figures 8 *b*, 8 *c*, pl. 29. of Goldfuss as illustrative of different conditions of fig. 8 *a*.

‖ Pl. 1. figs. 7, 8, Maestricht; pl. 5. fig. 1, Essen; pl. 29. fig. 8, Maestricht; pl. 34. fig. 8, Jurakalk of Streitberg, Hattheim, Gingen and Regensburg, p. 94.

in some specimens (pl. 1. figs. 7, 8, pl. 5. fig. 1) more the larger openings of ordinary corneous sponges than of those in *Manon*, while in the "adult" variety (pl. 29. fig. 8) they exhibit peculiarities not easily assignable to the specimens just noticed; and in the example delineated in pl. 34. fig. 8, they are as well circumscribed and simple in nature as in *M. tubuliferum* or *M. marginatum* (pl. 34. fig. 9). Lastly, it would be difficult to separate generically *M. piriforme* (pl. 65. fig. 10) from *Siphonia ficus* (pl. 65. fig. 14) or *S. punctata* (fig. 13), the slight central depression marking probably nothing but a very aged condition. These observations, though limited to one or two characters, and derived solely from figures or descriptions, justify, it is conceived, the belief that the fossils assigned in the work quoted to *Manon*, possess great diversity of characters, and require long study by a skilful physiologist before their true nature can be rightly understood. It may however be stated, that no structural agreement with the Atherfield fossil could be detected in any instance; and a comparison of the specimens examined with M. Roemer's delineations of the genus (*op. cit.* pl. 1) will satisfy the observer, that in those cases likewise there is no identity of composition.

3. The characters assigned to Achilleum by Goldfuss are, "stirps polymorpha, affixa, e fibris reticulatis lacunosa" (p. 1); and Herr Roemer states, that the polymorphous bodies consist of a trellis of round or straight fibres with knots at the junction-points; and that they have no special apertures (*op. cit.* p. 2). M. de Blainville passes over the genus in silence (Man. d'Act. p. 530); and M. Milne-Edwards, adopting all the species retained by Goldfuss, conceives "qui paraissent être des éponges proprement dites" (Lamk. ii. p. 576). The structures on which the genus is established deserve great attention—a simple network without any special apertures. Dr. Johnston says, "Many sponges are entirely destitute of oscula" (Brit. Sponges, p. 13); but it must not be inferred from this expression, that excurrent streams are denied in those cases*. On the contrary, the seeming absence of such openings should lead to a careful research respecting the means by which their functions are performed; and new data for accurate determinations may result from the inquiry. Dr. Grant has satisfactorily shown the manner in which the want of scattered oscula is compensated in *Grantia compressa* by the great central cavity†; and the necessity in certain species of *Halichondria* for their general distribution‡. He has likewise successfully combated the opinion, that water may be imbibed and ejected through the same osculum in ordinary sponges§. Should bodies apparently allied to Amorphozoa be discovered, in which the twofold operation is performed through one aperture, then it will become necessary to propose for their re-

* Consult Dr. Grant's Memoir on Sponges, Edinb. Phil. Journ. vol. xiii. p. 334, and vol. xiv. p. 117, 1825–6.

† Ed. Phil. Journ. vol. xiii. p. 334; Lectures, Univ. Coll. Lond.; Lancet, vol. i. 1833–34, No. 531. p. 199.

‡ Ed. Phil. Journ. vol. xiii. pp. 106, 334–5; also Todd's British Annual for 1838, p. 267, fig. 2.

§ Ed. Phil. Journ. vol. xiii. p. 105–107, p. 333 *et seq.*, vol. xiv. p. 117 *et seq.*

ception an order perhaps in Anthozoa; and should a deeply skilled physiologist detect among fossils, evidences that the functions of the living bodies were performed by peculiar processes, then also it will become possible to establish on a sure basis genera or higher groups, according to the nature of the detected properties.

Respecting the species of Achilleum enumerated by M. Goldfuss, *A. dubium* (pl. 1. fig. 2) has been rejected by him (p. 243); and additional information is requisite regarding *A. glomeratum* (pl. 1. fig. 1) as well as *A. Morchella* (pl. 29. fig. 6), before their nature can be surmised, although M. Roemer states (*op. cit.* p. 2), that the latter has a regular trellis-web visible to the unassisted eye: *A. fungiforme* (pl. 1. fig. 3) presents channels and apparently minor pores very analogous to those of common horny sponges, and therefore does not conform to the characters of the genus: *A. cariosum* (pl. 34. fig. 6) displays (fig. 6 *b* mag.) a curious resemblance to the corneous recent *Sp. cellulosa**; but fig. 6 *a* shows cylindrical cavities, the round deep piercing holes noticed in the description, and stated to penetrate lengthwise and transversely, and to have occasionally a regular distribution (p. 94). Should those cavities be truly structural, they would indicate great peculiarities in the living body, and remove the fossil from this genus. *A. truncatum* (pl. 34. fig. 3) in its enlarged representation (3 *b*) has a composition not very different from that of fig. 6 *b*, except that the interspaces between the cavities are wider and admit of a more complicated reticulation; but fig. 3 *a* is totally destitute of the deep-piercing holes of *A. cariosum*: it would be difficult also to suppose that the minor meshes represent incurrent openings, and the larger apertures excurrent channels, there being no evident relative proportion between the two structures. This species therefore, if rightly understood, approaches more nearly than the preceding to the composition assigned to Achilleum: *A. tuberosum* (pl. 34. fig. 4) has likewise apparently a simple network. *A. cheirotonum* (pl. 29. fig. 5), *A. muricatum* (pl. 31. fig. 3), and *A. cancellatum* (pl. 34. fig. 5), have also no visible special apertures, independent of the reticulated meshes; but the web is peculiar, differing somewhat in each species, though maintaining a general conformity. It is not very dissimilar from that which *Manon marginatum* or *M. impressum* (pl. 34. fig. 9, & fig. 10 *b*, *c*) would display, if stript altogether of the dense lamina, and if the preserved surface was beyond the range of the shallow oscula (pp. 94, 95); but there are no data for assuming that any analogous outer structure existed in Goldfuss's three species of Achilleum. Whether those fossils may be taken as types of the genus must depend on a minute and thorough examination of specimens, full descriptions, and the consent of competent authorities. For the present Achilleum must be regarded as a zoological term of doubtful signification.

One species of the genus, *A. costatum*† (Münster), remains to be

* Ellis and Solander's Zoophytes, or Lamouroux's Exp. Méthod. pl. 54. fig. 1 & 2, nat. size: also Esper's Pflanzenthiere, Sponges, tab. 60.

† Goldfuss's Petrefacten, p. 94, pl. 34. f. 7, from the middle beds of the Jurakalk near Streitberg.

noticed, and it has been reserved for a more direct comparison, because it is the only figured organic body known to the author which apparently partakes of the structures and mode of growth of the Atherfield fossil. The natural size of M. Goldfuss's example of *A. costatum* (*loc. cit.*) is four lines, or nearly that of a specimen of the Atherfield fossil presented to the Geological Society by Capt. Ibbetson, F.G.S. The Streitberg sponge is described (p. 94) as almost hemispherical, and to be distinguished by nine projecting ribs, which radiate from the apex to the base, and always widen downwards. The web is stated to consist of thick, curled, loosely interwoven fibres, and waved rind-like laminæ are mentioned as occurring near the base. A comparison of the Atherfield fossil (fig. 1) with M. Goldfuss's enlarged representation, and with his description, will establish an almost perfect general agreement, due allowance being made for the simple radiation of the ribs in one case, and for the contorted distribution in the other. Viewed under an ordinary pocket-lens, the Atherfield production will be found to be indented and pitted similarly to that of Streitberg (Goldf. pl. 34. fig. 7); and at the base of a fine specimen in Dr. Fitton's cabinet was noticed a largely-developed thin lamina (fig. 1). A distinction exists between the two fossils in the degree of downward thickening in the ribs; but this want of conformity, as well as the different arrangement of that structure, can be considered but specific variations. M. Goldfuss clearly regarded the secondary ridges as fibres, and the lacunæ as meshes; in the Atherfield specimens however, and from apparent analogy most probably in those found near Streitberg, the secondary ribs are not simple but compound structures, pierced by minute pores, and the lacunæ are interblended or circumscribed channels. From what has been already stated, it is evident that the Atherfield sponge does not possess the characteristics of Tragos, Manon, or Achilleum, nor can it be referred to any other genus known to the describer. It is therefore proposed to distinguish the English Amorphozoon by the term *Conis* (*κόνις*, *pulvis*), in allusion to the apparent pulverulent condition of the calcareous matter; and it is further proposed to include under the same generic name, but provisionally, *Ach. costatum* (*C. costata*).

Conis, n. g.

Gen. char.—Fixed, polymorphous, formed of variously-disposed ridges, blended towards the base into a uniform mass; the whole surface of the ribs and intervals lacunose, or indented by vertical and connecting channels: spaces between lacunæ minutely porous: constituent material calcareous, very finely grained (?), including a fibrous reticulation.

Conis contortuplicata, n. sp.

(Plate IV. fig. 1 to 4.)

Spec. char.—Ridges variously twisted and anastomosed, irregular in form; the lacunæ or channels, invisible to the unassisted eye*,

* It is perhaps requisite to state, that a Codrington lens or a Hooker's microscope was found necessary in attempting to ascertain the structures of this fossil.

generally numerous; intermediate spaces opake-white; pores very minute; fibrous structure microscopic, meshes irregular, fibres more or less curved, variable in character.

The largest specimen (fig. 1) submitted to examination was irregular in form; its extreme length was rather more than seven lines, breadth six lines, and thickness or height three and a half lines. It had been attached when living to an unequal surface by a thin layer, which extended beyond the base of the united ridges. The nature of this lamina was not clearly detectable, but it appeared to be intimately connected with the spongeous structure which sometimes extended over it, and in one part to have a striped surface with lacunæ or pits, similar to what was clearly exhibited in an indubitable portion of the fossil. The specimens were in general so intimately united to the sandy matrix, that it was almost impossible to obtain mechanically a clean, perfect exterior. So far as ascertained, it consisted of opake matter, more or less discoloured, and not a trace was detected of a dense or distinct surface-layer. Fractured portions exhibited an opake-white substance, and translucent spots of calcareous spar, which marked the inward range of the lacunæ or channels. Polished sections and transparent slices (fig. 3) displayed a similar general construction. Of the minuter textures some remarks will be found in subsequent paragraphs.

In the two perfect specimens, as well as in the fragments examined, the ribs or ridges (fig. 1) showed not the slightest approach to the regularity of the Streitberg species, or to a development from a determined centre, but the greatest irregularity in the mode of growth; and their outline, in place of being uniformly curved, was more or less tuberculated or conical; and their sides, so far from thickening symmetrically downwards, were often almost perpendicular, and the increase was frequently unequal on opposite sides, or in different portions of even the same side. These discrepancies are believed to indicate something more than varieties of a species.

It has been already stated, that the opake matter was not reducible, by the powers employed, to distinct spicula, but preserved an apparently granular texture under lenses which exhibited not merely the spicula of *Granticæ* and *Halichondriæ*, but most fully their peculiarities of form. That the matter was an original secretion, and not an infiltered calcareous sediment, was inferred from its not filling the immediately adjacent lacunæ; while the calcareous spar, which chiefly occupied those cavities, was unadulterated by the argillaceous or other finer particles of the overlying matrix. The minute particles visible, in greater or less number, in many of the lacunæ, and often giving them a cloudy aspect, were similar in nature to those which composed the surrounding dense substance, and were assigned, as well as an occasionally evident diminution in the size of the hollows, to progressive secretions dependent upon the changed wants of the living body during its upwards or outwards extension. In colour the matter resembled that of the solid portions of calcareous Anthozoa, and the texture was not very dissimilar from what may be noticed in tertiary corals—a point not unworthy of attention in attempting to ascertain the natural kingdom to which a spongoid body belonged.

The reticulated fibres were not visible, except in transparent slices, and not always in such sections. They were most conspicuous in some of the larger lacunæ or channels, and where the opacity of the interspaces was least (fig. 4); but they were also detectable in the denser portions. Under a power just sufficient to render them visible, the fibres appeared like dark reticulated filaments; but even in that apparent condition, bright points or lines were discernible in their substance, and they became more marked with a higher magnifier. How far those appearances were due to optical illusion no opinion is hazarded; but of the existence of a delicate fibrous reticulation, independent of the general calcareous matter, there was seemingly good evidence. It was further inferred, that the reticulations were not horizontal extensions of tubuli connected with the minor pores, as they ranged across the less-clouded large lacunæ, and had an independent composition; whereas the pores appeared to be simple perforations in the calcareous matter. The true nature of the network is, however, left for the development of more competent observers.

The minor pores (fig. 2), one of the most interesting structures in Amorphozoa, were detectable by a Codrington lens in external surfaces. Whether they penetrated inwardly, in a direct or tortuous course, no good evidence was obtained; nor if they communicated with the large lacunæ. Thin slices on glass, when viewed with the higher powers of a Hooker's microscope, armed with a plated reflector, exhibited very many translucent or transparent specks, not referable to accidental abrasions, being often well-defined, and they were considered as internal extensions of the pores detectable on the surface. So far as the very limited knowledge of the observer justified a conclusion, those microscopic channels resembled much more the imbibing pores of mineral than of corneous sponges, and those of Grantiæ rather than of Halichondriæ.

The lacunæ, believed to have performed the functions of excurrent canals in sponges, presented on the surface, as before stated, irregular pits (fig. 2), often perfectly circumscribed with clear surrounding areas; but they were occasionally united by shallow furrows. Internally their existence was abundantly shown, both in polished sections and thin slices (fig. 3), as well as in rough fractures; but it was not ascertained whether they preserved, in their inward course, an undivided character, or were branched. Though in general very numerous, they were occasionally less plentiful and small, and in some portions wanting; but the difference in size, as well as the total absence, was ascribed to progressive filling-up as the growth of a specimen rendered them of less importance or unnecessary in those portions, and not to primary conditions of development. Their transverse outline (fig. 3) was very irregular, and it had no definite boundary, the margin being clearly formed of the fine granular matter which penetrated more or less within their area; and often a gradually-increased opakeness was shown, according as the eye ranged from the open channel. The reticulated structure was frequently very marked within their area, reminding the observer of the network progressively formed within the excurrent channels of corneous sponges. In one of the thin slices which were obtained, the cavities had a partial tendency to an elongated form, in consequence of a more vertical intersection, but the range was in no case sufficient to assist in determining the inward characters of the channels.

Dark waved lines in one section proved that accidentally-destroyed surfaces had been covered by lateral extensions from adjacent living portions.

The second fossil to be considered is apparently the Heteropora of the published lists*, specimens procured for the describer from the Council of the Geological Society, by Dr. Fitton, having that generic name on their tablet; but this coral is not the one previously believed to have been assigned to the genus. In the collection with which the author was first favoured, no specimen of the present fossil was included; and it was inferred, that another without a label was the Heteropora of the lists (*op. cit.* p. 327*, *Chisma furcillatum*).

The coral to be examined is branched (Pl. IV. fig. 5); and the whole surface is beset with two varieties of pores (fig. 5*)—one, well-defined and circular, and surrounded, when perfect, by a projecting margin; the other smaller, and variable in form, margin not raised: internally (fig. 6) the coral consists of tubes more or less distant and divergent, being continuations of the circular surface-apertures; and they are crossed at unequal distances by transverse laminæ (6*): between the tubes is a cellular structure, represented on the surface by the minor pores, and disposed in layers, which may be separated mechanically (fig. 7, 8), and are rendered visible in weathered surfaces (fig. 5).

Heteropora was proposed by M. de Blainville† for three Maestricht fossils which M. Goldfuss had included in his genus Ceriopora‡. The essential characters given by its proposer consist in the surface having "cellules de deux sortes, les unes bien plus grands que les autres;" and the lobes or branches are stated to be composed "de couches enveloppantes." (*loc. cit.*) M. de Blainville however says, that he had never examined a species in detail (analysé). Milne-Edwards§, in his remarks on the genus, considers the minor pores not to be the apertures of cells, but "des pores pratiqués dans les parois des cellules, dont les grands trous seraient les ouvertures ovales, structure dont on voit beaucoup d'exemples parmi les Eschares," &c. He nevertheless adopted the genus, and removed to it the *Millepora dumetosa* and *M. conifera* of Lamouroux‖. Many other authorities have retained the genus, with two sorts of cells or pores as the essential character.

* Quarterly Journal Geological Society, vol. iii. No. for August 1847, p. 296, "Heteropora ——?" p. 302, "Heteropora."

† Manuel d'Actinologie, p. 417, 1830–1834.

‡ Petrefacten, *C. cryptopora*, p. 33. pl. 10. fig. 3; *C. anomalopora*, p. 33. pl. 10. fig. 5; and *C. dichotoma*, p. 34. pl. 10. fig. 9.

§ Lamarck, 2nd edit. tome ii. p. 317, 1836.

‖ Exposition Méthodique, p. 87. pl. 82. fig. 7, 8; and pl. 83. fig. 6, 7.

Were the lower greensand fossil to be studied solely with reference to the surface, little doubt might be entertained respecting the correctness of the published determination; but it is necessary to inquire what may be the internal composition of the typical species of *Heteropora*, and the amount of agreement with the English coral. Of M. Goldfuss's figures, only one exhibits a distinct interior; and, unfortunately, it was not drawn from the same specimen as that which supplied the enlarged surface; but the coral, *H. anomalopora*, is stated, as well as *H. cryptopora* (Petref. p. 33), to consist of tubes. Of the composition of the third, *H. dichotoma*, no information is clearly afforded in the figures, and it is not alluded to in the descriptions. The two first species may however be admitted to be tubular and not cellular corals; and from M. Goldfuss's figure 5 *b* (pl. 10) it may be inferred, that the larger openings are only terminations of tubes. As respects the minor pores, the great uniformity of size represented in the delineations quoted (fig. 3*c* and fig. 5*d*), and the equality in the dimensions of the large aperture as well as the distinctness of character in each case, impress the belief that the minor openings can hardly be regarded as young interpolations, but that they belonged, as M. Milne-Edwards suggests, to a peculiar, subordinate structure. M. Lamouroux's two species of Millepora* exhibit however, in the enlarged representation, so great a diversity of size in the openings, and want of separableness into two sets, that there is no difficulty in supposing the smaller may be the mouths of young tubes†. Again, in the fossil described by M. Roemer under the term *Heteropora verrucosa*‡, the secondary apertures have so symmetrical an arrangement, that they imply very distinctive properties in the inhabiting polypi; while in some of the Heteroporæ beautifully figured in M. Michelin's work§, the minor pores greatly resemble lacunæ, and, therefore, indicate other peculiarities in the constructing animal. It is not necessary to allude to additional examples, enough having been given to show that "two sorts of pores" are an insufficient basis for a genus. Two of the fossils described in these notices, the one under consideration, and *Siphodictyum gracile*, possess most markedly large and minor apertures, but so far from being referable to one genus, they belong to widely-distinguished classes. Nevertheless, M. de Blainville was fully justified in separating the three fossils from Ceriopora; but it remains to be ascertained whether they are to be received as types of one genus or of more than one.

The character, "couches enveloppés," is not insisted upon by M. de Blainville, being borrowed from Prof. Goldfuss's description of Ceriopora (Petref. p. 32); as the lower greensand coral however possesses such a structure, it must not be passed over in silence. The term

* *Op. cit.* pl. 82. fig. 8, pl. 83. fig. 7.

† M. Michelin has described under the terms *Ceriopora dumetosa* and *C. conifera*, fossils which he identifies with Lamouroux's Milleporæ, and the figures have only one kind of pores. Iconog. Zoophyt. p. 245. pl. 57. fig. 7 *a*, *b*; fig. 8 *a*, *b*.

‡ Verst. Norddeuts. Kreidegeb. tab. 5. fig. 26 *a*,*b*.

§ Iconographie Zoophytologique, pl. 57. figs. 2, 3, 4.

has been applied to two different modes of composition:—one, in which tubes springing from a centre form successively funnel-shaped layers or rows, the newest being developed within the one which preceded it, as in the fossil represented in Goldfuss's figure 4*c*, pl. 27 (*Calamopora polymorpha*); while by the other mode, the newest layer is constructed without the next older, constituting a cylindrical crust, the whole mass being composed of concentric layers. Figure 13, pl. 10 (*Ceriopora tubiporacea*) of the 'Petrefacten,' exhibits apparently such a structure (consult p. 35). Both those fossils M. de Blainville removed to Lamarck's *Alveolites*, which, he states, as well as that authority, is composed of layers enveloping one another (Man. d'Actinol. p. 404). If the structure exists in the original species of Heteropora, it probably conformed to the funnel-shaped plan (Petref. pl. 10. fig. 5*b*); whereas in the lower greensand fossil it exhibits concentric layers. In MM. Koch and Dunker's work on the oolitic formations of northern Germany†, a coral referred to *Heteropora* displays in one of its illustrative figures (pl. 6. fig. 14*c*) a concentric composition closely resembling that observable in some fractured branches of the English fossil (fig. 9 nob.); and it possesses a diversity of size in the pores. Whether that body has an aggregate of essential structures similar to that of the one under examination, no opinion can be hazarded; but supposing such an identity could be established, and it is not impossible, still, so far from the two fossils being distinct species of Heteropora, it would be necessary to sever the German production from the genus. Again, the *Ceriopora tubiporacea* of Goldfuss (pl. 10. fig. 13) alluded to before, displays in the transverse section a concentric composition closely resembling that shown in transverse slices of the lower greensand coral (fig. 10); but in the figures quoted, only one sort of aperture is delineated, and there are no proofs of continuous tubular cavities. M. de Blainville removed *Cer. tubiporacea* to Alveolites, as already stated; but it is not necessary to inquire if the fossil under discussion belong to the same genus; because, whether the second species described by Lamarck (*Al. suborbicularis*, t. ii. p. 286), the first being of a doubtful nature, or the recent species (*Al. incrustans*, p. 287, no. 4), be assumed as the type, neither of them has the structures of the Isle of Wight coral.

As a summary of differences between Heteropora and the subject of this notice, it may be stated, that in the tubes of *H. anomalopora* not a trace of transverse laminæ is shown, nor are such plates alluded to in the descriptions of any species; whereas, in the specimens represented by fig. 6 and 6*, they are often very conspicuous: the character expressed by M. Goldfuss's figure 5 is that of the tube of an Ascidian polype; while the laminæ in the section would intimate an Anthozoan inhabitant. Whatever may be the nature of the minor pores in Heteropora, they clearly belong to a peculiar, cellular structure in the greensand fossil: differences in the enveloping layers have been already mentioned; but it must be added, that in the English coral the concentric character is due to a cellular composition ar-

† Beiträge zur Kenntniss des Norddeutschen Oolithgebildes, &c., 4to, 1837.

ranged in more or less regular rows (fig. 6), which are separable mechanically with smooth surfaces (fig. 7, 8). Conceiving that these distinctions justify an altered assignment, and not having been able to discover an aggregate of similar structures in any genus known to him, the describer proposes to designate the greensand coral by the term *Choristopetalum* (χωριστὸς, *separabilis*, πέταλον, *lamina*), in allusion to the separable layers between the tubes.

Choristopetalum, n. g.

Gen. char.—Branched or encrusting: surface beset with apertures of two kinds,—one the terminations of tubular, abdominal cavities,—the other smaller and connected with an intermediate cellular structure: abdominal cavities crossed by transverse laminæ, no lamellæ or furrows; adjacent tubes more or less distant: interspace occupied by separable layers, perforated by pores: young cavities produced between the pre-existing.

Choristopetalum impar, n. sp.

(Pl. IV. fig. 5 to 11.)

Spec. char.—Unequally branched, or encrusting: apertures of abdominal cavities raised,—of the cellular pores immersed; no order of arrangement in the openings, nor numerical proportion between the large and small: abdominal cavities nearly vertical or slightly divergent in the axis of the branches, almost horizontal in the outer zone; distance between transverse laminæ variable: interspace dividing the cavities very small in the axis of the branches, often considerable in the outer zone; composition and range of cellular layers unequal.

As respects detailed remarks on the series of specimens submitted to examination, the manner of growth primarily demands attention; and it is best to consider first, the nature of the normal or branched mode. No example was afforded in the collections of a base or of a perfect upper extremity; but sufficient proofs that the plan of branching varied considerably. One instance exhibited a marked tendency to regular bifurcations (fig. 5); another had a principal stem with lateral off-shoots; while in some cases it was impossible to reduce the ramifications to any plan. There was also no uniformity in the distance between either the bifurcations or the lateral shoots. The process which attended the branching was not satisfactorily shown in the sections obtained; but if it was rightly understood (fig. 6), there occurred, at the point where the abdominal cavities diverged outwards, a considerable development of additional hollows, which assumed immediately the nature of a new axis, but less in diameter than that of the parent stem. How far the diverging cavities entered into the composition of the off-set was not visible; but it is presumed, from the dichotomous specimen, that they contributed, for a limited extent, to its composition: and a similar inference it is conceived may be drawn respecting the instances of irregular off-shoots generally. The branches gradually increased in thickness downwards;

but the apertures of the cavities maintained throughout the same character and relative surface-position or amount of protrusion, due allowance being made for the state of preservation. This description of increase deserves attention, as one means towards forming a correct determination of the class to which an obscure fossil may belong. In certain Bryozoa, as *Hornera*, a great downward thickening also occurs; but the visceral cavities, which at the upper extremity of a branch or main stem project considerably, are progressively immerged by external additions to the surrounding interspaces; and this surface-change depends on the viscera occupying permanently the same situation in the cavity, which, being once perfected, is not afterwards lengthened. On the contrary, among Anthozoa of similar branched modes of growth, the digestive organs occupy successively a higher position, forming generally below them a thin plate or a complicated structure; and they are thus enabled to maintain constantly the same relation with respect to the general surface, the cavity being extended proportionably. Allusion has been already made more than once to the existence of transverse plates in *Choristopetalum impar*; and in the character of the abdominal apertures is an additional confirmation of the fossil being a true Anthozoon; while Heteropora has been placed by general consent among the Bryozoa.

Respecting the parasitical mode of development, satisfactory evidence was afforded by a translucent slice of a specimen which had surrounded a well-defined apparently testaceous tube: that the enveloped body was not the sheath of a perforating mollusk, was evident from the characters about to be noticed. Immediately on the tube was an irregular layer of an indistinct nature, but plainly the base of the coral; and upon it rested, in some places, more or less conformably, abdominal cavities, which, after a limited but variable range, inclined upwards or outwards: occasionally the hollows assumed almost at once a position vertical to the base; and a few, distinct circles marked, it was conceived, transverse sections of tubes, which had taken a contrary line of growth: in one part also a decided fasciculus or branch-like group sprung from the base, but it did not extend to the surface, being overlaid by a confused aggregate of structures. The coral zone throughout its whole circuit and breadth abounded with indications of disturbed growth, with unconformable extensions over portions which had been accidentally destroyed: in some places likewise the abdominal cavities had a zigzag form; the whole amount of irregularities clearly indicating that the polypes had founded their edifice upon an unstable basis. Had this section been examined by itself, the coral might have been considered as an Ascidian zoophyte referable to the family Tubuliporidæ*. Many however apparently obscure signs of structure, and which might have been disregarded if seen alone, became with the aid of more satisfactory evidence important proofs of the fossil's true nature, and supported a different conclusion. In the best-developed abdominal cavities a transverse

* Consult M. Milne-Edwards's enlarged figure of *Tubulipora verrucaria*, Ann. Sc. Nat., 2nd Ser., Zool., tome viii. pl. 12. fig. 1 *b*, 1838; or Recherches sur les Polypes, &c.

plate was occasionally detected, agreeing with those fully exposed in the vertical slice of a branched specimen; while the absence of such a lamina in many cavities only accords with what frequently occurs in fossil Anthozoa, and has even led to a statement of their total absence. Again, in one portion of the coral zone a cellular structure was clearly shown between the visceral hollows, and distinguishable from intersected tubes by irregularity of form, and more or less marked approach to the arrangement of the layers in other slices. Still further, in a vertical translucent section was noticed an overlying or unconformable development, perfectly resembling those so abundant in the parasitic section.

The surface-characters varied according to the amount of preservation, and the state of development at the time of the animal's destruction. Respecting worn conditions no remarks are necessary; but attention must be solicited to variations due to different states of growth. The whole surface occasionally exhibited an irregular network, and the apertures of the abdominal cavities could not always be easily separated from the cellular composition. This indistinctness was ascribed to the specimen having lost its vitality while a cellular layer was forming, and the upper laminæ of the cells had not been produced. In cases of a tolerably preserved, mature surface (fig. 11), the larger openings had a raised, bold rim, but the secondary were small, sometimes almost inconspicuous, and depressed. It will be shown in a subsequent paragraph, that layers separated mechanically exhibited similar characters, proving that the condition last-mentioned indicated a periodical perfecting of composition.

Among the internal structures, the abdominal cavities first claim attention. Their great uniformity of dimension and considerable range, as well as slight divergence in the axis of the branch, with a sudden, almost horizontal course in the outer zone, were well-shown in vertical sections (fig. 6); and similar characters were clearly deducible from transverse slices (fig. 9, 10). The simple cross-laminæ were very often wanting, as already stated, but they occurred in sufficient number to prove, that they formed one of the essential structures of the coral. The interspace between the plates was variable, but always considerable and unoccupied (fig. 6*); and no marked difference was noticed between the laminæ and intervals of the axis and those of the outer zone (fig. 6). There was no accordance in position in adjacent cavities (fig. 6*); and when the range agreed with that of the upper or lower lamina of a concentric layer, the coincidence was evidently accidental. Similar transverse laminæ with clear interspaces are well known to occur in the recent *Heliopora cœrulea* and *Pocillopora damicornis*; also in *Favosites Gothlandica* and many other extinct corals; but always with an aggregate of structures different from that of *Choristopetalum impar*. In polished, opake sections the boundary of the cavities appeared to be thick, and those of adjacent cavities united; but in translucent slices, the thick wall was shown to have a complex texture, which became markedly cellular, where the intervals between the abdominal hollows increased; and even in the central axis the boundaries were divided by a fine, bright line, more or less continuous. The composition of the wall was not satisfactorily ascertained; but in roughly fractured sections, which afforded occasionally a limited portion of a cavity unoccupied by calcareous spar, minute foramina were visible.

The nature of the intermediate structure must next be noticed. A fine, bright line (fig. 6), separating the walls of adjacent cavities in the central area, has just been mentioned. It was not always equally distinct, in consequence of structural interference; and it was frequently crossed by filaments or laminæ; occasionally also in some sections by a bolder band, which had a symmetrical arrangement, and formed an apparently continuous arch. In transverse sections of the central area, the fine line was less evident, yet detectable. The passage of this delicate interspace from the axis to the outer zone was often obscured, but cases of decided increase of breadth occurred as well as of more prominent cross-filaments, which gave the interval a cellular character. The equivalent space in the outer zone was often narrow and clouded; but the degree of opacity was unequal, and where least, small, slightly translucent intervals were separated by darker lines; while in a transverse slice also with nearly approximated abdominal cavities, simple or circular lines formed a complete, intermediate, cellular structure. In some cases, the intervals with a decided composition were clearly continuous with those which separated the cavities in the central area. Where the space between the visceral hollows was considerable (fig. 6), it consisted of small, bright areas, sometimes oval, but more frequently of indefinite form, and surrounded by opake lines; occasionally these areas or cells were arranged in definite rows, parallel to the exterior of the branch, with a strong upper and lower continuous boundary; the latter structure however was not always conspicuous, and in many cases inclosed more than one row of cells. The natural surface of a specimen has been stated to exhibit, under certain conditions of growth, a general network; and its irregular meshes clearly occupied the same position relative to the abdominal cavities as that of the cells just mentioned: a branch likewise purposely worn down, as nearly parallel to the exterior as possible, and without penetrating beyond the outer zone, exhibited a similar network. The boundary of the meshes or cells in both the natural and exposed surfaces was continuous and thick, forming a perfectly surrounding wall, which with the upper and lower laminæ completely encompassed the areas. It is inferred, from the cross-filaments in the fine intervals of the axis, that those narrow spaces were cellular as well as the more ample, and, therefore, that the occasional cloudiness before-mentioned was due to the plane of intersection passing through or close to the side-walls. With respect to the communications between the abdominal cavities and the cells, and among the latter, where numerous, it is sufficient to allude to the microscopic pores, already mentioned, in the periphery of the visceral hollows, and to state, that similar foramina, or bright specks representatives of them, were noticed in the opake interspaces.

The concentric layers shown in fractured or weathered specimens (fig. 5) next demand consideration; but it is to the characters which they exhibit in prepared sections (fig. 6) and mechanically-parted surfaces (fig. 7, 8) that attention must be chiefly confined. The structure was not noticed in the central area of one vertical slice (fig. 6); but in another (fig. 6*), which displayed that portion of a branch to a much greater extent, it formed a series of arched lines of unequal curvature, and apparently continuous; but in many instances the layer did not extend across the abdominal cavity; and where it did, there was generally a slight cloudiness, as if a film of the wall or intercellular structure had been included in the section: occasionally also a transverse plate coincided in position with the curve. The greatest distance between the centre of the arches never exceeded half a line, and was often much less, while it gradually decreased as the lines bent downwards and entered the outer zone. In that portion of the coral, so far as could be ascertained (fig. 6), the concentric layers were never far apart; and this difference between the middle and surrounding areas apparently depended on the cylindrical mode of growth, the upward development far exceeding the transverse. It may be further remarked, that in the axis of the coral, the digestive organs had little to nourish except the periphery of the cavity and themselves, the intermediate structure being very small; whereas in the outer zone, there was always a considerable amount of cellular composition; and, it is believed, that this unequal demand necessarily allowed but a slow increase of outward to upward extension. Vertical or transverse slices afforded however no evidence of the actual nature of the concentric layers, as they exhibited not a sign of a bilaminated composition. Accidental cross-fractures gave sometimes a central boss (fig. 9), consisting of a smooth, apparently solid network with open meshes; the former evidently representing one of the arches of the axis; and the latter proving that the concentric layer did not extend across the abdominal cavities: moreover the smoothness showed, that the partition had coincided with naturally separating surfaces. Minute foramina not referable to young cavities were detectable in the substance of the network. Severed layers of the outer zone gave still more satisfactory signs of composition; and in one instance (fig. 7, 8) the parted upper and lower laminæ were preserved. First, as respects the upper surface of the lower plate (fig. 7). The general surface was more or less uneven, but smooth, or exhibited not the least trace of having been structurally united to the upper lamina; there were also no projecting lines, like fractured edges of a reticulation. The larger or abdominal openings were circular or oval, and had often a raised margin; while the smaller apertures, sometimes minute, had likewise a tendency to a round outline, but the margins were depressed: and between the openings a furrow was occasionally detectable, marking, it was believed, the boundary of the subjacent cell. The under surface of the upper lamina (fig. 8) presented structural counterparts to those just mentioned—the abdominal apertures being generally sunk, and the margin of the minor frequently raised; there were also traces of projecting lines answering to the furrows in the lower plate. These corresponding structures showed that the superior lamina had been moulded on the inferior, without being united to it; a pause having clearly intervened between the perfecting of one plate and the secreting of the other; and the adaptation in the irregularities, or in the projections and depressions, would account for a bifold composition not being visible in thin slices. The characters of the minor openings would lead likewise to the inference, that those apertures were, for a time at least, not wholly closed; but afforded a direct, often a large means of communicating between successive layers. Among existing corals the *Anthophyllum musicale* of Ehrenberg * possesses a cellular intermediate structure; but the cells or vesicles have no similar foramina in their upper and lower laminæ, nor are they arranged in rows separable mechanically as in *Choristopetalum impar*; the whole composition being an irregular aggregate of vesicular cavities, and produced, according to Ehrenberg, by appendages of the mantle (*op. cit.* Gen. Char. p. 89). On the contrary, it is believed, that the membrane, which secreted the outer surface of the raised margin of the abdominal cavity, did not range far beyond that structure, as it would be difficult to conceive, if an extension of the mantle alone produced the cellular composition, why a relatively large aperture should be kept open between a subjacent and superior layer of cells in this case, and none should exist in *Anthophyllum musicale*, &c. It is conceived, therefore, that the cells contained within themselves the secreting membranes by which they were formed, nourished as well as supplied with calcareous matter from the digestive organs, by means of the lateral pores in the abdominal cavity and the sides of the cells likewise: while at the fitting season for developing another layer, the secreting membranes were extended through the apertures in the pre-existing one, and when sufficiently grown commenced forming the superstructure, a constant communication being kept up by aid of the necessarily corresponding openings.

Respecting the mode of developing additional cavities, very few suggestions can be offered, and so far as was ascertained, they were produced chiefly in the central area. In the middle of horizontal thin sections (fig. 10), small polygonal spaces were surrounded by others of full size; but they were not numerous; and in a central boss of a fractured branch, similar minute cavities occurred: vertical slices also, to the extent to which they could be trusted, being necessarily more or less oblique, on account of divergence in growth, sanctioned an interpolated origin. Not a trace, under any circumstances, was noticed of a divisional process within a mature cavity, resembling that which exists in the *Chætetes*† of M. Fischer. No satisfactory evidence was obtained of additional cavities in the outer zone; but this want of positive proof must not lead to the inference, that they never exist in that portion of a branch. Among existing corals, as De Blainville's *Sideroporæ* and Lamarck's *Pocilloporæ*, young visceral hollows are produced most abundantly in the

* Beiträge, &c. p. 89; *Caryophyllia musicalis*, Lamarck, 2nd Ed., t. ii. p. 350, no. 6. Consult Esper's Pflanzenthiere, Madrep. tab. 30. fig. 2–4.

† Geology of Russia, by Sir R. I. Murchison, M. de Verneuil and Count Keyserling, vol. i. Appendix A. p. 594.

centre of a terminal branch, where the interspaces also are generally very narrow; but in the part equivalent to the outer zone of the lower greensand fossil, and at a considerable distance from the upper extremity of the branch, small abdominal cavities sometimes appear. In a specimen believed to be the *Sid. scabra* of De Blainville*, the young receptacle was produced by the plates of the interspace arranging themselves so as to form an imperfect star; while in *Pocillopora damicornis*†, which has only rudiments of lamellæ, the incipient cavity was a small irregular hole; in *Choristopetalum impar*, on the contrary, the additions were apparently made by the conversion of a cell into a visceral hollow.

It remains to hazard an opinion relative to the systematic position of the fossil. Little doubt can be entertained, that it should be assigned to the class Anthozoa; and its curious, complicated structures supply additional reasons why the term *polype* should not be restricted to the tentaculated mouth and digestive organs; but extended, if for convenience sake it be retained, to the whole of the animal, and anatomical terms applied to the individual structures‡. In attempting however to define more precisely the position of the extinct genus, the absence of lamellæ or all representatives of them presents a great difficulty. Among existing stony Anthozoa, *Tubipora* is the only genus known to the compiler of these memoranda which is equally deficient; but that zoophyte is furnished with eight pennated tentacula, and on that account is placed by Ehrenberg among the eight radiated or lamellated coral animals (Beiträge, Syst. Table). It would be clearly altogether incorrect to assume, that the fossil under examination possessed, when alive, eight similar tentacula; and much investigation is necessary before a positive agreement between the number of those appendages and that of the lamellæ can be admitted. Lesueur§ divided the corals, referred by him to Astræa, into two groups, one provided with tentacula, the other destitute of them; notwithstanding all the species are many-lamellated; and he describes *Agaricia purpurea* as without apparent tentacula (*op. cit.* p. 276). Ehrenberg states his whole family, *Milleporina*, wants that structure (*op. cit.* p. 122), but is furnished throughout with six to twelve obsolete lamellæ; Mr. Dana, however, alludes to its existence in the genus *Pocillopora*, as well as in a new species of *Seriatopora*‖. *Explanaria Hemprichii*¶, *Pavonia cactus***, *Tridacophyllia lactuca*††, and the small genus *Echinopora*‡‡, are described as wanting tentacula; but they are all lamellated. Some of these statements are possibly founded on animals which, at the time of obser-

* Man. d'Actinol. p. 384; Atlas, pl. 60. fig. 2.

† Lamk. ii. p. 442; Esper's Pflanzenthiere, Madrep. tab. 46 & 46 A.

‡ Consult Dr. Grant's Memoir on Flustræ, Edin. New Phil. Journ., No. 5, p. 116, 1827; also M. Milne-Edwards's Memoir on Recent Escharæ, p. 24, Ann. des Sc. Nat., 2nd series, Zool., tome vi. 1836, or Recherches sur les Polypes, &c.

§ Mém. du Muséum, tome vi. pp. 285, 286, &c.

‖ Exploring Expedition, Zoophytes, pp. 523, 521. *Ser. hystrix*, 1846.

¶ Ehrenberg, Beiträge, p. 82.

** Ibid. p. 105.

†† De Blainville, Man. d'Actinologie, p. 362.

‡‡ Consult Mr. Dana, Expl. Exped. p. 277–278.

vation, were not fully expanded; yet many of them are given by authorities sensible of the necessity of caution in that respect; and it is well known that those appendages vary greatly in their characters, and are frequently very short or obsolete. This inquiry must not be pursued further, but sufficient has been advanced to show, that there is not an absolute agreement between lamellæ and tentacula; and therefore that it is not safe to reason from one structure to the other in considering the place of an extinct coral in a systematic arrangement. If, however, attention be confined to *Tubipora*, still, as before remarked, it would be palpably wrong to assume, that a fossil, possessed of peculiarities totally wanting in the recent zoophyte, should have had the same number of tentacula as that body; and still more so, that those appendages, whatever may have been their amount, should have had a similar conformation and distribution. From established extinct genera, little assistance also can be obtained, though they have had definite positions assigned them. *Catenipora* is known to have twelve furrows*, and *Syringopora* has more than that number†; and such grooves are generally considered as representatives of lamellæ; the difference depending on the membranes, which connected the digestive sac with the sides of the cavity, not having been provided with secreting vessels. The *Chætetes* of M. Fischer‡ has neither rudiments of lamellæ nor furrows, but the fissiparous manner of producing additional hollows for the reception of digestive organs, clearly forbids its being regarded as allied to *Choristopetalum*. Ehrenberg states, from actual inspection, that the *Calamopora Gothlandica* of Goldfuss (*Favosites id.* of Lamk.) has from six to twelve interrupted lamellæ (Beiträge, p. 122). No such points or papillæ have been hitherto noticed by the author of these remarks in a coral, believed to be specifically identical with that described and figured by Fougt§, and quoted by Lamarck; though in British and foreign palæozoic fossils, allied to a variety of Goldfuss's *Cal. basaltica* (Petref. pl. 26. fig. 4 *a*) and *Cal. alveolaris* (fig. 1 *c*, same pl.), they are very conspicuous, but in many cases far exceed the number mentioned by Ehrenberg; and they are often not reducible to definite series. Fully admitting, nevertheless, the accuracy of his observation, still *Calamopora*, as retained by him, cannot be considered simply as a 12-radiated genus; its whole characters moreover being open to investigation; but, whatever may be its true systematic position, no aid can be derived from its composition in determining that of the lower greensand zoophyte‖. Lastly, the *Alveolites* of Lamarck (*op. cit.* p. 285), assuming *Alv. suborbicularis* as the generic type, wants apparently all equivalents for lamellæ (consult Goldfuss, pl. 28. fig. 1); but the

* Ehrenberg, Beiträge, p. 120.

† De Blainville, Man. d'Actinol. p. 353–354; also Geology of Russia by Sir R. Murchison, M. de Verneuil and Count Keyserling, vol. i. Appendix A. p. 591.

‡ Oryctographie du Gouvernement de Moscou, p. 159, 1837.

§ Dissertatio de Coralliis Balticis, Amœn. Acad. vol. i. p. 211, plate, fig. 27, 1745, edit. 1749; Lamarck, 2nd Edit., tome ii. p. 320.

‖ It is impossible in this notice to discuss the distinctive characters of the fossils composing M. Goldfuss's Calamopora, as a full investigation of them would occupy very many pages.

places assigned to it in general classifications* cannot be accepted now, whatever may have been their value at the time of proposing. Under this want of satisfactory guidance it is merely suggested that the lower greensand genus should be considered as inferior in composition to the lamellated, so far as the want of vertical plates within the abdominal cavity is concerned, leaving to future discoveries the determining an approximate, right position.

The fossil which next claims attention appears to have been originally named *Astræa elegans*, sp. n.† It consists (Pl. IV. fig. 12) of closely approximated, abdominal cavities or stars, with more than twelve unequal lamellæ; the bottom of the cavity is a simple, transverse lamina, more or less crossed by the four most prominent lamellæ (fig. 12*), but no central union of these plates was detected, nor any reticulated central structure: the stars have no definite outer boundary, the lamellæ of one cavity frequently blending with those of the adjacent hollows (fig. 12*): internally (fig. 13) the abdominal cavities present a succession of laminæ, varying in range, curvature and inclination, and are sometimes intersected by vertical plates; while between them is a coarse cellular reticulation: additional cavities within the area of a specimen occur between the pre-existing.

The only figured coral, known to the describer, which exhibits an apparently similar combination of *external* characters, is the *Astræa alveolata* of M. Goldfuss, found in the Jura-Kalk of Wurtemberg (Petref. p. 65. tab. 22. fig. 3)‡; but the internal structure is neither alluded to nor represented. The flat, simple flooring of the cavities resembles however very closely that of the Atherfield fossil; and its great dimensions are opposed to the inference of its being the upper end of a solid central axis: in the limited, inward range of the lamellæ, there is also an accordance, as well as in their outward blending; but the comparison cannot be extended. Prof. Goldfuss's species has been removed by M. de Blainville to his own subgenus *Siderastræa* §; it is therefore necessary to inquire, first, in what respect the lower greensand zoophyte differs from *Astræa*, its original generic assignment; and secondly, if it possesses the characters of M. de Blainville's subordinate group.

i. *Astræa* was one of Lamarck's great dismemberments from the

* Consult Lamarck, 2nd Ed. t. ii. "Polypiers à réseau," pp. 210, 212 and 286; also de Blainville, Man. d'Actinol. "Les Millepores," pp. 400, 401 and 404.

† Quarterly Journal Geol. Soc. vol. iii. p. 296, Aug. 1847. M. Goldfuss has described under the same designation a Maestricht coral (Petref. p. 69, pl. 23. fig. 6–6 *d*); subsequently removed by M. de Blainville to the genus Heliopora (*op. cit. ante*, p. 393). In the Transactions of the Geological Society of London, 2nd ser., vol. iv. pp. 204 and 351, 1837, Dr. Fitton notices the existence of an Astræa at Atherfield Point, possibly the fossil under consideration.

‡ M. Michelin, in describing his greensand coral *Astræa cribraria*, found at Avignon, notices a seeming agreement with *Ast. alveolata*, but he states that the lamellæ, in fully exposed cavities, extend to the centre. (Iconographie Zoophytologique, p. 21, pl. 5. fig. 4.)

§ Man. d'Actinol. p. 371, *Ast. Siderastræa cavernosa*; and 2nd Ed. Lamarck, t. ii. p. 421, No. †45.

Madreporæ and *Astroites* of preceding authorities; but the then* state of knowledge necessarily occasioned a want of definiteness of leading characters. He nevertheless limited his genus to hemispherical and globular corals, with circular or subangular stars on the surface; but he did not assign any restriction to the number of lamellæ; neither did he call attention to peculiarities of internal composition, and their influence on external characters; nor to the mode by which young stars are developed. This want of precision, unavoidable forty or thirty years ago, has gradually become an increasing source of error, by being too closely adopted; and the evil assumes a still graver aspect in extending the study from recent to extinct zoophytes, especially if the geological age of the fossil should be remote. Lamarck, in his edition of 1816, gave only two extinct species, *Ast. reticulata* and *A. emarciata*, corals possessing very opposite compositions; but M. De France† and Prof. Goldfuss‡ subsequently described a great amount of additional species, without however any essential improvement of the generic characters. M. de Blainville grouped in subgenera (*op. cit.* p. 366 *et seq.*) the great mass of materials, recent and fossil, of previous authorities, adopting for his basis chiefly the form and relative position of the stars, slight advantage being also taken of the nature of the lamellæ; but no allusion is made to structural combinations, or to the plan of producing young stellated cavities. "Plusieurs de ces groupes," says M. Milne-Edwards, "paraissent être naturels et devront probablement, lorsqu'on connaîtra la structure des polypes qui y appartiennent, constituer des genres distincts." (Lamk. ii. p. 404.) The groups however have not been adopted even for existing corals, though they undoubtedly present an onward arrangement; and if palæontologists, who can never hope to see the living animal of the subjects of their research, had studied M. de Blainville's subgenera with the aid of specimens and modern discoveries, many anomalous determinations might have been avoided. In Ehrenberg's Memoir on the Corals of the Red Sea (Beiträge, p. 95), far greater precision is given to the genus *Astræa*, by limiting it to those many-lamellated species which have the stellated cavities in juxtaposition, and which produce young stars, within the area of a specimen, by a fissiparous process; while the species in which a similar mode of increase exists, but the stars have more or less clear intervals between them, are placed in a distinct genus, *Favia* (*op. cit.* p. 93); and those which develope new cavities between the preexisting are removed to another family. Mr. J. D. Dana, in his recent work on Zoophytes§, arranges the corals referred by himself to *Astræa* in three subgenera:—

* Astræa was established by Lamarck in the 1st Ed. of his Hist. des Anim. sans Vert. published in 1801. The author of this notice cannot refer to it, but the classification is given by De Blainville, *op. cit.* p. 35. The Seven-volume Edition was commenced in 1816; and M. Milne-Edwards's edition, termed the second, in 1835.

† Dictionnaire des Sciences Naturelles, tome xlii. 1826.

‡ Petrefacta, &c., vol. i. 1826–1833.

§ Exploring Expedition, Zoophytes, pp. 200, 205, 1846.

1. *Orbicella*, in which the "cells" (stellated cavities) do not subdivide, or rarely, and appear to be tubular with interstices.

2. *Siderina*, in which the "cells" do not subdivide, nor appear to be tubular.

3. *Fissicella*, in which "the cells subdivide by growth and budding."

In this arrangement therefore corals are generically re-united, though the productive processes differ, being non-fissiparous in *Siderina*, rarely fissiparous in *Orbicella*, and essentially so in *Fissicella*. Lastly, Mr. Gray of the British Museum, in a paper published, February 1847, in the Annals of Natural History, "on an arrangement of Stony Corals," doubts where the *Astræa* of Lamarck should be placed; but introduces the genus provisionally (?) into the family *Agariciadæ*, one division of a great group or order characterized by "the animal growing by spontaneous division." (*op. cit.* p. 128.)

This brief summary of opinions entertained by five systematic writers, whose resources and means for forming a right judgement have been most extensive, leads to the inference, that the essential characters of *Astræa*, even as respects existing species, remain to be fixed. The abstract shows, nevertheless, that the latest authorities coincide in regarding the fissiparous process as an element of the genus; and it is believed that all the corals hitherto considered as *Astrææ*, in which it does not occur, or so rarely as to be an exception, possibly an accidental condition, should be removed to another family or order.

But the palæontologist must not consider a fissiparous increase in a circumscribed star as sufficient to prove that the fossil in which it is detected is an *Astræa*. Among existing globular corals with perfectly bounded cavities, the operation is not effected uniformly; and the variations in connection with other structural peculiarities may be found valuable in proposing generic or subgeneric groups. In a recent coral, believed to be the *Astræa* (*Favastræa*) *magnifica* of M. de Blainville*, the divisional process commences by the development of a reticulation among the lamellæ, or the forming on one side of the cavity of a new centre, equivalent in position with an additional digestive apparatus. It is not a partition from a previous reticulated centre, but a distinct structure separated by a clear, simply lamellated interval. Subsequently a divisional barrier is constructed, towards which the young digestive organs evidently supply a modicum of materials. *Ast. magnifica* belongs to Ehrenberg's true *Astrææ*; and the stars expand as they grow upwards, so as to leave no interspace; and it is impossible to conceive how, under such conditions, a new cavity could be formed, except within the area of one previously existing. *Astræa porcata* of Lamarck (*op. cit.* p. 406, No. 7)† affords an example of a different mode of effecting a subdivision. In

* Man. d'Actinol. p. 374, Group. I. pl. 54. fig. 3; consult also Mr. Dana, *op. cit.* p. 231.

† *Ast.* (*Meandriniforma*) *id.*, De Blainville, *op. cit.* p. 367. *Favia* of Ehrenberg, Beiträge, p. 94. Consult Esper's Pflanzenthiere, Mad. pl. 71; also Dana, Zooph. p. 226.

that coral the fissiparous process passes through the reticulation, sometimes producing a perfect bipartition. The characters of the abdominal cavity are also different, and the lineal extension of the central network is so much greater, that it would be almost impossible to form a new receptacle for viscera within a previous area without including a portion of the reticulation. There is a farther very marked structural distinction in the stars being separated by broad intervals, one of the characters on which Ehrenberg founded his generic separation, *Favia*. The existence of those spaces might lead to the supposition that young stars would be developed among them. Their existence however was clearly necessary for the peculiar construction of the animal; and in neither Esper's figures (*op. cit.* pl. 71), nor in a specimen of similar dimensions, was the upwards growth sufficient to occasion a considerable radiation; while the progressive thickening of the intervals between divided cavities seemed fully to meet the effects of divergence and prevent an excessive distance between the stars: moreover, not a sign of a young interpolation could be discovered. This inquiry must not be continued farther; but in the two cases quoted, considerable differences are shown to attend the fissiparous process, accompanied by marked structural variations, and they are sufficient to induce caution in studying organic remains. Among fossil corals other perfectly distinct modes occur of developing additional cavities within the pre-existing; and the author of this notice erred, when in 1839 he retained, even provisionally, the term *Ast. ananas* for a Silurian fossil*. With respect to the Atherfield zoophyte, not a vestige of a subdivision was discovered in the many specimens submitted to examination by Dr. Fitton.

ii. M. de Blainville having removed *Ast. alveolata* to *Siderastræa* (*ante*, p. 77), the composition of that subgenus must now be noticed, as well as the amount of agreement with M. Goldfuss's species and the lower greensand fossil. Prof. Edwards considers the group as possessing marked characters (Lamk. p. 404). It comprised originally three recent and twenty-eight fossil species; but respecting the former some diversity of opinion will be found in the following equivalents:—

1. *Ast. Siderastræa siderea*,	De Bl. p. 370	= *Pavonia id.*,	Dana, Expl. Exp.	p. 331, 1846.
2. — ——— *galaxea*,	,, ,,	= *Siderina id.*,	,, ,,	,, p. 218.
3. — ——— *cactus*,	,, ,,	= *Pavonia id.*,	Ehrenb., Beiträge,	p. 105.

Respecting the first species as originally described in Ellis and Solander little is known†, and Mr. Dana (*loc. cit.*) doubts the correctness of Lesueur's identification with it of a West Indian coral‡. The animal of the latter is moreover stated to be tentaculated, and that of *Ast. galaxea* to be non-tentaculated (Lesueur, *op. cit.* p. 285). Under these circumstances it would be unadvisable to adopt *Ast. siderea* as

* See Sir R. I. Murchison's work on the Silurian System, p. 688, pl. 16. fig. 6.

† Consult the figure, pl. 49. fig. 2, of Ellis and Sol., or Lamouroux, Expos. Méthod.

‡ Mém. du Muséum, t. vi. p. 286, pl. 16. fig. 14.

the type of the group. *Ast. Sid. cactus* was removed to *Pavonia* by Ehrenberg, who obtained living specimens in the Red Sea (*loc. cit.*), on the borders of which Forskål procured the coral originally, but in a semi-fossil state* (De Bl. p. 370).

Ast. galaxea is a well-known coral, and the animal has been described by Lesueur (*op. cit.* p. 285, pl. 16. fig. 13), who also states that Ellis and Solander's figure (tab. 47. fig. 7, or Lamx.) is "très bien faite." More than one species of possibly distinct genera have however been included under the term *A. Sid. galaxea.* Lesueur states that his West Indian coral is non-tentaculated, whereas MM. Quoy and Gaimard have referred to the same specific name a New Holland zoophyte found by themselves, the polypes of which had apparently white tentacules†. Specimens supplied by an experienced London dealer in natural history as *Ast. galaxea*, and which differed not to the unassisted eye from Ellis and Solander's figure, afforded the following structures. Small abdominal cavities of variable form, having at the base a bladder-like lamina or a series of minute projections: lamellæ numerous, knife-shaped, frequently but not regularly grouped in threes, edges serrated; in their outward range the lamellæ of adjacent cavities sometimes unite and constitute apparently continuous plates: spaces between them crossed by roundish bars which divide the intervals into a quadrangular network, the meshes penetrating deeply downwards; where the lamellæ of adjacent cavities coincide, the bars assume the appearance of a continuous line; but where the plates are disconnected, there is often a crenulated structure. In a vertical section, the lamellæ present broad, perpendicularly continuous plates imperforated except towards the axis of the coral; but they are beset with longitudinal rows of large papillæ, the broken extremities of the bars, and they are occasionally crossed by delicate irregular laminæ, the fractured edges of the bladder-like structure. The central axis is nearly solid, and composed of the union of the broadest lamellæ; the whole interior of the cavity, except that occupied by the living digestive organs, being traversed vertically by lamellæ and crosswise by the bars. The young stars are wholly produced in the network without the area of the mature. A careful comparison of these characters with the structures of Ehrenberg's *Astrææ* or *Faviæ* will lead to the conclusion that *Siderastræa galaxea* may be assumed as the type of a true genus; and the compiler of these memoranda has long possessed another well-distinguished species. It is not possible to compare the leading component parts of the recent coral with those of the twenty-eight fossil species. *Siderastræa cristata* has similarly papillated lamellæ (consult Goldf. pl. 22. fig. 8*c*), but the aggregate of structures appears to be different, while in *Sid. clathrata* (Goldf. pl. 23. f. 1) there is no resemblance whatever. Confining the attention, however, to *Ast.* or *Sid. alveolata* (Goldf. pl. 22. f. 3),

* Ehrenberg describes the animal as wanting tentacula (*loc. cit.*); and Mr. Dana, in his account of Pavonia, states, that "when alive and expanded, the tentacules appear as mere inflations of the exterior membrane around each polype mouth, and are extremely short."—Expl. Exped., Zoophytes, p. 320.

† Milne-Edwards, 2nd Ed. Lamarck, t. ii. p. 418.

it will be found that the resemblance is limited to additional cavities being in each case interpolated, with an occasional union of lamellæ in their outward extension. The latter structure presents in the fossil species, instead of thin plates, with a deep, open, intermediate network, broad, rounded ridges in close contact (Goldf. fig. 3*a*); and there is necessarily a total absence of intervening textures; the area of the abdominal cavity also, in place of being contracted by extensions of numerous lamellæ, is but slightly encroached upon, and the bottom of the cavity has apparently a uniform composition. The comparison cannot be extended. In these structures however, *Sid. alveolata* agrees perfectly with the lower greensand fossil, and the latter is consequently to that extent equally distinct from *Sid. galaxea*. If the internal composition of the recent coral be considered with reference to that of the Atherfield zoophyte, great dissimilitudes will be evident. The lamellæ, instead of being thin throughout and apparently simple, solid plates, are in the fossil, as already stated, broad (fig. 12*), and are internally cellular, and necessarily without separated sides beset with papillæ: the abdominal cavity again, in lieu of being progressively occupied by numerous vertical lamellæ united in the centre of the area into a solid axis, is penetrated to a limited extent by only four attenuated lamellæ-edges, and is successively crossed by laminæ of variable transverse range and curvature, without a trace of an axis. These differences, it is conceived, fully justify the conclusion that the fossil under examination is not a *Siderastræa*, and it is believed that M. Goldfuss's coral possesses a similar generic composition.

iii. It is not necessary to dwell even generally upon the established recent and fossil groups, which resemble the lower greensand zoophyte in being aggregated and many-lamellated; also in having the abdominal cavities crossed by laminæ without a continuous vertical axis, likewise in having additional stars developed in the interspaces; as in only one instance, the *Cyathophora* of M. Michelin, is there such a combination of structural agreements as to warrant a detailed comparison.

M. Michelin states that *Cyathophora Richardi*† consists of aggregated polygonal tubes divided by diaphragms; the stars deep, subpolygonal, radiated to a small distance, and the margin thick. He adds, that the lateral lamellæ are little visible, though numerous, resembling striæ; and that the plates in the terminal star cover scarcely half the surface of the last transverse lamina. His figure 1 *a* represents a considerable diversity of range, inclination and curvature in the plates which cross the cavities; but neither the description nor the illustrations afford any information respecting the composition of the lamellæ, or of the spaces between the abdominal receptacles; there is also no allusion either in the generic or specific notice to the mode of developing young "tubes," but the small, round depression in figure 1 *b* indicates an interpolated origin.

In attempting to compare these characters with the structures of the lower greensand fossil, it must be mentioned that weather-worn

† Iconographie Zoophytologique, p. 104, pl. 24. fig. 1*a*, 1*b*, 1844?

or abraded portions of the latter showed as little of the real nature of the intervals between the visceral cavities, as the delineations in the 'Iconographie Zoophytologique;' and such surfaces would not excite even a suspicion that certain lamellæ ranged from one star to another, or that they were cellular. The transverse laminæ in the vertical delineation of the French coral (*op. cit.* pl. 26. fig 1 *a*) differed in dimension only from those shown in cut sections of the Atherfield fossil (fig. 13), and the vertical edges of the lamellæ are about as distinctly marked in fig. 1 *a* (*op. cit.*) as in weathered internal portions of lower greensand specimens. The rays faintly, and no doubt faithfully represented in M. Michelin's figure 1 *b*, are more numerous than in the English species, but they are possibly not thinner than the four attenuated edges already mentioned; it is moreover impossible to surmise what might be the number of converging plates, or the amount of range, under particular conditions of growth. The lamellæ of *Heliopora cærulea* are almost rudimentary during the upward developement of the abdominal cavity, but on the latter attaining apparently its final extension, they stretch across the whole area, meeting in the centre. M. Goldfuss says that from six to eight plates of *Ast. alveolata* project beyond the others; but the edges are blunt, from abrasion probably, the usual state of those in Atherfield specimens. The number of protruded lamellæ, as well as the relative amount of range under equal stages of growth, should however be regarded only as specific distinctions, and in nowise opposed to generic identity. Additional cavities within the circuit of the English fossil were invariably interpolated; and such was most probably the case in the French coral. The agreements just noticed are few; nevertheless, in *Cyathophora Richardi* no structure has been detected which does not exist in the British zoophyte. It is therefore proposed to adopt provisionally M. Michelin's generic name with the specific term *elegans*, that the connexion with the original announcement in the Quarterly Journal of the Geological Society may be evident. Should however palæontologists hereafter show that the French coral differs in the unascertained portions from the English, it is suggested that the latter might be designated *Holocystis* (ὅλος, *totus*, κύστις, *vesica*), from its being wholly composed of bladder-like cells. In a systematic arrangement, the genus, by whatever name it may be distinguished, should be totally removed from the family or order in which Astræa is placed, and assigned to that which contains the many-lamellated, non-fissiparous groups.

Cyathophora? elegans, n. sp.

(Plate IV. fig. 12 to 15.)

Spec. char.—Incrusting, also hemispherical, globular or amorphous; abdominal cavities small, very numerous, polygonal or circular, margin not raised; interior of cavities formed of lamellæ-edges; bottom of cavities a slightly convex lamina, inferior or deserted portion occupied by transverse, irregular, bladder-like cells: interspaces between the cavities narrow, composed of outward extensions of lamellæ: lamellæ thick, four markedly prominent, dividing the cavity to a limited extent into four equal parts; three intermediate lamellæ, the middle one projecting slightly; perfect edges within the abdominal cavities attenuated, casts of edges blunt; crest of lamellæ, where preserved, sharp, casts obtuse; lamellæ of adjacent cavities sometimes confluent; sides in contact; interior composed of small bladder-like cells: young cavities developed at the junction of lamellæ belonging to two or more cavities.

Dr. Fitton describes the Perna beds of the Atherfield section as varying from dark blue sandy clay, or mud, to greenish sand; and the upper bed from which *Cyath.? elegans* was obtained, as differing chiefly in compactness and durability*. To the originally loose condition of the deposit, the variations in form presented by the series of specimens may, it is conceived, be chiefly ascribed. When the germ settled upon a Perna or a large fragment of a shell not easily overturned, the lateral expansion was great compared to the upper growth. In the Museum of the Geological Society is an encrusting specimen presented by Mr. Simms, F.G.S., which measures $3\frac{1}{2}$ inches in one direction and $2\frac{1}{3}$ in the other, while the vertical height in the centre was apparently limited to about $\frac{2}{3}$rds of an inch. On the contrary, where the base was small, the coral assumed more or less rapidly an hemispherical, globular or oval contour. In the first of these forms the shape may be readily ascribed to the arenaceous nature of the bed on which the specimen rested, and which did not allow of a lateral extension; while the nearly globular or oval examples evidently owed their configuration to a complete or partial inversion, which permitted the living margins to extend over the previous base more or less perfectly. In such cases the soft portions of the reversed surfaces must have perished, and proofs of such partial destructions were exhibited in many instances. In one case a limited area presented a rugged aspect, the roughness arising clearly from the animal of that part having been killed during the formation of a series of cells; and the adjacent living polype-matter had been prevented from extending afterwards fully over the dead surface, in consequence, it is conceived, of the latter having been immersed in sand or mud. A weathered or abraded area is easily distinguished from such an exterior by its uniform smoothness. Amorphous masses plainly resulted from successive interferences with development, and probably from an imbedding more or less deeply in sediment. In all these cases *Cyath.? elegans* exhibits a similar tendency to marginal expansions, limited or modified in direction by the extent of the body on which the germ originally settled, and the nature of the bed on which the subsequent specimen rested, as well as the liability to be displaced by waves; but there is an obvious effort to assume an hemispherical contour, when the base was small, and thence one more or less globular. In these respects the fossil agrees with *Siderastræa*, *Astræa*, *Meandrina* and other existing corals, provided with a creeping or downward expanding, proliferous mantle; by which the edge of a specimen is constantly

* Quart. Journ. of the Geological Society of London, vol. iii. p. 294, Aug. 1847.

brought in close contact with the subjacent surface, and inverted portions on being re-exposed are overlaid. On the contrary, throughout the fine series submitted to examination, not the least attempt was detected, under any irregularity of growth, to assume a turbinated outline, with a large pedicle, surrounded by a solid lamina—a mode of growth characteristic of Ehrenberg's *Manicina*, a dismemberment from *Meandrina*; also of some fossil Anthozoa; and due, in the former case at least, to the edge of the mantle being free and inclined upwards†.

Of the earliest plan of development, or from a single germ, no instance was observed; nor of a state resembling that which in some recent and extinct genera distinguishes the period when the coral naturally ceased to increase in part or wholly‡. The specimens generally varied in diameter from about 1 to rather more than 3 inches; the largest was an amorphous mass nearly 4 inches high, $3\frac{1}{4}$ wide, and $2\frac{1}{4}$ thick.

The original substance of the coral was rarely preserved on the exterior; but in two beautiful examples belonging to the Geological Society's Museum, one of which was obtained by Dr. Fitton at the Red Hill cutting near Reigate (fig. 14), it prevailed over the whole surface, and presented a uniformly opake-white layer. In polished sections of the interior it constantly occurred under the form of opake, whitish laminæ; generally, however, the specimens displayed externally broad, rounded casts (fig. 12*), in brown calcareous spar, of the inner surface of the original layer, in those cases in which the development of a set of structures had been completed previously to destruction; but in those in which that event happened while the work was in progress, the surface gave casts of narrow ridges with intermediate hollows or furrows (fig. 15).

The area of mature abdominal cavities rarely exceeded a line in diameter, and was often less, measuring from the lateral union of the lamellæ; while that of the simple stomach-sac, marked by the interval between the edges of the four projecting plates, was about half a line. The greatest depth of the cavity, so far as could be ascertained, was also one line. The shape was irregular, but a rounded outline prevailed, the periphery being defined by the sidewise-united lamellæ, without a trace of a distinct lining. The laminæ forming the base of the cavity were apparently concave or uneven, judging from the casts; and a similar character was shown in vertical sections. Beneath the last-occupied abdominal space, prominently defined in purposely-exposed interiors by a series of notches (fig. 13), occur numerous curved laminæ, forming a complicated cellular structure, which is sometimes traversed perpendicularly by the edge of a projecting lamella. The whole downward range of these deserted

† Ehrenberg, Beiträge, p. 101. For clear delineations of the mode of growth among recent species, consult Sol. and Ellis, or Lamouroux, tab. 47. fig. 4 and 5, tab. 51. fig. 1; also Esper, Pflanzenthiere, Madrepora, tab. 4: and among fossil corals, see M. Michelin, Iconog. Zoophytol. pl. 44. fig. 9*a*, pl. 51. fig. 1 and 4, pl. 54. fig. 9, pl. 68. fig. 4, and pl. 70. fig. 1*a* and 4*a*.

‡ Quart. Journ. of the Geological Society of London, vol. i. p. 498–499, 1845.

abdominal areas was very rarely exhibited, in consequence of the intersections being necessarily more or less oblique; and it was frequently obscured, especially towards the lower part of the specimen figured, by the intervention of portions of lamellæ with a still more intricate cellular composition. The sides of the cavities sometimes presented traces of a vertical wall, or a nearly even plate, the attenuated edge possibly of a lamella; but the boundary consisted very often of curved laminæ, belonging clearly to the cells which formed the body of the lamellæ. Occasionally (fig. 13(*)) a cavity displayed proofs of the polype-membranes having been lacerated, and for a time intermingled, the side-structure being for a limited distance defective or wanting, and the transverse laminæ apparently extended into the lamellated area. Other instances of abnormal development were noticed.

In considering the characters of the lamellæ, the perfect exteriors first claim attention. The beautiful specimen from Red Hill (fig. 14) already mentioned, and another equally fine, presented to the Geological Society by Mr. Warburton or Mr. Austen, if hastily compared with Atherfield casts, might be regarded as specifically distinct. The outline of the component structures, instead of being broad and rounded, was relatively narrow and crested, with more or less of interspace; but the number of the lamellæ as well as their detailed arrangement was similar in each case; a part also of the Red Hill specimen, slightly abraded, exhibited a considerable increase of breadth. The whole exterior of the perfect coral-layer was rugose or papillated; and the surface of the portion on the sides of the abdominal cavities was minutely perforated. That no specific differences existed between these specimens and those found at Atherfield will, it is hoped, be established by the following statements. A Peasemarsh coral (fig. 15), found by Mr. Austen, preserved also its original substance; but the structure was in an immature state, presenting narrow ridges and hollows, the animal having been destroyed while a probably periodical addition was in progress. The ridges bore the semblance of ordinary lamellæ; but some of those which had been accidentally broken showed that they were not portions of vertically continuous plates, the subjacent exposed substance consisting of pale brown calcareous spar; and fractured, attenuated edges of prominent lamellæ, subdivided, where the thickening commenced, into two plates, which diverged to the right and left. The ridges therefore must not be regarded as simple lamellæ, similar to those which occur in *Siderastræa galaxea*; nor must the intermediate depressions be considered the equivalents of the quadrangular network in that coral; the whole presenting the rudiments of a fabric, and not a perfected construction, as in the recent species. An Atherfield specimen, given to the Geological Society by Mr. Warburton, exhibited casts of a perfectly similar structure to that of the Peasemarsh example; and a comparison of it with an equally immature portion of one of the broad casts from the former locality, proved that the three compositions were essentially identical. Intermediate stages between the condition exhibited by the Peasemarsh fossil and the perfected exterior of that found at the Red Hill cutting were not observed; but wherever the original coral-layer had been accidentally removed from the crests of the latter, the subjacent substance consisted of brown calcareous spar, resembling that alluded to in the remarks on Mr. Austen's specimen; and in both cases a fine lamina could frequently be detected in the spar, not ranging in the direction of the crest, but transversely or obliquely to it. The broad lamellæ-casts (fig. 12*) often displayed a slightly raised line, moulded clearly in the crest of the perfect external layer; and the whole surface was minutely indented or pitted; but it would be difficult to infer from it, or even from abraded portions, without other aid, the actual composition of the lamellæ. Nearly vertical sections (fig. 13) afforded however the requisite evidence. By connecting the surface-ridges with the projections between the vacant abdominal cavities, it was manifest the structure of the projections must be that of the ridges, and the section proved it to be irregularly cellular. The breadth of these lamellated interspaces, as well as their characters, varied greatly on account of the exposed surface seldom passing through equivalent areas, or through similar portions of a lamella. Sometimes a single series of cells or arched laminæ indicated that the cutting passed through only one of the surface-ridges; but generally the space included two or more irregular, vertical rows, marking the intersection of an equivalent number of ribs or lamellæ. The boundary between the series was seldom well-defined, consisting chiefly of curved downward extensions of the laminæ forming the top of the cell; and it agreed, therefore, with that of abdominal cavities. The cells varied greatly in form, size and position, and it was often difficult to trace the complete contour; but the component element was clearly an arched plate; and the changes, whether in outline, dimensions or situation, were only such as would naturally result from the secreting membranes having been successively produced as the coral extended upwards. These cells were manifestly the hollows of the Peasemarsh specimen covered over; and the irregular manner in which they were often piled on each other would account for the complete filling-up between the crests of the perfected exterior. That the crests themselves were not detected in the sections, was ascribed to not an instance being observed of a directly transverse intersection of a lamella. Within the cells frequently occurred subordinate, thinner laminæ, not referable, it was conceived, to dislocated fragments, but they bore the semblance of a secondary structure more or less produced within the primary. In some recent corals, as the *Dendrophyllia ramea* of M. de Blainville, a considerable filling-up is effected in the area of the abdominal cavity not immediately occupied by the stomach-sac. The two cases are not strictly analogous; nevertheless the animal matter which occupied the cells in *Cyathophora? elegans* was doubtlessly nourished by the digestive organs, so long as they occupied a position to afford support to a given vertical area; and in addition to the minute pores in the sides of the cavities, the Peasemarsh specimen showed that the partitions between successive cells were also finely punctured, affording additional means for transmitting support and calcareous matter throughout the whole of the living portion of the polype. From the foregoing statements it is inferred, that the narrow crested lamellæ are only the perfect external state of the broad-ribbed casts, and that the lamellæ are strictly cellular bodies. A notice on the composition of that structure generally would occupy very many pages; but attention may be called to three different examples. In an appendix to Sir R. I. Murchison's work on the Geology of Russia*, instances of a bi-plated composition are mentioned; Mr. Dana alludes to hollow lamellæ in his description of *Ast. Orbicella curta*†; and Prof. Goldfuss, in his delineations of the *Astræa explanata* of Count Munster‡, exhibits a curiously catenated character. The intimate construction of lamellæ deserves the careful study of competent physiologists, and it is conceived that it will be found of great value in attempting to establish generic and specific distinctions.

The plan of producing additional cavities for digestive organs remains to be noticed. Respecting marginal developments, no satisfactory cases were observed of immature states; the boundaries of the lateral extensions presenting a smooth, solid edge (fig. 12), indicative of the animal having been impeded in its operations, and having completed its structures previous to death. Some of these visceral hollows were also small, as if sufficient room had not been afforded for a normal construction; one of the characteristics of such cavities being an area of full or mature dimensions at every stage of formation, whenever adequate space exists. Of young interpolations many examples were noticed. The Red Hill cutting specimen afforded a good instance of an early, but not the first condition (fig. 14). It was surrounded by mature hollows; the form was almost quadrangular, the width about half a line; and the lamellæ, so far as could be ascertained,—some having been broken,—had been equally developed on all sides, with indications of four projecting beyond the rest. Near that case was another rather more advanced, the size being greater and the lamellæ more numerous. Many similar productions occurred in the same specimen as well as among the broad Atherfield casts (fig. 12), allowance being made for different states of preservation. In all cases the relative degree of development was about equal around the interior of the young cavity; and the adjacent mature hollows did not display any defect on the side next the interpolation; whereas in fissiparous processes the lamellæ in early stages are rudimentary along the line of partition, as respects both the parent and the severed offspring, but elsewhere, in each case, of full dimensions. Twin productions were not uncommon. They resembled a long incipient hollow divided about the middle, each cavity being similar in size and

* Vol. i. App. A., art. *Stylastræa inconferta*, p. 621–622, 1845. Count Keyserling in his work on the Petschora-Land, dissents from the bi-plated structures mentioned in the notice of that coral; but the author begs to adhere to his original statement (Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land, p. 153, 1846).

† Exploring Expedition, Zoophytes, p. 209–210; consult also p. 53, 1846.

‡ Petrefacten, vol. i. p. 112, pl. 38. fig. 14 *a*, *b*.

structural development. All the interpolations of *Cyathophora? elegans* clearly originated in the hemispherical or radiating mode of growth, by which greater interspaces were produced than accorded with the ordinary range of the cellated lamellæ. At the incipient points that structure apparently ceased to be formed continuously, and a small area was the result, surrounded by the edges of a very limited number of parted lamellæ. Even in this earliest state, therefore, the essential parts of a cavity existed, and could be supported without the aid of a new digestive apparatus, the component structures being portions of the adjacent mature hollows and nourished by them. As the old lamellæ extended upwards, the young receptacle deepened and widened, and became fit to contain its own alimentary organs, and thereby add to the framework. This manner of production explains why some lamellæ may extend completely between two adjacent cavities, and the remainder have only a limited range. In *Siderastræa galaxea* the interpolating process is modified in conformity with the peculiarities of the coral. The mature abdominal hollows are separated by somewhat broad and raised interspaces, and the first signs of an additional one is a shallow depression, due apparently to a suspension of calcareous secretions. In that state no new laminæ are visible; the bottom and sides of the little concave area being composed of smooth plates and transverse bars belonging to the quadrangular network; but in a slightly advanced stage, finely attenuated additions had been made to the edges of the former, so far as they bordered the sides of the cavity, whereby they assumed a decidedly lamellated character; while in other cases, which exhibited a little further progress, similar plates had acquired the form and disposition of converging lamellæ, with a small central axis; the young hollow resembling a diminutive mature one; and the early perfecting of the star accords with the general structure of the coral. Another mode adapted to the peculiarities of the case is exhibited by a polyparium resembling Ellis and Solander's figure of *Astræa pleiades* (tab. 53. fig. 7, 8), but which does not strictly coincide with the descriptions of that species, or any other known to the author of these memoranda. The interspaces however are more or less concave, and traversed by outward extensions of the lamellæ, generally attenuated, and often curved; they occasionally present also distinct, prominent papillæ, and the base is an apparently continuous solid plate. In this case, the bottom of the interval being below the margin of the stars, no preparatory depression was requisite; and the first indication of an incipient cavity is an irregular convergence of thin laminæ, issuing from the edges of the old lamellæ, with the addition of others similarly slender; the whole uniting in the middle of the area and presenting an imperfect star: a little more advanced state has rays of greater regularity, a decidedly reticulated centre, and a projecting circular boundary; or it exhibits a completely formed, small visceral receptacle. In this coral, as in the preceding, the lamellæ occupy to a great extent the interior of the cavity, and are therefore primarily developed; no particular depression however is prepared, but a boundary is constructed; the former not being necessary in this instance, nor the latter in *Siderastræa galaxea*, which has interspaces uniformly on a level with the margin of the abdominal hollows. A third example may be mentioned, as it occurs in a coral the visceral receptacles of which have no central structure during growth, and only rudimentary lamellæ while in that condition. The *Heliopora cærulea* of M. de Blainville possesses considerable, uniformly level intervals formed of minute, continuous tubes crossed by laminæ. The additional cavities occur almost wholly towards the upper extremity of the foliations or lobes, but they are decidedly formed in the intermediate composition. The first indication is a shallow, irregular depression, due probably to a natural disruption of the tissues which had previously fabricated the tubuli. The little area is, apparently, soon modeled into a circular shape; and the slightly projecting perpendicular plates, which would have formed the sides of minute tubes, had no breaking-up of membranes occurred, become the first-formed narrow or rudimentary lamellæ. The network at the base of the hollow, arising from the discontinued structure, continues open for a time, but is ultimately covered by a solid layer, the first of the laminæ, by which the area is successively crossed. This is perhaps one of the simplest modes by which the operation is effected among Anthozoa; all that is wanted being a mere receptacle for the stomach-sac.

The statements given in a former paragraph respecting fissiparous developments, as well as those just mentioned, prove that in each of the two great processes, previously existing solid materials and animal tissues are associated in the young cavity with others which are new, and contribute towards its perfect formation. These combinations also plainly show, that however the modes of effecting the results may differ, they are but modifications of one plan. Distinctions nevertheless exist deserving the most attentive consideration, when an attempt is made to establish subordinate groups. In bipartitions, the contents of only one mature cavity are concerned; while in interpolations those of two or more contribute to the task: again, in fissiparous separations the additions are confined to the dividing structure, and are as necessary to the perfecting of the parent's composition as to that of the offspring; but in the other process old and new lamellæ or plates are intermingled throughout the circuit of the young area, and entirely confined to it. These are obvious differences, which require no skill in discovering; and though the experienced physiologist can alone appreciate their importance, the study of them with others of a similar nature cannot be too earnestly pursued by the palæontologist.

The next coral to be considered was labelled "*Cricopora gracilis*," but without stating whether the specific term had been adopted or was considered new*. The Isle of Wight fossil, however, is clearly not identifiable with the *Cric. gracilis* of M. Michelin†, nor with

* Consult Dr. Fitton's Memoir, Quart. Journ. Geol. Soc. pp. 302, 327*, vol. iii. Aug. 1847.

† Iconographie Zoophytologique, p. 4. pl. 1. fig. 8.

the *Ceriopora gracilis* of Prof. Goldfuss*, regarded by the former authority as the same coral. The English fossil consists of slender, forked branches, very numerous and closely aggregated in the specimen examined (fig. 16). On one side the branches present large circular apertures in general irregularly distributed, but sometimes arranged transversely (fig. 17); and now and then, in consequence of the occurrence of interrupted vertical lines, they appear to be disposed in perpendicular rows (fig. 18). Between these large openings are others much smaller, less regular in form and more numerous, constituting a kind of reticulation; the two series being easily distinguished. On the opposite side of the branches the major apertures are wholly wanting (fig. 19), care being taken to guard against deceptive indentations produced by grains of sand; and the entire surface offers to view a fine network similar to that between the visceral openings of the direct front. The central portion of the coral is composed of tubes which have a considerable downward range (fig. 20), the round apertures being their surface-terminations; and beneath the general reticulation, which forms an investing layer, minute tubuli range horizontally inwards (fig. 22).

Cricopora was proposed by M. de Blainville (Man. d'Actinol. p. 420) as an amended designation for the *Spiropora* of Lamouroux (Exp. Méthod. p. 47), the apertures of the visceral tubes being disposed in circles around the branches, and not spirally: the genus has moreover but one description of openings, independent of textile pores†. The surface-characters alone therefore are sufficient to separate the lower greensand fossil from *Cricopora* as established by M. de Blainville; and it is not necessary to notice species subsequently added to it. The bifold nature of the apertures would suggest that the extinct coral under examination might be an *Heteropora*; but the visceral tubes terminating only on one side of the branches, is opposed, in the present state of knowledge, to a generic identification. The portions traversed by longitudinal ribs (fig. 18) resemble strongly a fossil referred doubtfully by M. Roemer‡ to *Chrysaora* of Lamouroux§. If rightly understood, figure 29 *d* of the former authority exhibits in the transverse section a quaquaversal radiation of abdominal cavities; and it is evidently a careful delineation. Should the inference be correct, it would be necessary to show, before a generic identity could be admitted between the two fossils, that in all other essential particulars perfect agreement exists, and that the difference is only specific. No doubt however can be entertained that the English extinct zoophyte is not a *Chrysaora*.

The only genus known to the author of this notice which demands a detailed comparison with the lower greensand production, is

* Petrefacten, p. 35, pl. 10. fig. 11.

† Consult Lamouroux, tab. 73. fig. 19–22, tab. 82. figs. 9, 10, 11, 12.

‡ Verst. Norddeutsch. Kreidegebirges, p. 24, *Chrys. pulchella*, tab. 5. fig. 29, *a*, *b*, *c*, *d*.

§ Exposition Méthodique, p. 83. Consult pl. 81. fig. 6, 7, and fig. 8, 9, for generic external characters.

the *Hornera* of M. Lamouroux*, and founded on a recent coral obtained by Tilesius on the coast of Kamtchatka. In describing his only species, *Horn. frondiculata* (*loc. cit.* p. 41), M. Lamouroux refers doubtfully to the *Millepora lichenoides* of Linnæus†, the *Millepora tubipora* of Ellis and Solander‡, and Lamarck's *Retepora frondiculata*§; but M. Milne-Edwards, in his well-known memoir on the genus||, seems to consider the whole three as true synonyms of *H. frondiculata.* How far Tilesius's coral is really identical with that of Linnæus, Ellis and Solander, and Lamarck, can be gleaned only from Lamouroux's figures; but if they are correct delineations, that authority was apparently justified in marking his references as doubtful. Moreover, it should not be forgotten that Tilesius obtained his zoophyte on the coast of Kamtchatka, while that of Linnæus, &c. exists in the Mediterranean. MM. de Blainville and Milne-Edwards¶ having however adopted unqualifiedly the term *Horn. frondiculata* for the Mediterranean Ascidian polype, it must be considered in this notice as the type of the genus, and as such be the subject of comparison with the Isle of Wight fossil. The existing as well as the extinct coral is strictly tubular; in each, those visceral cavities open on only one side of the branch; each also has subordinate apertures independent of textile pores over the whole surface; but they are far less numerous in *Horn. frondiculata* than in the fossil; and the exterior of both is modified by age. Were these agreements considered by themselves, they might be regarded as warranting a generic identity; but a comparative analysis of each structure will show something more than specific distinctions.

M. Milne-Edwards's general figure of *Hornera frondiculata* (*op. cit.* pl. 9. fig. 1) represents most completely the peculiarities of growth, or strong main branches with numerous relatively slender side-shoots, the latter presenting a uniformly very small breadth even close to the base of the specimen: a similar character is visible in Ellis and Solander's figure (Nat. Hist. Zoophytes, pl. 26. fig. 1); likewise in that of Esper (Pflanz. Mill. tab. 3), and Pallas (Elenchus, Germ. Trans. tab. 12. fig. 42). They were still more prominent in specimens presented to the author by the Rev. W. Hennah, and which will be the chief source of the following remarks. The main branches in the youngest state are slender, and formed almost wholly of tubes; the large apertures project, particularly on the side of the

* Exposition Méthodique, p. 41. tab. 74. figs. 7, 8, 9. In the description of pl. 26. fig. 1, the coral so delineated by Ellis and Solander is also called *Hornera frondiculata* and without a note of interrogation; nevertheless, no allusion is made in the body of the work to that figure. See note ‡ *infra.*

† Syst. Nat., Edit. x. tom. i. p. 791, 1758. Consult Esper's Pflanzenthiere, Millepora, tab. 3.

‡ Natural History of Zoophytes, p. 139. pl. 26. fig. 1, 1786, apud M. Milne-Edwards's Memoir on Hornera, *infra* note ||.

§ Anim. sans Vert. Edit. 1816, tom. ii. p. 182; Edit. 1836, ii. p. 277.

|| Annales des Sciences Naturelles, 2nd Series, Zool., tom. ix., 1838, or Recherches sur les Polypes, Mém. sur les Crisies, p. 17 *et seq.*

¶ De Blainville, Man. d'Actinol. p. 419; Milne-Edwards, *op. cit.*, and 2nd Edit. Lamarck, tome ii. p. 277 and *note.*

stems, and between them are interlaced fibres with small pits or foramina. The reverse side of the same portion is strongly though irregularly ribbed, and there are considerable interspaces traversed also by fibres, often disposed obliquely as respects the area, but vertically with reference to the growth of the branch. The intervals have likewise distinct pores. In the specimen immediately under consideration the whole surface of the stems began to be modified about three lines from the upper extremity by a fibrous thickening, which gradually increased downwards, widening also the branches, and filling up more or less completely the spaces between the projecting openings, and finally obliterating, in very aged conditions, the latter, rendering both surfaces nearly uniform in character. The lateral shoots and their offsets preserved, on the contrary, an equal breadth from their point of divergence nearly to their extremity, even in a case nine lines in length, and on whatever part of a specimen they were situated. These shoots were apparently the young branches of M. Milne-Edwards*; but the long-continued, if not permanent differences between them and the main stems, are not apparently alluded to by him. The shoots with their offsets had a very hispid appearance. M. Edwards says, that in young branches, "la portion terminale des cellules est très saillante, et l'espèce intermédiaire rugueuse" (*op. cit.* p. 44, desc. fig. 1 *a*). On coating one with ink, and examining it under a Codrington lens, the intervals were clearly traversed by fine ribs, sometimes parallel, but often converged towards each other, forming a lozenge-shaped figure around the apertures. These areas were indented or foraminated similarly to those of the main stems, but no fibres were detected, nor decided thickening, though the shoot was five lines in extent. The reverse side was occupied by broad granulated ribs with fine intermediate furrows†, but not a vestige of a fibrous structure was visible throughout even the nine-lines shoot. The difference between a thickened and non-thickened surface is well-expressed in M. Edwards's figure 1 *a* (letters *a* and *b*); but it is most conspicuous in specimens themselves, and in those portions where the shoot issues from the side of an aged stem, not the least encroachment of the fibrous structure being visible upon the former. It is of little importance in the present inquiry whether the differences are permanent or not; it is sufficient to point out their existence under certain conditions. In the lower greensand fossil no similar distinctions exist, all branches being perfectly alike; and the thickening is not effected by longitudinal fibres, but by local amorphous secretions. Respecting the minor openings in main stems of *Horn. frondiculata*, fragments purposely worn down showed that they were only foramina which penetrated the general crust of the coral, and not distinct tubuli with a surrounding open area. Lateral shoots prepared in the same manner also proved that the surface minor openings were pores in the wall of the tubes. In the Isle of Wight fossil, however, the secondary apertures on both sides of a branch have, within the body of the

* *Op. cit.* pp. 18, 19; also pl. 9. fig. 1 *a*, with description of figure, p. 44.

† Consult M. Milne-Edwards's figure 1 *c*, *op. cit.* pl. 9, and description, p. 44.

coral, a distinct boundary often more or less encompassed by translucent, brown calcareous spar; intimately a tubular structure, and an occasional isolation from all other organic matter. Without extending the comparison, these differences are deemed sufficient to separate the lower greensand fossil from *Hornera*; and as similar subordinate tubuli have not been included in the characters of any established genus, it is proposed to make the extinct zoophyte the type of a new one, with the designation *Siphodictyum*, from *σίφων*, *tubus*, and *δίκτυον*, *rete*, in allusion to the horizontal tubuli terminating in a network on the surface. The specific name "*gracile*" is retained for the sake of identification with the previous determination.

Siphodictyum, n. g.

Gen. char.—Tubular; the tubes forming branches, and opening only on one side of them; interspaces and all the reverse surface occupied by a network of minor pores; exterior of branches progressively altered by local secretions; interior occupied by downward prolongations of the visceral tubes, and traversed horizontally by small subordinate tubuli, connected with the surface-reticulation; additional tubes developed between pre-existing.

Siphodictyum gracile.

(Pl. V. figs. 16 to 23.)

Spec. char.—Branches cylindrical, slender, forked, cæspitosely aggregated; surface sometimes traversed vertically by discontinuous, longitudinal ribs; in aged conditions rugose; openings of the visceral tubes circular, very distinct, margin sometimes slightly projecting; order of distribution generally irregular, occasionally transverse, where the longitudinal ribs occur, vertically lineal; minor openings arranged in rows between the ribs, elsewhere retiformly.

The fine specimen submitted to examination by Dr. Fitton consisted of innumerable slender branches, the upper extremities of which presented a cæspitose area nearly 2 inches long and $1\frac{1}{4}$ wide. On the side where the general character of the branches was shown, considerable dislocations occurred; but in one instance was a clear succession of forked branches for $1\frac{1}{3}$ inch. Not the slightest means were afforded for determining the nature of the original base, but it probably resembled that of M. Roemer's *Chrysaora? pulchella* (*op. cit.* tab. 5. fig. 29*c*), or a solid disc, from which sprang single, closely aggregated stems. The branches were simply and in general uniformly forked (fig. 16); and the plane of separation was almost invariably the same in successive bifurcations. The intervals between the points of subdivision were very irregular, varying from $\frac{3}{4}$ths of a line to 3 lines. The differences in the dimensions of a branch due to thickening were small, the breadth of the younger conditions being about $\frac{3}{8}$ths of a line, and that of the older half a line. Most frequently no increase preceded a bifurcation; and sometimes no difference was perceptible between the undivided branch and each of the shoots.

Notwithstanding the great extent of the specimen, a very young state was not observed. Supposed early but mature conditions (fig. 17) exhibited round, sometimes slightly raised tubular terminations, which opened in the same plane with that of the general surface; and when arranged transversely, they in general constituted well-marked ridges. The longitudinal ribs also scarcely projected (fig. 18). The secondary apertures varied in form, likewise in size and distinctness; and their margins were depressed or inclined inwards*. A presumed somewhat older state had a rougher surface in consequence of increased boldness in the framework of the reticulation; while the tubular openings were depressed rather than raised, and the transverse rows did not form ridges: in an apparently still older fragment the rugosity of the exterior was much greater, the major apertures were irregular in outline, and the minor diminished in size; the network was also obliterated: lastly, in what was considered an aged condition the mouths of the tubes were often indistinct, and the secondary pores were reduced to punctures in rugose projections. The changes on the reverse side agreed completely with those just mentioned, so far as concerned the network.

Transverse sections (fig. 21) presented a tubular area, and an exterior opake zone, in which could be detected occasionally the outward range of the visceral tubes; also horizontally-intersected minute tubuli, which in two cases apparently ranged from the surface-network to an abdominal hollow. The internal vertical composition, so far as respected the tubes, was tolerably shown in two translucent slices (fig. 20). Those cavities, as before stated, had a considerable extension, the inferior termination being generally in the axis of the branch. Their area was invariably clouded by peripheral structures, in which very minute bright specks could be detected; and occasionally a larger circle, believed to be one extremity of the slender, horizontal tubuli just mentioned; but not a trace was discovered of a transverse lamina indicative of the digestive organs having changed their position. Between the walls of adjacent tubes was very often a fine line similar to that mentioned in the notice on *Choristopetalum impar*; but in some cases it was evidently an early condition of a young cavity, as it gradually expanded upwards, and assumed the characters of a mature state; while in others less clear, it appeared to mark a structural separation between the walls, being more or less continuous without any increase in width. The nature of the reticulated zone was ascertainable only in fragments purposely abraded to different depths, and even then the detection of the characters required care. A small portion of a branch slightly rubbed down presented obliquely exposed visceral cavities, with minor opake circles generally in contact, but sometimes with a faint indication of a separating paler line, the circles clearly representing the secondary surface-apertures. Another fragment (fig. 22), more deeply worn, exhibited in the middle longitudinally exposed tubes, but at the sides and upper extremity of the branch, where less had been removed, large ovals

* A Shanklin specimen, obligingly lent the author by Mr. Morris, afforded perfectly similar characters. For a notice of the existence of the coral at that locality, consult Dr. Fitton's Memoir, p. 318 *op. cit.*

with small circles similar to those just mentioned, but occasionally surrounded by a narrow translucent interspace resembling in colour the spar which filled the cavities, and the minute area within the circles. A third portion, laid open nearly to the centre, differed not in character from translucent slices. A slightly-abraded reverse surface of an Atherfield specimen, presented to the Geological Society by Prof. Edward Forbes and Capt. Ibbetson, exhibited (fig. 23) vertical rows of opake-white links with narrow, translucent, intermediate lines; and a little lower, where the surface had been more deeply exposed, the links were not arranged lineally, and were detached from each other by a very narrow pale band. Part of a thin slice displayed also several detached circles, the inner areas and intervening spaces agreeing in colour and amount of clearness. Again, a fragment purposely worn down unequally, gave in the upper or least abraded portion, irregularly distributed circles, either in contact or separated by very fine pale lines; while lower down a deeper wearing laid open first circles of smaller dimensions with an increased interspace; and still nearer the lower extremity, intersections of three tubes with gradually narrowing intervals in which circles could just be detected. From these observed characters, it is inferred that the meshes of the exterior network were not mere pores in the outer layer of the coral, but tubuli possessed of as distinct walls as the visceral tubes.

Additional cavities, so far as concerned the upward growth of the coral, were developed chiefly in the middle of the branch, converging to the very centre as they descended; but occasionally a minute opening surrounded by mature tubes was detectable near the outer or reticulated zone.

As regards the position of *Siphodictyum* in a general classification, little doubt can be entertained of the coral having been formed by an ascidian polype. The simple abdominal cavities, uncrossed by transverse laminæ, were clearly adapted for the reception of digestive organs, which did not change their position; and the length of the tubes is not greater than that requisite for complicated viscera with rigid tentacula. Among the great groups comprising that class, the nearest agreement is with the family Tubuliporidæ of M. Milne Edwards, and to which he has removed *Hornera* (*op. cit.*). Some of the best-known genera however, as *Tubulipora* and *Crisia*, do not thicken conspicuously, if at all, the exterior of their tubes; and the mode in which the process is effected in *Hornera* differs, as already stated, materially from that in *Siphodictyum*. In this respect the fossil resembles the Escharidæ, the additions being purely local, and producing external irregularities of surface; but the absence of all signs of an operculum essentially distinguishes the extinct coral from *Eschara* and allied genera, and associates it with those forming the Tubuliporidæ*. It is therefore proposed to place *Siphodictyum* provisionally in that family of ascidian zoophytes.

The fifth fossil had not apparently been named; but when first examined, it was conjectured to be that which is alluded to in the

* Consult M. Milne-Edwards, *op. cit.*, Mém. sur les Tubulipores, p. 5.

published list, No. 13. (Quart. Journ. Geol. Soc. vol. iii. p. 302) under the term Heteropora; and the mistake was not detected till the describer was favoured, through Dr. Fitton, with the Atherfield polyparia in the Museum of the Geological Society of London. In that collection a branch of *Choristopetalum impar* was labelled 'Heteropora.' The specimen of the coral about to be considered, and which forms a portion of Dr. Fitton's private cabinet, was imbedded in the same mass of sandstone as the fine example of *Siphodictyum gracile* mentioned in the preceding notice.

The fossil consists of cylindrical, forked branches (fig. 24), occasionally anastomosed; the exterior (imperfectly preserved) has round apertures (fig. 25) irregularly distributed over the whole surface, and variable in character according to age, and, in the specimen examined, to the state of preservation; the general surface is also modified by external additions; secondary or minor apertures are detectable occasionally near the large openings: internally the coral is composed of elongated simple tubes, more or less separated by an open interspace or fissure (fig. 26). These characters must be regarded as very imperfect indications of the fossil's structure; the surface of the specimen being so incrusted with matrix, that it was impossible to obtain satisfactory evidence of external composition.

If the portions with slightly projecting tubular apertures were considered as presenting a mature, characteristic condition, the Atherfield coral might be referred to the Pustulopora of M. de Blainville*, especially as exhibited in *P. madreporacea* (Goldf. pl. 10. fig. 12) and *P. pustulosa* (pl. 11. fig. 3), but in those fossils no open space or line of separation between the visceral tubes is either delineated or alluded to under any condition; nor are secondary openings or irregular thickenings noticed or represented. M. de Blainville states that the tubes or "cellules" are "peu saillantes, pustuleuses ou mamelonnées" (*op. cit.* p. 418); but M. Milne-Edwards† describes an existing Mediterranean species, *P. proboscidea* (*op. cit.* pl. 12. fig. 2), with projecting, free extremities "exactement comme chez les Tubulipores" (*op. cit.* p. 27). The lower greensand fossil had not, it is believed, at any time free, protruding, visceral tubes similar to those represented by M. Edwards (*loc. cit.*), with a simple, tubular extremity in the most advanced stage, but in a mature state, a pustulous aperture developed at that particular period of growth. The author of this notice is indebted to the liberality of Prof. Edward Forbes for two specimens of a Mediterranean coral agreeing perfectly with M. Edwards's figure, but differing most materially from that found at Atherfield. Two new extinct species, described and figured in the memoir above-quoted (*op. cit.* pl. 11. fig. 4, pl. 12. fig. 1), agree in general composition with *P. proboscidea*; and if the inquiry be ex-

* Man. d'Actinol. p. 418: see Goldfuss's delineations of the four species of Cerioporæ, on which the genus is founded, Petref. pl. 10. fig. 12. fig. 8, and pl. 11. fig. 3. fig. 1.

† Ann. des Sc. Nat., 2nd series, Zool., tome ix., Mem. sur les Crisies, &c., or Recherches sur les Polypes, &c.

tended to the additions made by M. Michelin * and Herr Roemer †, the characters of the Isle of Wight zoophyte will not be apparent; but should those structures be hereafter shown to exist, still as they do not occur in the fossils on which the genus was founded, such species would have to be removed from M. de Blainville's *Pustulopora*. It is not considered necessary to prolong the comparison to other delineated corals which present a limited amount, not an aggregate of agreements; and the compiler of these memoranda not being aware of any established genus possessing a union of characters similar to that already mentioned, and to be further noticed in the following remarks, it is suggested that the Atherfield fossil may be designated *Chisma* (χισμα, *fissura*), in allusion to the intervals between the tubes.

Chisma, n. g.

Gen. char.—Tubular, branched; tubes simple, in contact, or separated by an interspace of variable breadth; apertures irregularly distributed over the whole surface, not mere tubular terminations; exterior of branches formed of more or less exposed portions of tubes, progressively modified by external additions.

Chisma furcillatum, n. sp.

(Plate V. fig. 24 to 28.)

Spec. char.—Branches cylindrical, forked, occasionally anastomosed: plane of successive bifurcations at right angles; tubes variable in form, slightly divergent, seldom bent suddenly outwards; aperture at distal extremity of exposed portion of the tubes; in mature and advanced states pustulose; breadth of tube uniformly small in the middle portion of the branch, considerable at the sides; external thickening of branches rugose.

The specimen submitted to examination occupied an area about one inch and a half square, throughout which the branches were loosely distributed, but possibly at about their original relative distance. There was not the slightest indication of a base or mode of attachment. The diameter of the stems was nearly a line; and no marked difference in dimension was noticed between the undivided portion and the two shoots, near the point of separation. The bifurcations occurred at irregular distances, and the mode of branching had not been strictly uniform; but there was a marked tendency to divide in alternate planes. Wherever the branches had come in contact, a perfect union had taken place.

A fragment (fig. 25) which was believed to represent in part an unthickened, though not perfectly preserved exterior, displayed in the upper portion, a surface composed of a variable amount of exposed

* Iconog. Zoophyt. p. 210 to 212, pl. 53. figs. 2 to 6.

† Versteinerungen des Norddeutschen Kreidegeb., pp. 21, 22. pl. 5. fig. 23, 24.

tubes, the boundary of which was defined by a distinct line, arched at the distal extremity, and straight or curved at the sides according to the relative position of the adjacent cavities. The visible surface was nearly flat or very slightly concave, and though not completely preserved, was yet clearly composed of the original coral, being penetrated by minute pores similar to those in the side of vertically intersected tubes: one limited area also presented between and around the apertures a nearly smooth surface with very faint traces of boundary-walls. The opening situated at the very distal extremity of the tube, but in the same plane with the surface of the branch, varied in form from circular to transversely oval, occupying the whole breadth of the interior of the cavity; and the margin was in general slightly raised. In this part of the specimen, the space between the interior of two adjacent visceral hollows was very narrow, with scarcely a trace of the walls being divided medially; but lower down, where the interval was greater and the abrasion apparently deeper, a distinct partition-line was occasionally visible, especially around the arched end of the tube. A seemingly thickened exterior exhibited an irregular surface with projecting apertures, and no signs of boundary-lines either above the mouths or down the sides of the cavities, the occasional lacunæ being evidently partial abrasions. No satisfactory proofs of a change in the openings were visible; but in another branch a small foramen appeared in the middle of mammillated casts, and indicated an advanced stage, possibly a precursory one to a total filling up.

The characters of the cavities within the branches was well shown in nearly vertical translucent slices (fig. 26) and polished sections (fig. 27). The difference between the breadth of the tubes immediately adjacent to the exterior, and those in the middle area of the branch was very great, where the intersection passed through the centre (fig. 26); but that the latter were mere downward attenuations of the former, no doubt could be entertained, as broad cavities were traced into narrow. Nevertheless the dimensions of the tubes were not always strictly uniform in equivalent positions; circumstances which affected the plan of growth evidently influenced the breadth also. The total range of the cavities could not be clearly determined, but it was manifestly considerable, exceeding many times the widest portion; not a trace however of a transverse lamina was detected. The form was cylindrical where an interspace existed (figs. 27, 28); but when the tubes were nearly or quite in contact, the outline was more or less modified by mutual interference. In the notice on external structures, the surface is stated to consist of exposed portions of visceral hollows with a flat or slightly concave outline, the aperture being situated at the distal extremity. The equivalent part in translucent slices (fig. 26) almost invariably consisted of a curved or nearly straight, thin, opake layer, which did not range conformably with the side of the tube, but crossed obliquely the broad extremity, constituting a special structure for closing at a particular period the ample tubular area. The apertures were not always apparent, yet, in some cases, at the upper extremity of the oblique layer was a marked prominence, agreeing in position and form with the openings on the surface of the branches; and it occupied only a limited portion of the oblique covering; or its depth was very much less than the diameter of the cavity. These characters prove, to the extent of the fragments examined, that the apertures were not simple tubular extremities, like those in *Siphodictyum gracile*, *Tubulipora*, &c., but a distinct structure. In the genus *Eucratia** of Lamouroux, the visceral cell swells out from a very narrow base (Lamarck's 2nd Ed. *loc. cit.*), and the ample interior is closed obliquely in a manner similar to that stated above, as shown in M. Milne-Edwards's figure (*op. cit.* pl. 8. fig. 1); but Prof. J. Reid† has explained that the covering is a membrane, and that it falls off when the polype is dead; and M. Edwards had previously delineated the operculum by which the small aperture is closed when the tentacula are drawn in (*loc. cit.*). In *Chisma furcillatum* the oblique layer differed not in composition from the sides of the tubes, and no signs of an operculum were noticed. The walls of the cavities were distinctly foraminated, presenting sometimes even a sieve-like texture; and they appeared to vary in thickness, in consequence of the intersection including a portion of the curvature of the tube (fig. 27); but the actual dimension was small. The character of the interval between adjacent walls depended seemingly on the position of the cavities, and on circumstances which permitted a certain amount of divergence. Sometimes scarcely a vestige of an interspace was detectable in the middle area of a branch (fig. 26); while in other sections less centrally exposed, a small divisional line was occasionally quite distinct; and in a third case (fig. 27) a fissure prevailed nearly throughout, acquiring in one part great prominence of character. The principal specimen afforded instances of each condition. Oblique or transverse slices exhibited also a variable amount of interval. In general the minor fissures were more or less clouded, and at times appeared to be crossed by a bar or filament; but in the wide spaces (fig. 27) the evidence was in favour of a clear chasm, allowance being made for the interference of tubular walls situated behind the plane of section. A transverse slice (fig. 28), with considerably separated cavities, showed no regular intermediate structure, but the cloudiness in the fissure was generally greater than that within the tube and dissimilar in character. The indications of cross-bars were likewise few and unsatisfactory, as proofs of composition, when examined with a sufficient power. This want of connecting structures under certain circumstances suggests the inference, that the walls of adjacent cavities were not primarily united, or that there was no interblending of the secreting membranes. Roughly fractured branches afforded sometimes a crenulated surface

* Lamouroux, Expos. Méthodique, p. 8, pl. 65. fig. 10 (*Euc. chelata*): consult also Milne-Edwards, 2nd Edit. Lamarck, tom. ii. p. 188 *note*, and Ann. des Sc. Nat. 2nd Series, Zool. tome ix. pl. 8. fig. 1. p. 11, Des Crisidies, or Recherches sur les Polypes, Mém. sur les Crisies, &c.

† Ann. and Mag. Nat. Hist. vol. xvi. p. 392 (*Crisia chelata*), pl. 12. fig. 10, 1845. Consult also Dr. Johnston's Brit. Zoophytes, 2nd. Edit. p. 288–290, 1846–1847.

composed of salient and re-entering angles, proving considerable lateral interference; yet it was difficult to determine how far the severed portions gave freely parted walls. The apparently outer sides of these compressed hollows were punctured in the manner mentioned in noticing the composition of the tubes; but if rightly understood, the best exhibited surfaces were not smooth, although they displayed no rough broken edges or points indicative of a fractured intermediate structure. The nearly perfect exteriors, it must be remembered, afforded very faint or no signs of a dividing line; and the supposed thickened area had a continuous layer around and between, intimating a complete union in that state. These imperfectly observed characters are nevertheless believed to be in nowise opposed to the conclusion of the adjacent walls having been unconnected when first developed. The foramina in their sides were necessarily designed for a specific purpose; and possibly they afforded a passage to vessels that nourished the animal substance which occupied the narrowest as well as the broadest interspaces; and as this portion of the polype was unprovided with the means for forming a definite structure, calcareous matter was probably deposited in a pulverulent state, filling partially or wholly the finer intervals, and clouding more or less the wider, according to the relative age or position of the examined fragment. Whatever may have been the real nature of these spaces, or the functions of the animal matter, it is perfectly clear the polype-tissues which constructed the whole body of the coral must have had a far simpler organization than those that developed the solid fabric of *Siphodictyum gracile*. Better examples of the impropriety of limiting the term *polypus* to the viscera and the appendages around the mouth could not be advanced. In both the fossil genera, the digestive apparatus and the tentacula could not, reasoning from what is known of existing ascidian zoophytes, have differed greatly; whereas the animal matter which occupied the interspaces, and in one case produced a complicated structure, but in the other has left scarcely a trace of a regular composition, could have possessed little organic sameness. Limit the term *polypus* to the portions that filled the tubes, and the animals might be considered identical; extend it to the whole of the soft parts, and the most marked differences become apparent.

Additional cavities sprang chiefly from the direct centre, but a minute circle or angular area could be detected occasionally nearer the circumference, and in some cases they were arranged on each side of a faint curved line which traversed more or less medially cross sections. Though no direct evidence was obtained, yet these lines were considered as precursors of a bifurcation. They were clearly not the effects of anastomosis.

The foregoing statements, it is conceived, justify the inference that the extinct coral was formed by an ascidian polype; and that it should be placed provisionally among the Tubuliporidæ.

Diastopora, Lamouroux and Milne-Edwards.

A specimen belonging to an affixed species of this genus was noticed on a fragment of *Choristopetalum impar*, but its state of preservation did not permit the characters to be ascertained.

Summary of Species.

Amorphozoa.

1. Conis contortuplicata.

Anthozoa.

2. Choristopetalum impar.
3. Cyathophora? elegans.

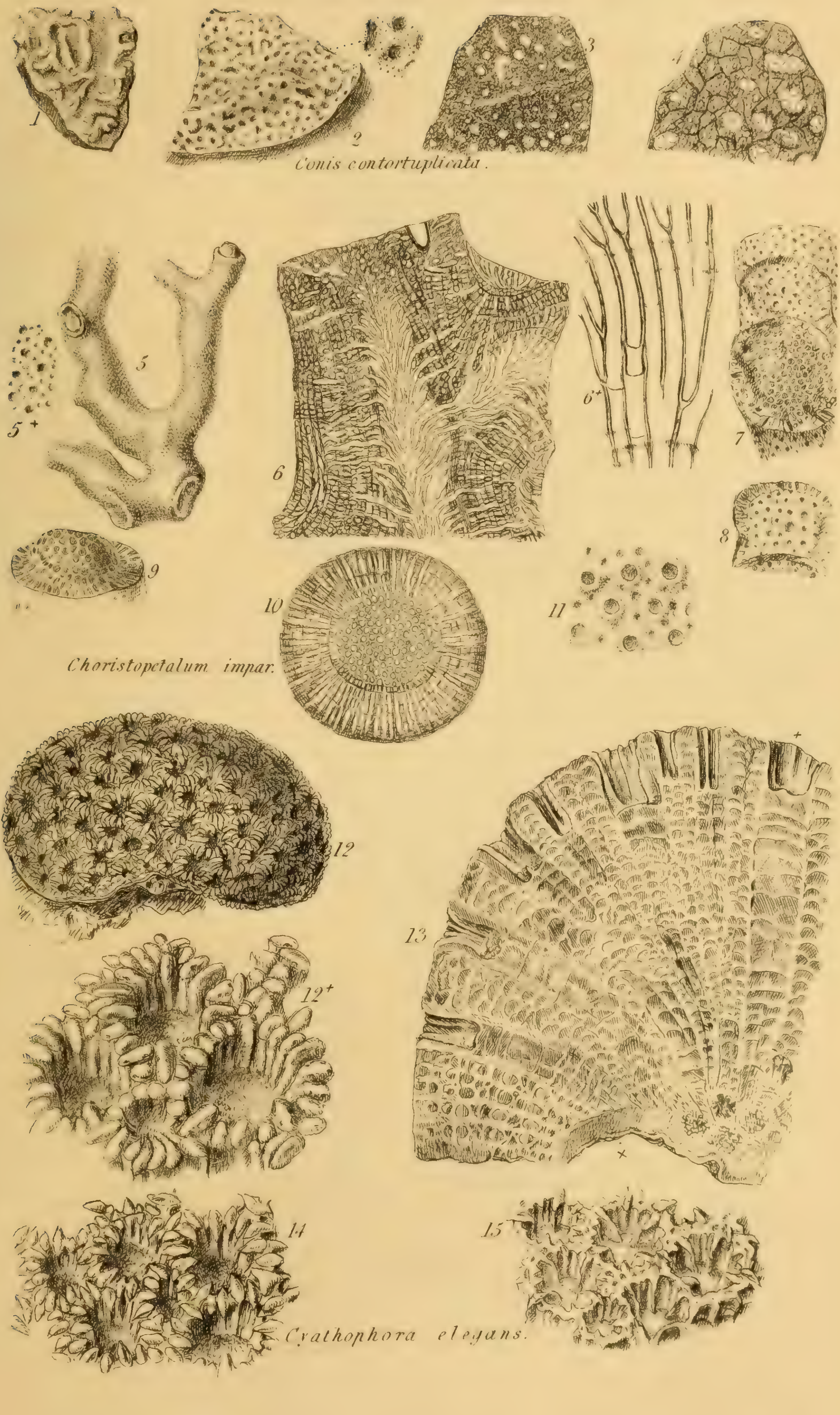
Bryozoa.

4. Siphodictyum gracile.
5. Chisma furcillatum.
6. Diastopora ——.

EXPLANATION OF PLATES IV. AND V.

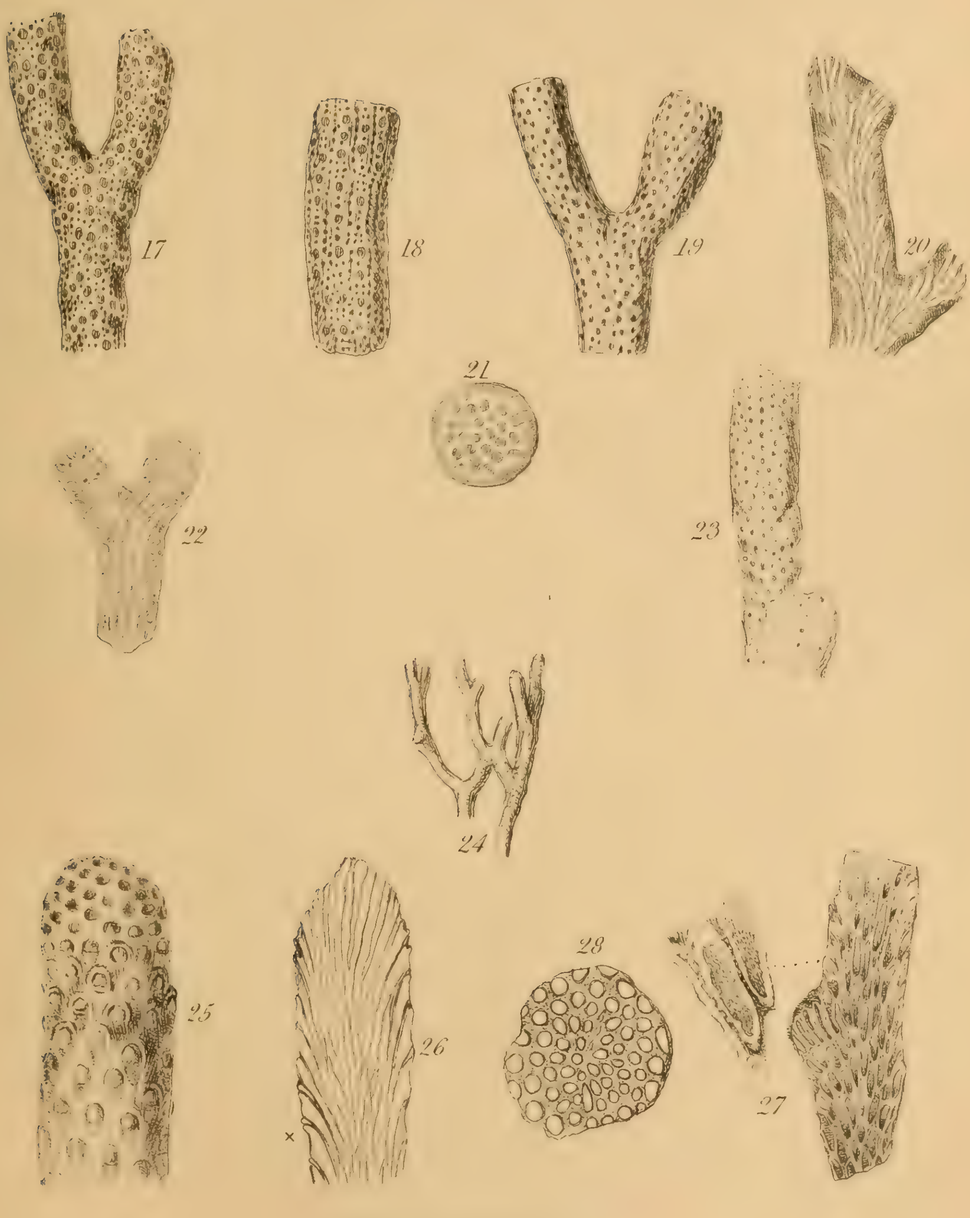
Plate IV.

Fig. 1. *Conis contortuplicata.* External appearance, nat. size.
2. Portion of surface, enlarged, to show the characters of the lacunæ and pores.
3. Internal structure, enlarged.
4. Another section in which the fibrous structure is shown.
5. *Choristopetalum impar.* General mode of branching, nat. size. 5*. Portion enlarged to give the two sets of openings.
6. Vertical section, mag. 5 diameters. 6*. Outline from a direct centre to exhibit the transverse laminæ in the tubes, and traces of concentric layers.
7. The portion immediately above the transverse fracture displays the surface of the lower lamina of a concentric layer, mag. 5 diam.
8. Surface of the upper lamina or counterpart of fig. 7, mag. 5 diam.
9. The central boss, gives a transversely exposed concentric lower lamina, mag. 5 diam.
10. Transverse section, mag. 5 diam.
11. Perfect surface, enlarged.
12. *Cyathophora? elegans*, nat. size. General appearance. 12*. Portion, mag. 4 diam.
13. Nearly vertical section. Fig. 13 to 15 mag. 4 diam.
14. Portion of a perfectly preserved exterior, figures 12, 12* giving only casts.
15. Portion of a specimen killed during development.



J. De C. Sowerby. fecit.

Siphodictyum gracile.



Chisma furcillatum.

J. De C. Sowerby fecit

PLATE V.

Fig. 16. *Siphodictyum gracile.* General plan of growth, nat. size.
17. Front of a branch. Fig. 17 to 23 mag. 7 diam.
18. Front of another branch, traversed by fine longitudinal lines.
19. Reverse surface.
20. Vertical section through the centre.
21. Transverse section.
22. Slightly worn down front.
23. Slightly worn down reverse side.
24. *Chisma furcillatum.* General plan of branching, nat. size.
25. Nearly perfect exterior, mag. 7 diam.
26. Vertical section. The position of the mouth to the tube is indicated in some cases, as near x, by a small projection; and the interval between the tubes by the little space immediately above the projection: mag. 7 diam.
27. A section nearer the original surface, mag. 4 diam.: the character of the intervals between the tubes is shown in the portion greatly enlarged.
28. Transverse section, mag. 7 diam.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

July 1st to October 31st, 1848.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Agricultural Society (Royal), Journal. Vol. ix. part 1.

American Academy of Arts and Sciences, Proceedings. Vol. i. pp. 297–346.

——— Philosophical Society, Proceedings. Vol. v. No. 40.

Annales des Mines. Quatrième Série, Tome 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 (liv. 4), 20 (in all 37 Parts).

Asiatic Society (Royal), Journal of the Bombay Branch. No. 11, 1847.

Athenæum Journal, July to November.

Belgique, Académie Royale de. Mémoires, tomes xxi. et xxii.—Mémoires Couronnés et Mémoires des Savants Étrangers, tome xxii.—Bulletins, tome xiv. partie 2, et tome xv. partie 1.—Annuaire, 1848.

Berlin Academy, Abhandlungen for 1846.

————, Bericht, July to December 1847 and January to June 1848.

Dublin Geological Society Journal, vol. iii. part 4. Nos. 2 and 3.

Chemical Society, Quarterly Journal of. Vol. i. Nos. 2 and 3.

France, Société Géologique de, Mémoires. Deux. Série, tome iv. feuilles 53–62, and tome v. feuilles 4–8.

Comptes Rendus de l'Académie. Nos. 1–25. Tome xxvi. Prem. Sem. and Index and Contents to Tome xxv.

Geographical Society (Royal), Journal of the. Vol. xviii. part 1.

Indian Archipelago, Journal of the. Vol. ii. Nos. 3, 4, 5, 6, 7, 8.

Irish Academy (Royal), Transactions. Vol. xxi. part 2.

Moscou, Bulletin de la Société Impériale des Naturalistes de. No. 2. 1847.

New York, Annals of the Lyceum of Natural History of. Vol. iv. Nos. 10 and 11.

Philadelphia, Journal of the Academy of Natural Sciences of. Vol. i. part 1.

Philosophical Magazine. *From R. Taylor, Esq., F.G.S.*

Tyneside Naturalists' Field Club, Transactions. Vol. i. part 3.

Vaudoise, Bulletin des Séances de la Société des Sciences Naturelles de. Nos. 16, 17 & 18.

Wien, Berichte über die Mittheilungen von Freunden der Naturwissenschaften in. 3 band. Nos. 1–6, 1847. From Herr W. Haidinger.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Bloede, M. Tabelle über die in den Öffentlichen Museen zu St. Petersburg befindlichen Aerolithen.

Davidson, M. M. K. et *Bouchard Chantereaux.* Note sur le Magas pumilus.

De Koninck, L. Recherches sur les Animaux Fossiles. Part 1.

D'Orbigny, A. Paléontologie Française, Terrains Crétacés, livraisons 131, 132, 133, 134, 135 & 136. Terrains Jurassiques, liv. 48, 49 & 50.

Dumont, A. Mémoire sur les Terrains Ardennais et Rhénan de l'Ardenne, du Rhin, du Brabant et du Condros.

Fischer de Waldheim, G. Notice sur quelques Sauriens Fossiles du Gouvernement de Moscou.

Gibbes, R. W., M.D. Monograph of the Fossil Squalidæ of the United States.

Geological Survey of Great Britain, Memoirs of, and of the Museum of Practical Geology in London. Vol. ii. parts 1 & 2. Presented by Sir H. T. De la Beche, from the Commission of Woods and Forests.

Helmersen, G. v. Herrn von Middendorffs geognostische Beobachtungen auf seiner Reise durch Siberien, bearbeitet von.

————. Aulosteges variabilis, ein neuer Brachiopode mit artikulirtem Schlosse, aus dem Zechstein Russlands.

Jobert, A. C. G. Ideas or Outlines of a New System of Philosophy.

King, Capt. P., R.N. On the Specific Gravity of Sea-water in the North and South Atlantic Oceans.

———. Selections from a Meteorological Journal kept during the Survey of the Southern Coasts of South America.

King, Wm. Catalogue of the Organic Remains of the Permien Rocks of Northumberland and Durham.

Lubbock, Sir J. W., Bart. On the Theory of the Moon, &c.

Mantell, G. A., Esq., LL.D. On the Structure of the Maxillary and Dental Organs of the Iguanodon.

———. Observations on Belemnites, &c., discovered by Mr. R. N. Mantell.

Meteorological Observations made at Madras in 1841, 1842, 1843, 1844 and 1845. Presented by the Hon. East India Company.

Meteorological Observations made at the Meteorological Bungalow on Dodabetta in 1847–48. Presented by the Hon. East India Company.

Nyst, H. P. Tableau Synoptique et Synonymique des especès vivantes et fossiles de la Famille des Arcacées. Part 1.

Quetelet, A. Sur le Climat de la Belgique. Deux. part.

Reeve, Lovell. Elements of Conchology. Part 9.

Sismonda, Eugenio, M.D. Synopsis Methodica Animalium Invertebratorum Pedemontii Fossilium.

Strickland, H. E. A General Catalogue of all Books, Tracts and Memoirs on Zoology and Geology. By Prof. L. Agassiz; corrected and edited by. Presented by the Ray Society.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 1, 1848.

Douglas Galton, Esq., Lieut. R.E., was elected a Fellow of the Society.

The following communications were read:—

1. *On the supposed impression in Shale of the soft parts of an* Orthoceras. By James Hall, F.M.G.S., State Geologist of New York. (Communicated by Sir Roderick I. Murchison, to whom the notice was sent in a letter dated Feb. 8, 1848, and whose absence from England prevented its being read last session.)

Having read, in the Quarterly Journal of the Geological Society for August 1847, a letter from J. G. Anthony of Cincinnati, Ohio, to C. Lyell, Esq., V.P.G.S. London, "*on an impression of the soft parts of an Orthoceras,*" it occurred to me that the accompanying remarks and illustrations might not be uninteresting to the Society, and at the same time, perhaps, help towards a rational opinion relative to such bodies as are there described.

It has long been a favourite theory with some naturalists that the fossil Orthocerata are internal shells, of which the external soft parts have perished; but no person, I believe, until the present time, has claimed to have discovered remains of these fleshy or muscular parts of the animal. The position in which the body described was discovered, and the condition of the other fossils in the same bed, show the existence of circumstances peculiarly favourable to the preservation of the more delicate *solid* portions of all the then existing species of that immediate neighbourhood. But we have still a right to ask for more evidence as to the nature of these soft parts, and the manner of their connexion with the shell. It appears natural to suppose that the external soft parts of the animal, if any such existed, would be connected with that portion of the internal animal occupying the large outer chamber of the shell. In this example, judging from the figure, and from my recollection of the specimen, the fossilized "soft parts" are found enveloping the smaller extremity of the shell, while the outer chamber and larger extremity is broken off. This condition of the enveloping soft body seems to me an objection to such an explanation, even admitting that the "soft parts" could be petrified under the circumstances. This objection however may not be conclusive, and I would only suggest it for consideration before noticing other facts.

Bodies similar to that described by Mr. Anthony have been known to me in the shales of New York for ten years, but I have always regarded them as concretionary, though on their first discovery they were supposed by several naturalists to be the remains of the external fleshy body of the Orthoceras. The peculiar striated surface of Mr. Anthony's specimen corresponds with all those seen in New York, and the bilobate form is likewise the ordinary one. This character however appears to be due to previous compression, for the shell is usually flattened and broken along a central depressed line.

It is scarcely probable that such an opinion would be advanced by any one unless the mind had been pre-occupied by the belief that the Orthocerata were composed of an internal chambered shell, and an external soft body enveloping that shell. This prejudice is therefore strongly sustained by such a discovery, should it be proved that bodies of the kind described are found only in connection with shells of the Orthoceras; but this is far from being true.

To commence with the lower strata—I have found both the bivalve acephala and the spiral univalves with a similar sac-like attachment of what is here regarded as the "soft parts" of the animal, but which I prefer to regard as a shaly accretion with a striated surface*.

* Concretionary action takes place in all our shaly deposits in which animal matter exists, particularly if iron be present, to form particles or nodules, or even diffused particles of iron pyrites which aid in producing this action. Vegetable matter is sometimes a nucleus for such aggregation. Often there is no visible nucleus, and we cannot readily determine the first cause of the action. When the nucleus is organic, the concretionary masses or enclosing sacs usually assume a bilobate or bilateral form, in other cases they are of various and irregular forms. The surface of these bodies is almost always striated, and where there is only a thin coating of shaly matter around the organic body, or a harder inorganic calcareous nodule, it appears not unlike the effect produced by smearing some hard body with adhesive clay, and then removing as much as possible by hard pressure and direct motion of the palm of the hand. These surfaces have often the pecu-

These for the most part I have destroyed to procure the enclosed fossil, and have no good representatives from this period.

Fig. 1.

In the Hamilton group such appearances are quite common, and excite little attention. The accompanying figure (fig. 1) represents a *Chemnitzia* (*Loxonema*) with a concretion or sac on either side, which appears as if it may once have been a soft or pulpy mass. In another specimen the shell is nearly covered by this sac, which still preserves its proportions, corresponding to the form of the shell.

In this case there could have been no external animal or soft body to become fossilized; and had the entire soft part of the animal been protruded from the shell, it would not have been half so large as the attached concretion or sac, nor would it have assumed this position. It is evident nevertheless that the form and size of the shell, or of the animal within it, has determined the form and proportions of the adhering concretionary mass; and if it could so act in this instance, why may it not have done the same in the case of the Orthoceras? I am unwilling, at least, to admit the existence of such a preservation of the "soft parts" of a Cephalopod, while we have an example so similar among the Gasteropods. I regret that I have no other specimens at hand to show that these are far from being solitary examples.

Among numerous specimens of Orthocerata, I select the accompanying figures 3 and 4, which present some analogy with the figure of Mr. Anthony*.

liar appearance of the "slickensides," except that the striæ are finer. Such action takes place almost universally in our black carbonaceous shales of all ages in the palæozoic period; not only appearing in such concretionary masses enclosing fossils of all classes, and in distinct concretions, but also marking the plane shaly or slaty cleavages where there is no evidence of metamorphic action, and where the strata are in nearly a horizontal position. In all these cases iron pyrites, or some action dependent on its presence or production, seems to perform an important part, even to the formation of pseudo-organic forms.

* [As these figures by Mr. Hall closely resemble that given in a former number of the Journal, from Mr. Anthony's specimen, and here repeated, fig. 2, it has not seemed necessary to engrave them. Mr. Hall also sent a drawing of the second specimen of Chemnitzia mentioned above, which has likewise been omitted.—Ed. *Quart. Geol. Journ.*]

Fig. 2.

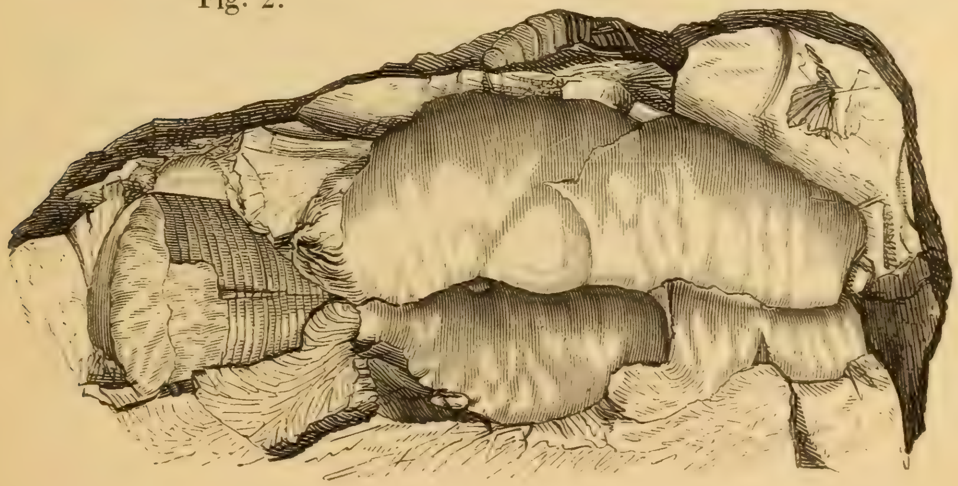


Fig. 3 is from a specimen of the smaller extremity of an Orthoceras which has been crushed, and broken along the centre, and where subsequent action has caused a slight accumulation of shaly matter upon the shell, showing the incipient stage of these sac-like concretions. The surface is striated after the peculiar manner of these concretions, and a few of the septa are shown in the middle of the lower part of the figure.

Fig. 4 is from a specimen where the original form of the shell of the Orthoceras is lost, and the accumulation of the surrounding material has assumed the aspect of a fleshy sac surrounding the tube as the external fleshy body of the Orthoceras is supposed to envelope the internal shell.

These peculiar results of concretionary action are seen in the greatest perfection in the soft, fine shales which are formed from a sediment of impalpable mud, which must have been deposited in the most quiet waters, as evidenced both from its character and from the perfect preservation of almost all the imbedded fossils. The perfect preservation of the fossils in such localities is used as an argument to convince us that these soft parts may be preserved; but we find similar fossils equally well preserved in calcareous deposits, while there is never any evidence of the existence of the softer parts. Again, in these examples the shell is often partially or entirely destroyed by the action of acids, apparently resulting from the decomposition of iron pyrites, leaving only a cast of the interior. In the calcareous deposits of the Trenton limestone, the Orthocerata preserve their delicate shell in great perfection; and yet among the multitudes thus preserved, we find no appearance of the preservation of the softer parts of the animal.

Mr. Anthony, in a letter of January 1848, called my attention to the paper cited above, and suggests that this discovery, which seems so well sustained, both by evidence and high opinion, conflicts with the views I have expressed in my 'Report on the Palæontology of New York,' vol. i. I have therefore briefly examined the facts in relation to this specimen, and the conclusions drawn therefrom; and I must leave it to naturalists to decide how far these conclusions can be sustained, or whether they are in any degree impaired by the accompanying facts and illustrations.

With regard to the opinions on the Orthocerata advanced in the work just cited, I am far from being anxious to sustain them at the expense of truth, or by the concealment or abridgement of any fact connected with the subject. I have there expressed, however imperfectly, the results of my observations; and I have even hesitated to insist upon conclusions which the facts seemed to warrant. While preparing that work, I examined all the authorities on this subject within my reach. I found little to assist me in regard to the peculiar forms and arrangement of parts of those species peculiar to our Lower Silurian rocks, and was forced therefore to depend on my own investigations. I have proposed a generic name (*Endoceras*), indicating a peculiarity in the mode of development and growth, simply; while I believe the facts would justify a still wider separation than that of generic distinction. The specimens indeed reveal to us, in the clearest manner, a feature in the physiology,—a mode of growth and reproduction, which separates them widely from all the modern cephalopods; or even from the ancient forms having the usual siphuncular and septate arrangement of recent species*. If the characters there given can be reconciled with the theory of a large external soft animal, enclosing the shell, the question may remain in its present undecided state; bearing on one side the array of facts, and on the other the theoretical views of naturalists, deduced from those modern cephalopods possessing few characters in common with these ancient forms.

---

2. *On Slaty Cleavage* (second communication). By DANIEL SHARPE, Esq., F.G.S.

IN a paper read to the Geological Society on the 2nd of December 1846, on the cleavage of slate rocks†, I endeavoured to work out certain general laws relative to the compression which such rocks had undergone, to the position of the planes of cleavage, and to the connection between their direction and the elevation of the beds. The conclusions were founded upon observations chiefly made in North Wales, Devonshire and Cornwall: I have since visited parts of Westmoreland and Cumberland, with the view of enlarging the field of observation, and the result is contained in the following remarks, which are thrown into the order adopted in the former paper.

Compression of slate-rocks in a direction perpendicular to the planes of cleavage.—In the former paper, p. 87, I stated that in all the slaty fossiliferous rocks examined, the distortion of the fossils proved that the mass of the rocks had undergone considerable compression in a direction everywhere perpendicular to the planes of cleavage, and some expansion in the direction of the dip of the cleavage; but that there was no reason to suppose that the rocks had suffered any change of volume in the direction of the strike of the cleavage. And it was inferred that these changes must be general in all slaty rocks, although it might not be easy to find proofs that they had occurred, where organic remains were absent.

There is however more evidence of compression to be found among the beds of unfossiliferous slate than might have been expected; and the examination of their mechanical structure affords quite as strong proofs of pressure as those derived from the distortion of the organic remains.

In the neighbourhood of the roofing-slates there are frequently found beds of a brecciated structure which cleave readily, but from their irregular composition are liable to break. Such beds are

* The modern Cephalopod, *Nautilus Pompilius*, the anatomy of which is so well known from the labours of Prof. Owen, affords little or no assistance in enabling us to form conclusions as to the physiology and habits of animals like those inhabiting the shells of *Endoceras*.

† Journal of the Geological Society, vol. ii. p. 74.

largely exposed in the upper part of the quarries of green slate at Patterdale, and in the Langdale quarries and many other places in Westmoreland and Cumberland. In all these slaty breccias, the included masses are flatter between the planes of cleavage than in any other direction. Their irregular forms prove them to have been imbedded pebbles or fragments, and cannot be explained by reference to crystallization: indeed they have rarely any crystalline character, but consist of slate, differing more or less in grain, colour and hardness from the matrix in which they are imbedded. In the localities mentioned, the bedding is most distinctly marked, and we can judge with certainty of the position of the fragments with reference to it: if they had been originally flat pieces of slate accidentally deposited, we should find them lying on their flat sides in the bed, but this is not the case; their flattest sides are always parallel to the cleavage-planes, and consequently where the cleavage cuts the bedding at a high angle, as is the case in all the Langdale quarries, and in some of those at Patterdale, these thin masses appear to be standing upright in the bed on their edges; a position which they never could have reached if their forms had been originally those we now find. We can only explain the circumstances by supposing that these masses were flattened when the rock was subjected to a pressure which acted in a direction perpendicular to the planes of cleavage.

When we examine the outline of these imbedded masses, as it is seen on the face of a sheet of slate, we usually find them to be rather longer down the dip of the cleavage than across it or along its strike: this confirms the opinion that the rocks have expanded in the direction of the dip of the cleavage.

As we do not know the original forms of the imbedded fragments, we can only guess at the amount of compression they have undergone; but we may be certain that it has been very considerable, for in many localities their thickness between the cleavage-planes is seldom equal to half their diameter as seen on the planes of cleavage.

To illustrate the forms of the fragments imbedded in the brecciated slates, I have added two sketches of a piece of slate from the Patterdale quarry.

Fig. 1 is taken from the surface of the plane of cleavage showing the largest and flattest side of all the fragments, which are longest in the direction of the dip of the cleavage *y y*. Fig. 2 shows the side of the same sheet of slate with all the fragments flattened between the planes of cleavage. The lines *a a* represent the planes of bedding, with a considerable dip.

Between the well-marked slates and the great bands of porphyritic rocks which traverse the "green slate" district of the Lakes, there are extensive masses of metamorphic rocks more or less crystalline, which appear to have been sedimentary deposits altered by the neighbouring igneous action. In these rocks the cleavage is usually well-marked, and the bedding can frequently be distinctly traced. But the nearer we approach the axis of igneous action, the more obscure do we find the bedding, till it is gradually lost; the cleavage then becomes more faint, and we soon reach a mass of crystalline rock without either bedding or cleavage. Many of these metamorphic slates appear to have been originally of a brecciated structure, and contain a confused mixture of crystals with what appear to be fragments of

Fig. 1.

Fig. 2.

foreign origin. In slaty rocks of this description all the enclosed portions which can be supposed to have had a mechanical origin are flattened between the planes of cleavage, but nothing of the sort can be observed of the crystals, which are scattered through the mass without any reference to the cleavage-planes either in their form or position.

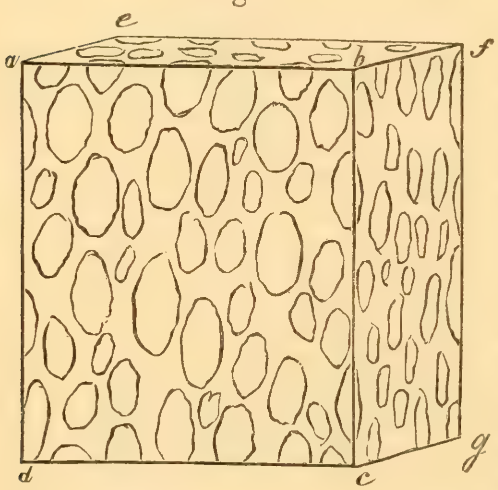
In good roofing-slates, which are distinguished by the fineness and uniformity of their grain, it is difficult to observe the forms of the parts of which they are composed: yet even in these, with the assistance of a lens, we can see that the constituent particles are flattest between the cleavage-planes, and longest along the dip of the cleavage. Thus, under whatever circumstances we are able to observe the forms of the component parts of slate, or of the foreign bodies contained in it, (whether these are pebbles, fragments of other rocks, or organic remains,) we find evidence that the mass has been compressed by a force which has acted in a direction perpendicular to the planes of cleavage.

The distinctive character of slate appears to be that it is composed of particles of a form more or less amygdaloidal, arranged in a similar direction. Its tendency to split with different degrees of resistance in different directions is the consequence of this arrangement and form of its constituent parts, and is therefore only a secondary character.

Two planes of cleavage in slate.—In preparing slates, the first process is to split them along the planes of cleavage to the thickness required, they are then to be cut to size; most slates of good quality can be split tolerably straight down the sides of the sheet by applying the tool at the top, from which we see that besides the true or principal planes of cleavage, there is also another direction in which the rock has a tendency to split in a slighter degree; this may be called the plane of secondary cleavage; the workmen call it the "side of the sheet." The ends of the sheet must be chipped or sawed to the size required, as the rock will not split at all in this direction, which is across both the other planes of cleavage: in fact it will give way in any other direction more easily than in this, which may be called the plane of greatest resistance.

A diagram will make this more intelligible, and will also explain the relation which these various planes have to the position of the constituent particles of the slate. Let us suppose fig. 3 to represent a block of slate, of which *a b c d* is one of the planes of cleavage, *ad* and *bc* showing the dip, *a b* and *d c* the strike of the cleavage; *b c g f* is the plane of secondary cleavage, *a b f e* is the plane of greatest resistance. The component parts of the rock are represented enlarged, of an almond shape, with their largest and flattest sides parallel to the true cleavage-plane *a b c d*, and with their longest diameters in the direction of the dip of the cleavage *a d*.

Fig. 3.



It is obvious that with such a distribution of its particles, the rock can offer less resistance to an attempt to split it down the plane of cleavage *a b c d*, than in any other direction; for that plane, and all planes parallel to it, pass along the flat surfaces of many of the particles, and intersect a smaller number of them than any other plane which can be drawn through the block.

Next to the true cleavage-plane, the direction in which the rock will offer least resistance is along the planes of secondary cleavage *b f g c*, for the particles being all lengthened in that direction, it will more readily separate down that plane than in any cross direction. Nevertheless the cleavage along these planes is very imperfect, and the sheets often fly off in a curve instead of splitting straight down.

In any other direction the particles must from their form and position offer greater resistance than along the two directions just mentioned, but the greatest resistance will be along the plane *a b f e* and all planes parallel to it, as they have to cut through a greater number of the constituent almond-shaped particles of the rock than any others: these therefore are the planes of greatest resistance. In the quarries in Langdale these planes are parallel to the bedding, nevertheless the rock will not split along them.

In splitting up slate, the workmen have observed that the sheets will bear a greater force without breaking, when the tool is applied "at the end" of the sheet, than if it is applied "at the side." This is an illustration of what has just been stated; when the tool is applied at the end of the sheet, it opens the slate down the dip of the cleavage-planes, and produces a strain on the sheet in the direction of its greatest power of resistance; but when the tool is applied "at the side" of the sheet, the strain falls along the planes of secondary cleavage, and the sheet easily breaks.

Slate-pencil Rock.—Slate-pencils are cut from a slate which is soft enough not to scratch, and which can be split down the planes of secondary cleavage with nearly the same facility as along the true cleavage. The latter character is not common. There are two quarries near the village of Shap which have long been worked for pencils, but the manufacture has declined in consequence of the softer-grained pencils imported from Holland being preferred.

The Southern Quarry is on Thornthwaite Gill in Ralphland, about a mile and a half west of Shap. The rock is the Skiddaw slate, apparently hardened from its proximity to the Shap granite; the beds strike N.E., and dip to the N.W. at about 60°: they contain many layers of large ferruginous clay nodules; the principal cleavage coincides with the bedding and dips N.W. 60°, which is about the usual direction of the cleavage along that line of beds: the secondary cleavage is nearly at right angles to the true cleavage, and dips S.E. between 20° and 30°.

The other quarry is on Rosgill Moor, between two and three miles north of the former, and about three miles north-west of Shap; the rock is a soft black clay-slate, readily decomposing from exposure, and containing beds of large ferruginous clay nodules: it belongs to the Skiddaw slate, and agrees in all its mineral characters with the upper part of that formation as seen near Keswick. The beds dip N.E. 30°; the principal cleavage dips N. by W. 60°, the secondary cleavage dips S. by E. 15°. In both these quarries the beds are intersected by a remarkable number of joints cutting through them in various directions. At Rosgill Moor the weathered surfaces of rock break up along both the planes of cleavage, and the sides of the quarry present the ends of innumerable four-sided prisms of slate, from a quarter to half an inch square, resembling those cut by the workmen to make pencils from; in this the pencil-rock contrasts with the ordinary slate rocks which when weathered break up into thin sheets.

I was anxious to examine all the circumstances connected with pencil-rock, in hopes of finding the cause of the peculiar development of the secondary cleavage, but the situation of the quarries near Shap is very unfavourable to such an object, and I could not learn of any other similar rock in the district. The quarries are worked on low moors where very little of the rock is exposed for several miles round, and little can be seen of its relations to the neighbouring beds. Judging from analogy with the supposed cause of the principal cleavage, it may be conjectured that the secondary cleavage is due to a second compression which the rock has undergone in a different direction from the first. This is in harmony with the position of the Shap pencil-rock, between two great masses of erupted rocks of different dates, the granite of Wastdale Head on the south, and the porphyritic bands on the north ; and is confirmed by the numerous joints observed in the quarries, which show that the rock has undergone great and complicated pressure.

Cleavage not connected with crystallization.—In the rocks examined, I could find no connection between crystallization and cleavage ; on the contrary, everything tended to show that the cleavage has been produced by causes solely mechanical. In many of the beds of slate there are cubical crystals of iron pyrites scattered through the rock without any reference to the direction of the cleavage : various rhomboidal crystals of different minerals also occur in slate, but I have seen no instance of their sides being based on the cleavage-planes, or of their having any definite position in the rock. In the chiastolite slate of Skiddaw, the long prisms of chiastolite traverse the rock in all directions, without showing any preference either for the planes of bedding or cleavage.

But the most conclusive evidence is found in the altered slates resting on the igneous rocks, in which the original mechanical structure of the rock is seen in combination with a considerable degree of crystallization. In these rocks, which are common in the green slate district, all the mechanical portions of the rock appear to have been compressed between the planes of cleavage, but the crystalline portions are quite independent of the cleavage, both in position and form.

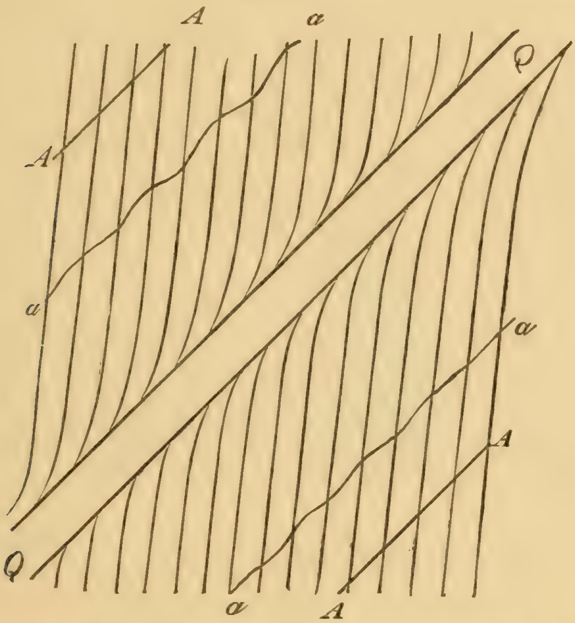
Moreover, in tracing the gradual change of character as we pass from true slates, through the metamorphic rocks to those of decidedly igneous origin, we always find the cleavage more developed in proportion as the rock is least crystalline. In the best roofing-slate, where the cleavage is strongest, there is no trace of crystallization : in the metamorphic slates the cleavage is fainter in proportion as the crystals in them are more abundant ; and on reaching a thoroughly crystalline rock, we lose the cleavage entirely. This alone is a sufficient proof that the cleavage had an origin unconnected with crystallization.

There are apparent exceptions to the above remarks in the thin laminæ of talc and mica which are found lying along the cleavage-planes of certain slates ; for although those laminæ have no definite form, their segregation from the mass of the rock is undoubtedly a process approaching to crystallization. Probably the reason that they have been formed on the planes of cleavage is, that the rock separated more readily on those planes than elsewhere, and thus admitted them to form along them. If this be true, the laminæ of talc and mica must have been formed after the cleavage, and present no contradiction to the views previously stated.

Irregularities in the direction of the cleavage-planes.—There are occasional irregularities in the direction of the cleavage which should be studied, as they may assist our search after the general laws which have regulated its arrangement. Some of these are mentioned by Mr. Phillips in the Report of the British Association at Cork in 1843, p. 60, and other cases have been mentioned to me verbally by that gentleman.

In one of the slate-quarries at Patterdale, a sheet of quartz about an inch thick lies between two beds of slate : the cleavage does not pass into the quartz, and the planes of cleavage are slightly bent out of their course into a curve on each side of the quartz bed, as shown in figure 4.

Fig. 4.

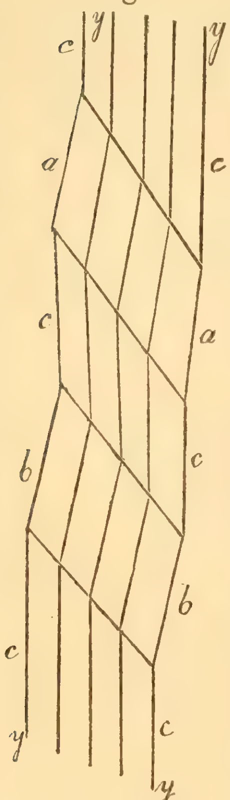


Here the lines A A and *a a* represent the surfaces of the different beds of slate dipping to the north at an angle of 45° ; Q Q is a bed of quartz interstratified in the rock. The upright lines represent the cleavage-planes which dip N. 25° W. 85° : they do not enter the sheet of quartz, and appear slightly deflected by it on each side for the distance of about two inches. The surfaces of the beds *a a* are not flat, but are slightly waved in parallel lines coincident with the strike of the cleavage, a peculiarity to which we will return shortly.

In one of the Langdale quarries there is a similar bending of the cleavage against a sheet of quartz which cuts through the bedding along a joint in the rock : the circumstances are so nearly the same, that it is not necessary to add another drawing.

Such irregularities are of frequent occurrence, and their cause is obviously mechanical; the resistance offered by the oblique sheet of quartz to the pressure forward of the mass, has caused the bending of the sheets of slate at the ends which abut against the quartz.

Fig. 5.



A slight change in the direction of the cleavage may frequently be observed in its passage from one bed of rock to another, arising probably from beds of different hardness offering different degrees of resistance to pressure.

Figure 5 represents the section of a fragment of slate from Langdale, in which the thin beds *a a* and *b b* are rather softer than the other beds *c c*; the lines *y y* show the direction of the planes of cleavage, which are perpendicular in passing through the beds *c c*, but dip 80° to the southward in the beds *a a* and *b b*, the beds dipping to the north at an angle of 60°.

Here the change in the direction of the cleavage in passing from bed to bed is fully 10°, which is an unusual amount of deviation; but a variation of two or three degrees under such circumstances is often met with. The cause of these irregularities must also be mechanical.

The surface of particular beds of slate is sometimes found broken up into a series of steps parallel to the strike of the cleavage: the front of each step is formed by the plane of cleavage, and the top by a portion of the bed which has been displaced from its original position and appears to lie at an angle towards the original plane of bedding.

Fig. 6 represents the section of a fragment of slate from the

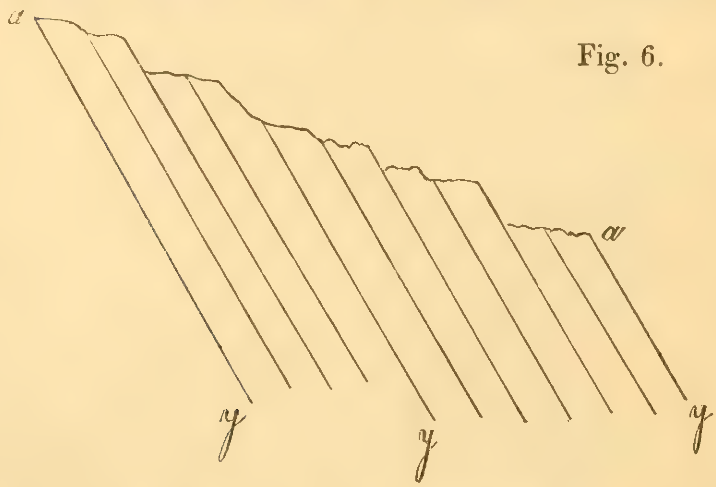
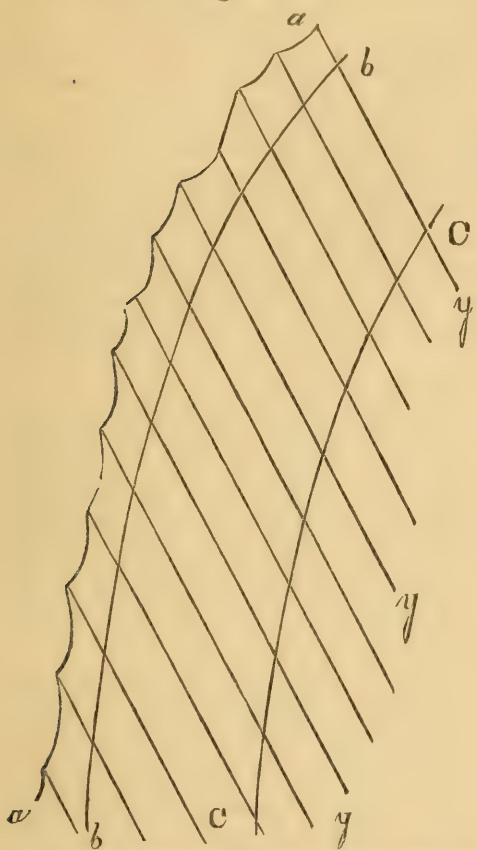


Fig. 6.

"Pilton beds" two miles north of Barnstaple: the upper broken line *a a* shows the present form of the surface of a bed covered with organic remains. The lines *y y* show the direction of the cleavage-planes. The plane of bedding *a a* has been broken into a very irregular series of steps by some force which has either moved each sheet of slate forward in advance of its neighbour, or has caused an uneven expansion of the parts of the rock. The fossils have suffered from this movement of the surface. The whole bed is covered by small irregular ridges parallel to the cleavage, which make it impossible to measure the angles accurately.

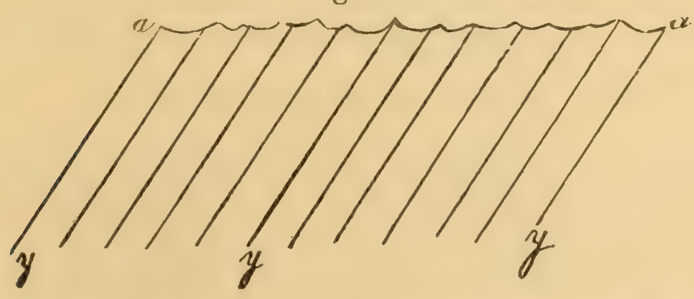
Fig. 7.



In figure 7, *a a* represents the section of the surface of a bed of black calcareous slate in the Bickington limestone quarry, North Devon, which is bent over in a steep arch, and dips rapidly to the north; it is intersected by cleavage *y y*, dipping nearly 70° to the south. In this instance the surface of the bed *a a* is bent into parallel waves without its continuity being broken: but the outlines of the beds below *b b* and *c c* may be traced in the solid rock unchanged; so that the disturbance of the surface seems only to have taken place where the looser packing of the rocks allowed room for some play of their parts.

Figure 8 represents another case of the same kind, observed in the Brathay flag-stone quarry near Ambleside; *a a* being the surface of a bed, and *y y* the planes of cleavage.

Fig. 8.



In cases like the last two, the whole surface of the beds *a a* is covered with irregular flutings running in the direction of the strike of the cleavage: such flutings vary in width from a fraction of an inch to six inches or more, and they are usually closer together in the slates of finest grain, in which the whole surface of the beds is sometimes roughened by numerous ridges parallel to the strike of the cleavage; in such cases it is useless to search for fossils, for if they ever existed, they must have been chopped up and destroyed in the change of surface of the bed. Similar flutings and ridges are also to be seen on the sides of many open joints as well as on the beds.

There seems here to have been an irregular expansion of the rock, owing to a softer and more yielding bed or an open crack affording less resistance to the pressure it has been proved to have undergone. More numerous observations are required before we can explain the changes that have taken place; but it may be inferred that these changes were connected with the cleavage, because the direction of the flutings and ridges on the surface always corresponds with the strike of the cleavage.

Arrangement of the cleavage-planes in the Cumbrian mountains, and their relation to the position of the beds.—Although my present object only relates to the cleavage of the Cumbrian district, it is necessary to give a slight sketch of the position of the strata to show the connection between the arrangement of the cleavage-planes and the elevatory movements which the rocks have undergone: this is derived from Professor Sedgwick's various accounts of the geology of the Lake district*, combined with my own observations in various parts of it.

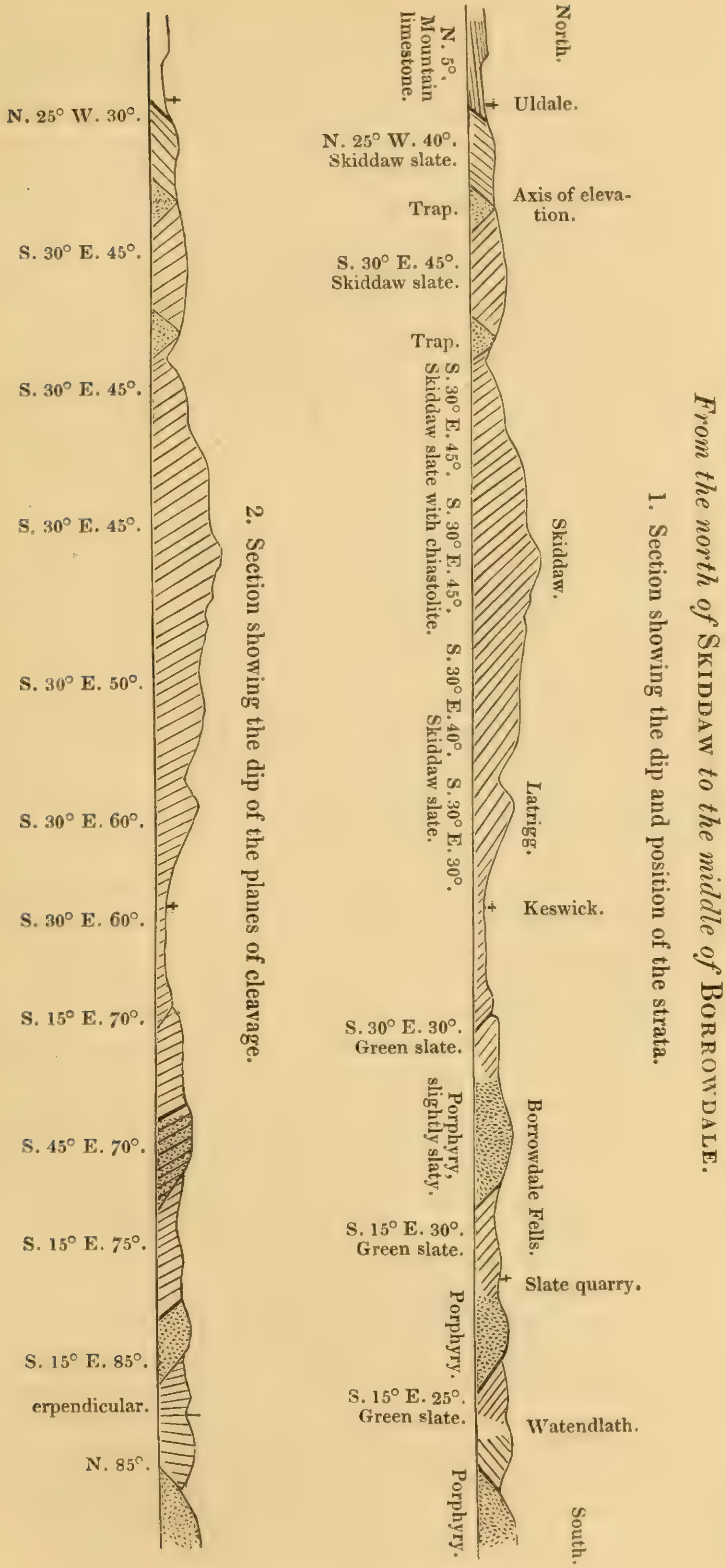
The mountainous district occupied by the Skiddaw slate and the green slate, bounded on the north by the mountain limestone, and on the south by the Coniston slate and limestone, appears to consist of two great areas of elevation of about equal extent, separated by a line running about W.S.W. to E.N.E. from Wastwater across Borrowdale, and passing a little to the north of Scawfell and Helvellyn†.

The position of the beds throughout the northern area is tolerably regular, as they dip away from an anticlinal axis on the north of Skiddaw which passes through the sienite of Carrock Fell. The structure of the southern area is more complicated, and appears to have been determined by several elevating forces connected with the eruptions of the great bands of porphyry which traverse that part of the country, and of the granites of Wastdale Head, Booth, &c. As the circumstances attending the position both of the beds and of the cleavage in the two areas are very different, they will be described separately.

Northern area of elevation.—The two sections Nos. 1 & 2 drawn

* Sedgwick's Introduction to the General Structure of the Cumbrian Mountains, Trans. Geol. Soc. 2nd series, vol. iv. p. 47; On the Fossiliferous Slates of Cumberland, &c., Journ. of Geol. Soc. vol. ii. p. 106; and Letters to Wordsworth, published in the 3rd edition of Wordsworth's Guide to the Lakes.

† In dividing the Lake district into two areas of elevation, I am departing from the guidance of Professor Sedgwick, who has given a section from Kendal to the Eden with a single axis of elevation on the north of Skiddaw (Journ. of Geol. Soc. vol. ii. p. 106).



From the north of SKIDDAW *to the middle of* BORROWDALE.

1. Section showing the dip and position of the strata.

2. Section showing the dip of the planes of cleavage.

through Skiddaw illustrate this district; No. 1 shows the position of strata, and No. 2 the dip of the planes of cleavage, along the same line of section from the mountain limestone of Uldale on the north to the middle of Borrowdale, where a change of dip of the beds indicates the commencement of another area of elevation.

The axis of this northern area consists of the sienite of Carrock Fell and of sandy bands and dykes of igneous rocks of various characters running to the westward nearly as far as the foot of Bassenthwaite Water: on both sides of this axis the beds of slate dip away from the igneous rocks at nearly the same angle.

From the anticlinal axis at Carrock Fell to Rossthwaite in Borrowdale, the beds dip constantly to the southward (between S. 15° E. and S. 30° E.); the distance is twelve miles, which is the semidiameter of the area of elevation. The series of beds, commencing with the lowest, is as follows:—

1. Skiddaw Slate, viz.—

a. Black clay-slate with crystals of chiastolite in all the northern half of Skiddaw and Saddleback: the chiastolite seems to be due to the neighbouring igneous agency, as the western continuation of the same beds near Bassenthwaite consists of soft brown clay-slate without chiastolite. In Skiddaw these beds dip S. 30° E. 45°, and the cleavage coincides both in dip and strike with the bedding.

b. Hard black clay-slate, forming the northern part of Skiddaw, where it dips S. 30° E. 30°, with a cleavage which dips S. 30° E. 50°.

c. Rotten dark brown clay-slate, with layers of ferruginous clay nodules approaching a clay ironstone. This forms the lower hill of Latrigg and the valley of Keswick: the beds dip S. 30° E. 30°, and the cleavage dips S. 30° E. 60°.

2. Green slate, which overlies the Skiddaw slate in the first high hills on the sides of Derwentwater. It is usually either a hard gritty siliceous rock of a light grey colour, unfit for use as slate, or a roofing-slate of light greenish tint, somewhat approaching steatite in its softer beds, and containing numerous plates of dark green indurated talc on the surface of the planes of cleavage. Many beds are brecciated, the foreign masses usually consisting of slate differing in colour and hardness from the matrix. On the line of the sections Nos. 1 & 2, the green slate is interrupted by two bands of porphyry, which alter the character of the slates near them without disturbing the direction of the beds or cleavage: one of these bands crosses Derwentwater near its head, the other crosses Borrowdale at the Castle Hill.

At the side of Derwentwater the green slate dips about S. 30° E. 30°, the cleavage dipping S. 15° E. 70°. A little way up Borrowdale the slate is quarried on a large scale, it here dips S. 15° E. 30°, and the cleavage dips S. 15° E. 75°; near Rossthwaite the beds dip S. 15° E. 25°, and the cleavage dips S. 15° E. 85°: just beyond this spot the dip of the beds changes to the west of north, and the cleavage is perpendicular with a strike of N. 65° E. The line which separates the two great areas of elevation of the Lake Mountains passes here, and the position of the beds to the south of it must be explained by examining the forces which have acted farther south.

Starting from the anticlinal axis north of Skiddaw, the elevation of the beds has gradually diminished as they are farther from the axis, from an angle of 45° to one of 25°; a result which agrees with the ordinary phænomena of elevation, which diminish in amount in proportion to the distance from the elevating power. But the angle of inclination of the cleavage-planes has increased as they recede from the axis from 45° to 90°, being lowest at the axis, and perpendicular exactly on the line where the elevating force ceases to act, or is neutralized by meeting an opposing force proceeding from another axis of elevation. This is so precisely analogous to the two cases described in my former paper as occurring in North Wales and Devonshire (pp. 90 and 94), as to make it probable that wherever the beds throughout a large area are elevated from a single axis, the cleavage will be found to be arranged in an arch over that axis, with an increase of elevation from the axis to the boundary of the area of elevation, on which line we may expect to find it perpendicular.

On the northern side of the area, the Skiddaw slate is only visible for a breadth of one or two miles on the north of the igneous axis of Carrock Fell; beyond that distance, both that and all the rest of the older formations are covered up by an overlap of the mountain limestone, which is nearly horizontal, and rests unconformably on the Skiddaw slate, which dips N. 25° W. 40°, being a dark brown clay-slate without chiastolite; the cleavage dips N. 25° W. 30°, being less inclined than the bedding, which is rare in the north of England, though of common occurrence in Cornwall and Devonshire.

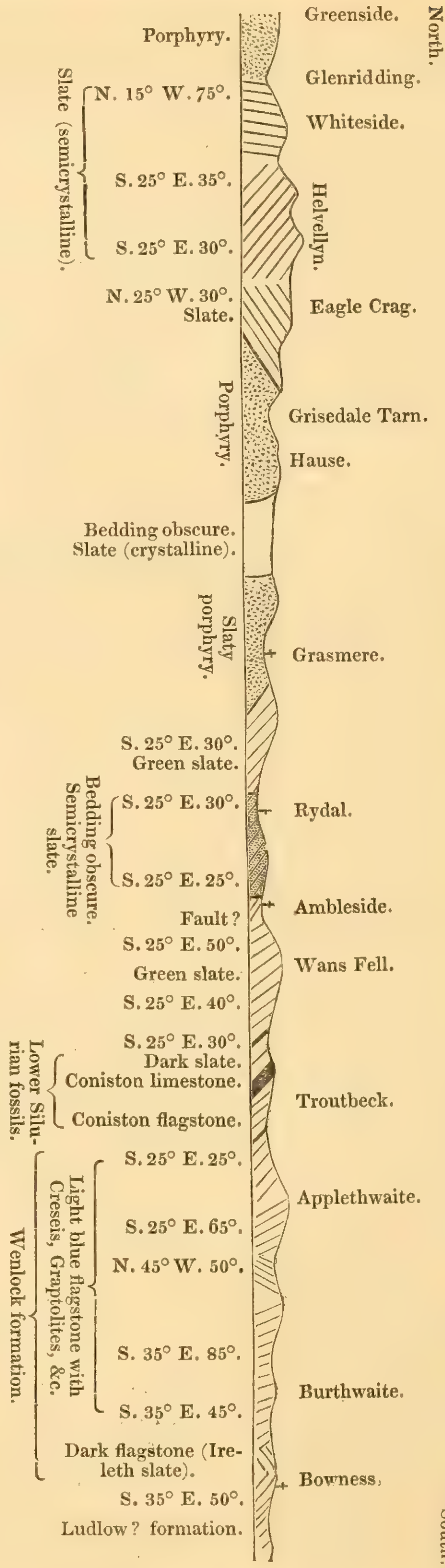
From the mountain limestone of Uldale and Hesket Newmarket covering up and concealing the older formations to the northward, we are prevented from seeing the rest of that side of the area of elevation; but enough is visible to show us that the Carrock Fell sienite is the axis of the elevation both of the beds and of the cleavage of the area.

Southern area of elevation.—The Sections 3 and 4 are drawn along the same line through the middle of the southern portion of the slate district of the Lakes, and are arranged on the same principle as the former sections; No. 3 showing the position of the strata, and No. 4 the dip of the cleavage-planes. They commence on the north of Helvellyn at the porphyry of Greenside, which is on the line of separation between the two areas of elevation of the district, and extend southward to Bowness, beyond which place the cleavage is more faint, and only to be traced at intervals with some difficulty. These two sections are not exactly in continuation of the former, Nos. 1 and 2; but, together with them, complete a section across the Lake Mountains. There are however, on the east and west of the line of sections, two small districts where the Skiddaw slate has been raised to the surface by the eruptions of the granites of Booth and Shap Fell, which are not described in this paper*.

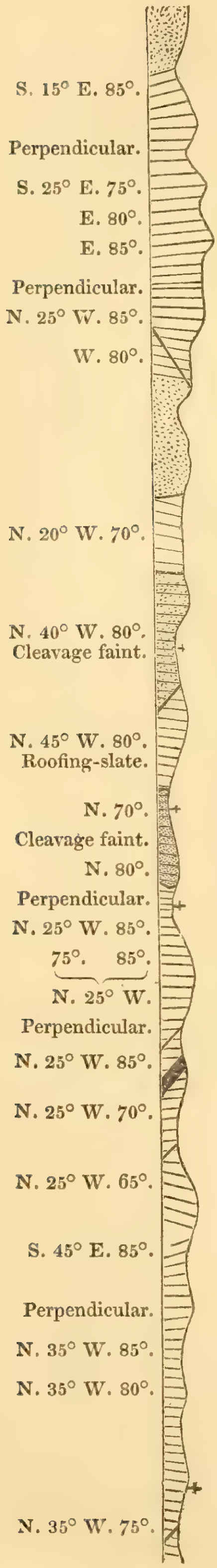
The district traversed by these sections presents in its complicated and disturbed features a most striking contrast to the regularity of

* For the elevation of the slates of Black Comb by the Booth Granite, see Sedgwick, Journ. Geol. Soc. vol. ii. p. 111.

From the north of HELVELLYN *to* BOWNESS.



3. Section showing the dip and position of the strata.



4. Section showing the dip of the planes of cleavage.

the northern area; and the position of the planes of cleavage is as complicated as that of the strata. It would be tedious to go into these disturbances in detail, but we must glance over them, as they show how the position of the cleavage-planes has depended on the eruptive forces which have elevated and disturbed the strata, and thus confirm the opinion that the cleavage is due to mechanical causes.

The most complicated part of this area is that occupied by the green slates which has been broken through by several bands of porphyritic rocks: these have modified the arrangement both of the strata and of the cleavage, and have influenced the physical geography, so that we must first examine their position on the line of country crossed by the sections.

Commencing on the north, the first great band of porphyry seen on section 3 is that of Greenside, on the north side of Glenridding, which forms the limit of the section, and belongs to the northern area of elevation just described: the general direction of this band is east from the southern part of Derwentwater to the southern part of Ulswater.

The Greenside porphyry is succeeded by the slates of Helvellyn, the line between them being well marked by a great fault running down Free Mosedale and the lower part of Glenridding: throughout Helvellyn the slate is more or less crystalline, but both the cleavage and the bedding are well seen. In Raise and Whiteside the slate dips N. 15° W. 75°, its cleavage dipping S. 15° E. 85°: there is a fault at the head of Glenridding forming an anticlinal axis on which the cleavage is perpendicular and strikes with the beds; beyond that fault in the higher parts of Helvellyn, the slates dip S. 25° E. 30° to 35°; the cleavage dips close to the fault S. 25° E. 75°; but its elevation gradually increases to the southward, and it is again perpendicular on the south side of Helvellyn High Man where another fault occurs, at which the beds form a synclinal axis: in the Eagle Crag the slate is more crystalline, and dips N. 25° W. 30°, resting on the porphyry of Grisedale Head. In the Eagle Crag the cleavage dips N. 25° W. 85°, and at the junction of the slate and porphyry N. 25° W. 80°.

The band of porphyry which crosses the country south of Helvellyn is about two miles wide: on the line of section 3, it divides the waters of Cumberland and Westmoreland at the ridge of which Dunmail Raise is a part: its general direction is east. At the south end of Raise Gap, it is succeeded by a metamorphic slate with a cleavage dipping N. 20° W. 70°, in which the traces of bedding can hardly be distinguished; this crosses the Keswick road about $1\frac{1}{2}$ mile north of Grasmere.

South of the metamorphic slate we find another great band of porphyritic rock nearly a mile and a half wide, which reaches to the banks of Grasmere: on section 3, this rock has a faint but regular cleavage dipping N. 40° W. 80°, so that we might be tempted to regard it as a slate rock of which the bedding has been obliterated, and the structure rendered crystalline by igneous agency below the surface. But farther east, the same band forms the summit of the

Kirkstone Pass, where it is a purely crystalline rock without cleavage, but flanked at each end of the Pass by slaty semicrystaline rocks gradually passing into slate.

The slaty porphyry of Grasmere is overlaid by a hard green slate, which has been quarried largely at the head of Rydal Water, where it dips S. 25° E. 30°, with a cleavage which dips N. 45° W. 80°: the rock is too hard to work for roofing, yet it is the continuation of the beds which supply the excellent roofing-slates of Langdale.

South of Rydal, the usual dip of all the beds is to the southward (generally about S.S.E.), although there are many local changes of the dip and repetitions of the beds: it is therefore clear that on quitting the porphyry of Grasmere we have passed the axis of elevation of the district. Apparently all the porphyritic rocks between Helvellyn and Grasmere must be regarded as one great band of igneous eruption; the intervening metamorphic slates being perhaps overlying masses raised up on the surface of the porphyry. The total width of the bands of porphyry thus united is about four miles, and their direction very nearly east: the slates rest on them and dip away from them on each side, and they thus form the axis of the elevation of the southern area of the Lake district.

The green slate of Rydal Water is succeeded by a metamorphic semicrystalline slate, which, as far as its obscure bedding can be seen, dips S. 25° E. 25°, reaching from Rydal Water nearly to Ambleside, with a faint cleavage dipping N. 70° and N. 80°. But in Loughrigg Fell, a little to the west of the line of section 3, we find a mass of igneous rock without bedding or cleavage bearing east; and some distance to the eastward, a similar igneous rock breaks out on the same line in Kentmere and Long Sleddale: thus the metamorphic slates appear to cover a band of igneous rock below. In this instance the cleavage strikes east in accordance with the direction of the band of porphyry, instead of following the usual direction of E.N.E., which is the ordinary strike of the cleavage and bedding of the slates throughout the Lake Mountains.

At Ambleside the green slate dips south, and the cleavage is perpendicular with a strike to the east; but this position is connected with some faults at the head of Windermere which require working out. In Wans Fell the green slate dips S. 25° E. 50° to 40°, the cleavage dipping N. 25° W. 85°.

In Troutbeck the green slate is overlaid by the fossiliferous series of the Coniston beds, which have been often described: at the junction of the two formations the cleavage is perpendicular, striking with the beds E. 25° N., but it soon returns to a dip to N. 25° W., the angle of inclination gradually diminishing from 85° to 70°.

The flagstones above the Coniston beds have been referred by Professor Sedgwick to the Denbighshire flagstone, or in other words to the Wenlock formation: I formerly combated this opinion, but now concur in its accuracy, having seen the face of the flags of Applethwaite Common covered with the remains of Creseis and Graptolites similar to those of Denbighshire. In these beds the cleavage is still marked, but its planes are more distant than in the true slates.

The Wenlock flags rest conformably on the Coniston beds, and end with a black slaty flagstone, quarried on the north side of Bowness, which is the equivalent of the Ireleth slate of North Lancashire. There are several anticlinal and synclinal axes in this series, and the beds are frequently repeated on the surface, but on the whole the formation dips about S.S.E. The cleavage meets in an axis on Applethwaite Common, and then dips S. 45° E. 85°. It is perpendicular on the line of one of the faults, and then dips N. 35° W. 85°; the dip continues in the same direction as far as Bowness, the inclination diminishing from 85° to 70°.

In the series of coarse greywackes south of Bowness, the cleavage is less marked, and there is sometimes a danger of confounding it with some of the numerous joints which traverse the rocks: for this reason I carried my observations no farther in that direction, although I believe that a careful examination of the beds would detect cleavage much farther south. The evidence of the compression of the rock, which is afforded by the distortion of the organic remains in uniform directions, is found in a slight degree through the Upper Ludlow rocks south of Kendal, in beds which hardly show a trace of cleavage; so that it seems that a slight degree of compression was not sufficient to produce the cleavage.

If we take a general view of the stratification, overlooking minor disturbances and irregularities, we must regard the great porphyritic bands of Raise and Kirkstone as one great axis of igneous eruption, running nearly east, and elevating the beds into a saddle, those of Helvellyn dipping principally northward, and those south of the axis dipping on the whole southward. But on taking a similar general view of the cleavage, we find no approach to any arch like that seen in the northern area of elevation; nor even to any regularity of position. From Helvellyn to Bowness the cleavage (with some few exceptions) dips at high angles to the N.N.W.; the extreme variation lying between N. 25° W. 65°, and S. 45° E. 85°. Thus it seems that the eruption or the presence of the bands of porphyry has interfered materially with the arrangement of the planes of cleavage.

On comparing closely the relative positions of the bedding and cleavage, it will be seen that there is a fault or axis in the stratification wherever the planes of cleavage are perpendicular, and this coincidence occurs too often to be due to accident. This is in harmony with the views stated in my former paper, that the direction of the planes of cleavage depended on the direction of the pressure on the beds which accompanied their elevation, and that the cleavage was perpendicular where that pressure ceased to act, or was arrested by another force meeting it in a contrary direction; for in a district traversed by so many bands of eruptive rocks, the compressing forces which accompanied the elevation of the various masses of rock may have acted independently between each of the erupted masses, and these forces must have neutralized one another where they met at a fault, on which the cleavage is perpendicular.

Or if it should appear that the cleavage was formed during an elevation of the beds at a later period than the eruption of the porphyries, it might then be conjectured that the hard vertical bands of porphyry had interrupted the regularity of the pressure, and had caused that want of order in the arrangement of the cleavage which is so remarkable an exception in this district to its usual symmetry. In either case the co-occurrence of faults and lines of perpendicular cleavage points to a mechanical cause of the phænomenon.

It is a singular feature of the Lake district, that though the formations strike about E.N.E., and the planes of cleavage usually follow the same direction, the great bands of porphyritic rock run nearly east. The physical geography of the district also presents a remarkable feature connected with this subject, which is that most of the valleys and great mountain ridges run nearly north, and very rarely follow the strike of the strata, or cross it at right angles; their usual direction being at right angles to the bands of porphyry.

Thus there seem to have been two great periods of elevation; the one when the porphyries were forced through long parallel chasms running east, and those great rents in the surface were formed nearly at right angles to them, which are now the lines of the great valleys running north; the other connected with the eruption of the sienites, and probably also of the granites which have thrown up the slates as we now find them with a strike of E.N.E., and have given the same direction to the cleavage, but without effacing the leading physical features of the district. I have not studied the country enough to go more at length into the details of this difficult subject, but I could not omit the mention of it, as it has an indirect bearing on my present object, and has great interest in itself; and has, I believe, been hitherto overlooked.

Conclusion.—The following is a general summary of the conclusions drawn from the observations detailed in this and the preceding paper.

The direction of the cleavage-planes is in direct relation to the movements of elevation of the strata, being everywhere at right angles to the direction of the elevating force; and where the beds have been raised with regularity over a single axis, the cleavage-planes appear to be portions of curves, of which the width of the area of elevation is the diameter.

In slaty rocks there has been a considerable compression of the mass of rock between the planes of cleavage; that is, in the direction corresponding to that of the elevating force; this compression being shown by the distortion of the included organic remains, and the flattening of the component portions of the rock, and bearing a proportion to the degree in which the cleavage is developed.

The compression of the mass in a direction perpendicular to the cleavage has been partially compensated by its expansion along the dip of the cleavage, in which direction only its expansion was permitted as the elevation of the beds enlarged the area occupied by them. The difference between the amount of compression in one direction and of expansion in another, is accounted for in the greater density of the rock after compression.

No connection has been detected between cleavage and crystallization, beyond a tendency of plates of talc and mica to arrange themselves along the planes of cleavage: but as on these planes there would be the least resistance to their intrusion or formation, this may have been a subsequent operation, and should not alter our opinion of the cause of the cleavage.

Thus all our observations and deductions ultimately converge to the conclusion that the cleavage must be attributed to pressure caused by the elevation of great masses of rock under conditions of which we are ignorant. And if to this conclusion it should be objected that no similar results can be produced by experiment, I reply that we have never tried the experiment with a power at all to be compared to that employed; and that this may be one of many cases where our attempts to imitate the operations of nature fail, owing to the feebleness of our means, and the shortness of the period during which we can employ them.

NOVEMBER 15, 1848.

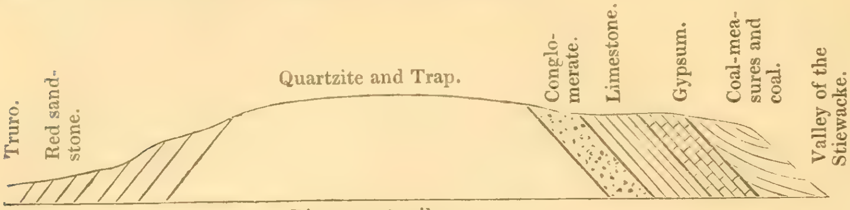
The following communications were read:—

1. *On the Gypsum of* NOVA SCOTIA. By ABRAHAM GESNER, For. Mem. G.S.

(In a letter to Sir Charles Lyell.)

SINCE my return to Nova Scotia I have had an opportunity of examining several places the geology of which had been unexplored. I scarcely need say that at the time of your visit to this country I had based my opinions in regard to the position of the gypsiferous sandstones and coal-measures of Nova Scotia upon the facts that I was then acquainted with, and the views of those who had worked in the same field. The declarations also that have been often made in reference to the situation of the gypsiferous strata of England had, I must say, diverted my attention from the subject to which you have since fully adverted.

I feel it now but just and honourable to state, that subsequent observations have convinced me that the order of succession which you have laid down in your remarks in the Proceedings of the Geological Society, and in your Travels in America, in reference to the above rock series, is correct. In a new work now in course of publication, on the Industrial Resources of this Province, I have adverted to this subject, and have given my reasons for renouncing my former opinions in this matter, and I doubt not that in the gratification this acknowledgment will afford you, on my part I shall receive as much indulgence as the case deserves; nor need I add, that even in the advancing state of the science similar errors will occur, especially in cases involved in more or less obscurity. In reference to the question, which, so far as I am concerned, is now no longer at issue, I will add a section taken between the village of Truro and the valley of the Stiewacke, which I have found to be as follows.



A similar section presents itself northward of Truro. At the St. Croix River in the county of Hants, the Silurian slates are succeeded by conglomerates, the conglomerates by gypsum and fossiliferous limestones, like those of the Shubenacadie, and the whole by coal-measures, which I believe embrace workable beds of coal. The dip and order are such as leave no doubt on my mind of their true position. It is my intention, as soon as my time will allow, to make a communication to the Society, and to supply such facts as will, I presume, set the matter at rest.

---

2. *A comparison of the structural features of disturbed districts in* Europe *and* America. By Henry D. Rogers, For. Mem. G.S., Professor of Geology in the University of Pennsylvania.

[In consequence of Professor Rogers's return to America, the publication of this paper is postponed for the present.]

November 29, 1848.

Charles Timms, Esq., was elected a Fellow of the Society.

The following communications were read:—

1. *On Fossil Plants from the Anthracite Formation of the Alps of* Savoy. By C. J. F. Bunbury, Esq., F.G.S.

The question which I propose to bring before the notice of the Society on this occasion may be considered one of the most curious in geology, with relation to the distribution of organic remains and their value in determining the age of rocks. Attention was first called to it by the celebrated French geologist, M. Élie de Beaumont, in a paper which was published in the fourteenth volume of the 'Annales des Sciences Naturelles,' in the year 1828. He described the strata observed in the neighbourhood of the village of Petit Cœur, near Moutiers in the Tarentaise, and stated that beds of black schist, which abound with impressions of ferns and other plants *identical with those of the coal formation*, are there found interposed *between* beds of argillaceous limestone containing belemnites. He appears to have completely satisfied himself that the strata containing ferns and those containing belemnites really belonged to the same geological epoch, and he refers the whole group, without hesitation, to the age of the *lias*. This paper was followed by one from M. Adolphe Brongniart, stating the result of his examination of the fossil plants from this anomalous deposit. He enumerates nineteen species, besides some others which were not in a state to admit of determination; and of these nineteen he pronounces seventeen to be positively identical with species of the coal formation, the remaining two being peculiar and previously undescribed. In a subsequent communication, published in the fifteenth volume of the 'Annales,' M. Élie de Beaumont described a series of strata of vast thickness occurring in the Alps between Briançon and St. Jean de Maurienne, and which he considered as belonging to the same system with those previously described in the Tarentaise. In the upper part of this series, at the Col de Chardonnet, not far from Briançon, he collected several additional specimens of fossil plants, which were likewise ascertained by M. Adolphe Brongniart to be identical with well-known species from the true coal formation. M. de Beaumont arrived at the conclusion that this great system of beds, containing (according to his observations) fossil plants of carboniferous species both in its upper and lower members, and containing also belemnites and even ammonites, was the representative not only of the lias, but of the whole or greater part of the Jurassic series. Thus the fossil plants (*Calamites*, *Sigillariæ* and *Lepidodendra*) of the Col de Chardonnet, which are absolutely identical with those of the coal-measures, belong to strata which (according to this view) are equivalent to the middle or upper parts of the oolite.

I am not aware that any further observations were made upon this singular anomaly until the year 1844, when the Geological Society of France held their meeting at Chambery, and their attention was naturally directed to so remarkable a fact. A great number of the members then visited the localities in the Tarentaise which had been described by M. Élie de Beaumont, and the observations which they made are recorded in the Bulletin of that Society, to which I must refer for ample details of the geological structure of that part of the Alps. They confirmed the previous observations of M. de Beaumont, and arrived (I believe unanimously) at the conclusion that the strata containing ferns really alternated with those containing belemnites, and could not be considered otherwise than as parts of the same formation.

In 1846 Mr. Horner, then President of our Society, called the attention of English geologists to this subject in his Anniversary Address, and he proposed an explanation of the anomaly, on which I shall afterwards have occasion to make some remarks.

When I was in Italy, during the past summer, it was suggested to me by some of my friends that I should examine the fossil plants from the Tarentaise, of which a considerable collection exists in the museum at Turin. Twenty years had elapsed since the publication of M. Adolphe Brongniart's memoir, and it was thought that the additional materials which had been collected might possibly tend to throw some new light on the question. Accordingly, during my stay at Turin, I devoted some days to a careful examination of the specimens from the Tarentaise, and I must add that I received the kindest assistance from Professor Sismonda and his brother, who afforded me every possible facility for a full and satisfactory investigation. The detailed descriptions of the species will be found at the end of this paper. But I must observe in the first place that I found very considerable difficulty in arriving at any satisfactory conclusions. The portions of plants contained in these Alpine slates, though very numerous, are in general very imperfect; they are crowded and jumbled together in great confusion, often much crushed and distorted; they are almost always converted into, or coated with, a silver-white talc, which, while it gives them a beautiful appearance, is not very favourable to the preservation of the more minute and delicate markings; and, in particular, the details of the venation, on which the determination of fossil ferns so much depends, are seldom well exhibited. Above all, the fronds of the ferns are very often distorted in a most singular manner, whether in consequence of drifting, or of a process of crystallization, perhaps accompanying the upheaval of the slates. This distortion causes the leaflets, not only in different parts of the same frond, but even on opposite sides of the same pinna, to differ widely both in apparent form and in direction, so that it is often exceedingly difficult to determine what was their original and normal character. Under these circumstances it will not be thought surprising that I should speak with a certain degree of caution and hesitation as to the specific identity of most of these plants.

The results of my examination may be thus stated. Among the specimens preserved in the museum at Turin I was able to distinguish only fourteen different *forms*, for I will not venture to call them species. Of these nine are Ferns, two *Calamites*, and three *Asterophyllites* or *Annulariæ*. Two of the Ferns, namely *Odontopteris Brardii* and *Pecopteris Cyathea*, may be pronounced with tolerable certainty to be identical with characteristic and well-known plants of the coal-measures. Three, or perhaps four others have a strong resemblance to coal-measure plants, with which they may very probably be specifically identical, but I cannot feel certain of them. Another seems to be a remarkable and hitherto unnoticed variety of *Odontopteris Brardii*, connecting that species with *O. obtusa* of Brongniart. The eighth is perhaps a new species, but its nearest allies are plants of the coal formation. Of the ninth the specimens are too imperfect to admit of determination. Of the remaining plants *Calamites approximatus* and *Annularia longifolia* appear to be absolutely identical with coal-measure plants; and the other two *Annulariæ* or *Asterophyllites* are at least very similar to carboniferous forms. The other Calamite is undeterminable.

I now proceed to the fossil plants of the Col de Balme and other localities near Chamounix. Sir Henry De la Beche was, I believe, the first to record* the occurrence of impressions of ferns in the schistose rocks of the Col de Balme, and he noticed their close resemblance to those of the coal formation. These impressions have since become well known, and are familiar to most visitors to Chamounix,

* In 1819.

where examples of them are generally exhibited for sale. Specimens from this locality were examined and described, together with those from the Tarentaise, by M. Adolphe Brongniart, in the paper already quoted. The black slates of the Col de Balme and the Valorsine, in which these plants occur, are admitted on all hands to belong to the same formation with those of Petit Cœur; but in the former localities they present, as far as I can learn, no anomalous features, containing no belemnites, nor, I believe, any animal remains whatever. When at Chamounix, in August last, I visited the slate quarry near the Col de Balme, from which, as I was informed, most of the specimens of fossil plants had been collected, but I was not able to meet with anything beyond some very slight and obscure traces of impressions. I procured, however, at Chamounix a considerable number of well-preserved specimens, and others were shown to me by Professor Pictet in the museum at Geneva. The Col de Balme is not the only locality near Chamounix from which these fossil plants have been procured; they occur also in the mountains above the village of Servoz, from which the Dioza torrent comes down to join the Arve; and in the mountains on the right bank of the Rhone, opposite to Martigny. But in none of these places, as I was informed by M. Pictet, have belemnites been found, nor any characteristic fossils, except the vegetable impressions.

It may be worth while to add, that M. Élie de Beaumont himself told me that he considered the slates of the Col de Balme as belonging to the *lowest* part of the lias formation. They are the lowest fossiliferous rocks of that district, and rest immediately on crystalline talcose schists, which pass downwards into the gneiss and protogene that constitute the mountains on both sides of the valley of Chamounix.

My specimens from the neighbourhood of Chamounix, and those which I examined in the museum of Geneva, include ten different forms of fossil plants, of which eight are Ferns, one a Calamite (species undeterminable), and one an *Asterophyllites*. The two latter are extremely like, if not absolutely identical with, common forms of the coal-measures. Of the ferns, there are, I think, only two which I did not observe among the Tarentaise specimens: one of these is the well-known *Neuropteris flexuosa*, very distinctly characterized, and perfectly agreeing with specimens from Pennsylvania and Cape Breton. The other comes near to *Neuropteris conferta* of Göppert (a plant belonging to the upper part of the coal-measures), but the specimen is not sufficiently perfect for accurate determination.

Lastly, I may mention that M. Élie de Beaumont showed me, in the collection of the École des Mines at Paris, a well-preserved specimen of *Lepidodendron ornatissimum* of Brongniart (Lindley's *Ulodendron majus*), with its characteristic markings, and especially the large round scars of abortive buds or branches, very distinctly exhibited. This was brought from the Col de Chardonnet, not far from Briançon. The strata in that locality are considered by M. de Beaumont as belonging to the uppermost part of the Alpine anthracite formation, and as probably equivalent to the Oxford clay.

It will be seen that after the most careful examination which I have been able to make of the fossil plants in question, I have come to the same conclusions as M. Adolphe Brongniart with respect to their general agreement with those of the coal-measures; though I have not been able to distinguish so great a number of species as he did, nor to speak with the same confidence respecting the greater part of them. So remarkable a fact as the association of plants characteristic of one formation with animal remains supposed to characterize another and much later one, seems well-deserving of the attention of geologists. The twenty years which have elapsed since this fact was first observed,—twenty years rich in geological research and discovery,—have brought to light no parallel case; nothing has been discovered tending to soften or explain the anomaly; the association of coal-plants with belemnites at Petit Cœur still stands an isolated and exceptional phænomenon.

Some, perhaps, may be disposed to object that our materials are not sufficient to establish the fact of the identity of these plants with those of the coal-measures. It is quite true that the greater part of them are in an unsatisfactory condition; and it is also true that in many instances plants of very distinct species, and even belonging to distinct genera, cannot be distinguished unless by an examination of specimens in a perfect state. But two or three of the fossil plants contained in this Alpine formation are so distinctly characterized, that there seems no reason to doubt their identity. And this at least may be affirmed with confidence,—that many of them are undistinguishable from plants found in the true coal-measures, while none have any close resemblance to those of the lias or the oolites.

The fact, that the strata which yield these plants do really alternate with those containing belemnites, seems to be established by such strong testimony that it is difficult to dispute it. We have not only the evidence of M. de Beaumont on this point, but that also of Professor Sismonda and of the Abbé Chamousset, both of whom are intimately acquainted with the district in which these fossils occur, and have had great experience in the investigation of Alpine geology; and both assured me, that no one who examined the localities could doubt that the beds containing these different kinds of fossils were really members of the same geological formation. But it was suggested by M. Michelin, at the meeting of the French Geological Society at Chambery, that the belemnites (which I believe are undeterminable as to species) might not be of the importance that had been supposed, in reference to the age of these rocks. He was inclined to consider it an instance of the occurrence of the belemnite form in the carboniferous period, rather than of the continuance of the same species of plants through several successive epochs. It is true that ammonites also have been found in certain strata of the same district, and which both M. de Beaumont and M. Sismonda consider as forming part of the same series with those in question; but this latter conclusion is, I believe, not admitted by the Abbé Chamousset. If the determination of the age of these strata rests on the belemnites alone, it may, I think, well be considered doubtful.

Mr. Horner, in his Anniversary Address, to which I have before alluded, regards this phænomenon as merely an instance of the permanence of certain species of plants; and as illustrative of the law, that species which have had a wide range in space have also had a long duration in time. "We know," he observes, "that the same species of plants are found in the coal-fields belonging to the palæozoic carboniferous rocks of Europe and of North America, and in regions with differences of more than thirty degrees of latitude; and therefore they may have been able to live through the many vicissitudes of condition of the earth's surface that must have occurred between the carboniferous and liassic periods." This explanation, as it appears to me, does not meet the difficulties of the case. If no plants different from those in question occurred in the lias formation of Europe, and if none of the intermediate rocks, between the carboniferous and the liassic periods, were characterized by markedly distinct forms of vegetable life, then the principle brought forward by Mr. Horner would be strictly applicable; and there would indeed, in such a case, be nothing peculiarly anomalous or difficult of explanation. We should merely have to conclude that vegetable remains were of no importance whatever in determining the age of rocks. But the facts are far different. The Permian system, indeed, which immediately follows the coal, appears to resemble it closely in the character of its vegetation *. But in the Trias we have a very distinct flora, confined indeed to few localities, but marked by strong peculiarities both specific and generic. The fossil vegetation of the *Grès bigarré* of Alsace, so well illustrated by Messrs. Schimper and Mougeot, is tolerably rich in species, and is quite different from that of the carboniferous period; it is characterized particularly by numerous coniferæ, of two genera (*Albertia* and *Voltzia*), and by a very remarkable fern, *Anomopteris Mougeotii*, to which nothing similar has been found in any other formation. The number of ferns found in this deposit, at Soultz-les-bains near Strasbourg, amounts altogether to eleven or twelve species, all of which, without exception, are clearly distinct from those of the coal-measures. Now we must bear in mind that the prevailing and most common ferns, at the present day, are, with two or three exceptions, the same over nearly the whole of Europe; and this appears to have been the case, in at least an equal degree, during the carboniferous æra. Therefore, when we find the variegated sandstone of Alsace, at so moderate a distance, comparatively speaking, from some of the coal-fields of France and Germany †, characterized by an entirely different set of ferns, with not even one species in common, —we are warranted in concluding that a great change of climate or other conditions, producing a remarkable change in the vegetation, must have occurred between the deposition of the coal-measures and that of the sandstones in question. Yet during that time, according to the hypothesis I am considering, the Tarentaise and a small region near it continued to retain unchanged the vegetation of the coal period; although the distance from Soultz-les-bains to the Tarentaise

* See Murchison's 'Russia.'

† It is scarcely twenty geographical miles from Saarbrück.

is trifling when compared to that between the British and the Silesian coal-fields, which have so many plants in common.

The few traces of vegetable remains which have been found in the variegated sandstone in other parts of Europe, agree, as far as they go, with those of Alsace.

In the Keuper formation we have again another very distinct assemblage of plants, more numerous than those of the Grès bigarré, and still more different from the coal-measure plants,—indeed, much more approximating to the flora of the oolite. In truth, it is difficult, as far as fossil plants are concerned, to fix a limit between the Keuper and the lias: some of the beds most rich in vegetable remains (such as the sandstone of Hoer in Scania, and the "*Lettenkohle*" of Bareuth,) are referred by some authorities to the one of these formations, and by others to the other; and many species really seem to be common to both. Of not less than sixty-eight species or forms, enumerated in Unger's Synopsis as belonging to the Keuper, not one has been discovered in the coal-measures, and the *Pecopteris Meriani* seems to be the only one that has even any close resemblance to a plant of the true carboniferous age.

There may be some difficulty in precisely defining the fossil flora of the lias, for although Unger gives a long list of plants from this formation, many of them seem to belong more properly to the lower oolite; while the sandstone of Hoer in Scania, which M. Adolphe Brongniart referred to the age of the lias, is considered by M. Schimper as equivalent to the Keuper. As far as it is known, the fossil vegetation of the lias is scarcely distinguishable, on the whole, from that of the middle and lower oolites. I need not dwell on the flora of these latter formations, which is so well displayed in our own country, and is so rich in species and so strongly characterized. It is abundantly distinguished from the coal-measure flora, not only by an invariable difference of species, but by the prevalence of altogether different tribes of plants, and especially by the great number of Cycadeæ. Nor are these characteristics of the Jurassic vegetation confined to Europe: the only rocks of that age which are known in the United States (namely those constituting the Richmond coal-field in Virginia) agree remarkably in their vegetable remains with the oolites of Europe; and even in so distant a region as Cutch, the Jurassic rocks are characterized by similar, though not identical, species of fossil plants.

It is worth while to mention that, as is stated by M. Scipion Gras, in the Bulletin of the Geological Society of France, Jurassic strata in their ordinary condition appear in the department of the Isère, at no very great distance from the limits of the anthracite formation of the Alps; and these strata contain impressions of plants, entirely different from those of the Alpine anthracite, and exhibiting the usual characteristics of the oolitic flora. We must bear in mind that the Alpine formation in question is considered by M. Élie de Beaumont as equivalent, not only to the lias, but to all the lower and middle part of the Jurassic system. It is difficult to conceive such a peculiarity of local circumstances, as could have occasioned one limited tract of the western Alps to retain its vegetation unchanged through so many geological periods, while that of the surrounding regions was undergoing repeated changes.

Some few instances certainly are known of the insulated occurrence of tropical species, especially of ferns and Lycopodia, in temperate regions, far beyond their ordinary geographical range; as, for example, *Trichomanes radicans** in Ireland, and *Lycopodium cernuum* in the Azores. But to find a parallel case to that under consideration, we must suppose an island, or a small tract of country, in which *all* the ferns were specifically different from those of the surrounding countries, and identical with those of some far-distant region; for, in such cases, distance in space may be considered as representing distance in geological time. I know of nothing analogous to this in the present state of things.

Lastly, I must mention the hypothesis proposed by M. Adolphe Brongniart. He holds, that the plants which we find preserved in the slates of the Savoy Alps did not grow in those regions, but were drifted from great distances; that the peculiar vegetation which had been widely spread over the globe in the carboniferous period, continued to exist in the hotter parts of the earth long after it had become extinct in our temperate regions; and that plants belonging to those hotter climates were occasionally drifted as far north as where the Alps now exist, and buried in the deposits in which we find them alternating with belemnites. This is perhaps the most plausible explanation that has been offered, and yet there seem to be some considerable difficulties in the way of it. Although the vegetable remains in the Alpine slates are not in general very well preserved, yet their condition is not so very different from that of ordinary coal-plants as it would seem that, according to this theory, it ought to be; and it is not easy to conceive how the delicate leaves of ferns could be drifted, either by the sea or by rivers, for so great a distance as from a tropical to a temperate climate, without being so much damaged as to lose all their distinctive characters. Fruits, and seeds, and branches of tropical plants are occasionally wafted by the sea to our coasts; but I never heard of any instance of leaves being so conveyed. Nor is it easy to understand, on this supposition, how it happened that these tropical ferns were not drifted to other parts of Europe, besides the district under consideration.

Nevertheless, I must acknowledge that I have no more satisfactory explanation to offer; nor do I see any way out of the difficulty, unless by adopting the opinion of M. Michelin, to which I have already referred. My attention has been directed chiefly to the botanical aspect of the question, and I must leave the farther discussion of it to those more versed than myself in strictly geological investigations, and especially to those who have had experience in the difficult researches of Alpine geology.

* See Hooker's 'Species Filicum.'

Descriptions of Fossil Plants from the Tarentaise.

1. Neuropteris tenuifolia? (Brongn. Veg. Foss. p. 241. t. 72. f. 3?)

This is abundant, and some of the specimens are large, and tolerably complete. Leaflets very variable, even in the same specimen: many of them agree well with the ordinary appearance of *N. tenuifolia*, as seen in the coal-fields of England, and as figured by Brongniart; but very often they are longer and narrower than in the normal state of that plant,—sometimes so long and narrow that they might be thought to belong to *Pecopteris lonchitica*; while others again, on the very same frond, agree almost exactly in outline with those of *Neuropteris flexuosa*. I am inclined to refer the plant to *N. tenuifolia* rather than to *flexuosa*, because the midrib is much more strongly marked, and longer in proportion to the leaflets, than in normal specimens of the latter. The side-veins are very obscure in all the specimens, and this necessarily throws a doubt on the determination of the species. There are many other variations, probably depending on the distortion which the plants have undergone: sometimes the leaflets are closely crowded, and even imbricated, sometimes remote; in some parts they lie almost flat along the *rhachis*, and again, in the very same pinna, they are perpendicular to it, or even bent back.

N. tenuifolia was described by Brongniart from specimens collected in the coal-mines of Saarbrück. It has since been found in those of Merthyr Tydvil and of Northumberland; in the district of Osnabrück (according to specimens in the British Museum); and in the Permian formation of Russia. I am not aware that it has been observed in America.

2. Neuropteris gigantea?

Two or three detached leaflets, much resembling this species.

3. Neuropteris?

Fragments of very large leaflets with the venation of a *Neuropteris*, apparently belonging to some species like *N. ingens*, or possibly to a *Cyclopteris*.

4. Odontopteris Brardii (Brongn. Veg. Foss. v. i. p. 252. t. 75 & 76).

Fragments of this plant are numerous in the slates, and in many of them, fortunately, the peculiar and characteristic venation is so well preserved as to leave no doubt of the genus. The leaflets are generally smaller and less acute than in the French plant figured by Brongniart; but there appears to be no difference of any importance. None of the specimens however are sufficiently perfect to exhibit the characteristic basal leaflets of the pinnæ. *O. Brardii* appears to be a very local fossil: there is no record of its having been found in the coal-fields of England, Germany, or America; nor indeed anywhere (in the old coal formation) except in the mines of Lardin, near Terrasson, in the department of the Dordogne.

5. Odontopteris obtusa? (Brongn. Veg. Foss. p. 255. t. 78. f. 3 & 4).

Of this I observed some very incomplete fragments, entirely agreeing with Brongniart's figure and description of *O. obtusa*; but other and more numerous specimens are exactly intermediate between his *O. Brardii* and *O. obtusa*, or rather exhibit the characters of both together. In the best-preserved specimen, the leaflets are strikingly different on the opposite sides of the same pinna: on the one side they are short, almost round, or rather broader than long, and very obtuse, much resembling those of *O. obtusa* in Brongniart's fig. 4. t. 78; on the other side they approach closely to the normal form of *O. Brardii*. This singular incongruity is most strongly marked towards the base of each pinna, the leaflets towards the extremity becoming gradually more and more symmetrical, and, at last almost wholly so. It is possible that the want of symmetry may be produced in part by distortion, for the leaflets are dissimilar in direction as well as in form. The venation in this particular specimen is beautifully preserved, and thoroughly characteristic of the genus *Odontopteris*.

Other fragments exhibit the dissimilarity of the leaflets in a greater or less degree, with a variety of intermediate forms; and, with every reasonable allowance for distortion, they lead me to the conclusion that the *Odontopteris obtusa* (of which small fragments only have been hitherto observed) is merely a variety of *O. Brardii*.

The localities assigned by Brongniart to the *Od. obtusa* are, Lardin, near Terrasson (where it was found in company with *O. Brardii* and *O. minor*), and the Col de l'Ecuelle, near Chamounix. This latter locality belongs to the ambiguous formation of which I am here treating. The *Od. obtusa* of Lindley and Hutton's 'Fossil Flora' (from the Shropshire coal-field) is considered by Göppert as a distinct species, which he calls *O. Lindleyana*.

6. Pecopteris Cyathea (Brongn. p. 307. t. 101).

Specimens well characterized, and referable with tolerable certainty to this species, or rather perhaps to the variety called *P. arborescens*.

Pecopteris Cyathea appears to be one of the most generally diffused of the fossil ferns of the coal-measures. It has been observed in the coal-fields of Saxony, Bohemia and Silesia; at St. Etienne, and various other localities in France; near Osnabrück; in many of the English coal-fields, and in most of those of North America. In this enumeration I include the localities of the so-called *P. arborescens*, as I find it impossible to distinguish between the two forms.

7. Pecopteris ——?

A fern very like *P. Cyathea*, but with larger leaflets, of a rounder form, and remarkably broad in proportion to their length. Main-stalk excessively thick. Venation not distinguishable.

8. Pecopteris pteroides? (Brongn. p. 329, t. 99. f. 1?)

Two large specimens seem to approach near to this species. The leaflets are rather narrower and less closely set than in Brongniart's figures; the venation very indistinct; and the basal leaflets of the pinnæ are not sufficiently well preserved to determine the species with certainty.

9. Pecopteris ——?

This seems more nearly allied to *P. Plukenetii* (Brongn. t. 107. f. 2) than to any other described species; but the lobes of the leaflets are of a much rounder form than in that plant; the leaflets themselves larger and more obtuse, except those towards the extremity of each pinna, which become successively more and more acute; and the pinnæ are broader and more ovate in their outline; venation very obscure. Another specimen, which I conjecture to belong to the same plant, and which is perhaps one of the lowest and largest pinnæ of the frond, is pinnated, with broad ovate leaflets, divided half way down into rounded lobes. The venation in this specimen is well preserved; the midrib of each leaflet is pinnated with rather strong lateral veins running into the several lobes, but not reaching to the extremities of them, and these veins are again pinnated with slender and sometimes forked veinlets.

10. Calamites approximatus (Brongn. Veg. Foss. p. 133, t. 24).

A very large specimen, decorticated, but well characterized.

Calam. approximatus has been found in the coal-mines of Alais, in the department of the Gard, of Liége, of St. Etienne, of Kilkenny; in several of the English coal-fields, and abundantly in those of Nova Scotia and Cape Breton.

11. Calamites Suckowii?

Many fragments, but none sufficient for the satisfactory determination of the species.

12. Asterophyllites ——?

A species with short internodes and very narrow incurved leaves many in a whorl, much longer than the internodes.

13. Annularia longifolia.

(*Asterophyllites equisetiformis*, Lindl. and Hutt. Foss. Fl. v. ii. t. 124.)

Certainly the plant of the 'Fossil Flora,' and the same as No. 40 of my paper on the coal-plants of Cape Breton.

Found in the Newcastle coal-field, at Wettin near Halle, and in the island of Cape Breton.

14. Annularia ——?

A small species, with short, wedge-shaped, very obtuse leaves; I think the same as No. 41 of my paper above-quoted.

Descriptions of Fossil Plants from the Col de Balme *and other places near* Chamounix.

1. Odontopteris Brardii.

The same as from the Tarentaise. The leaflets are usually rather less falcate and less acute than in Brongniart's figures, and it passes by intermediate specimens into the next form.

2. Odontopteris obtusa?

Identical with No. 5 of the preceding list, but I do not find in any of the specimens from the Col de Balme that curious want of symmetry which is so striking in some of those from the Tarentaise.

3. Neuropteris flexuosa (Brongn. Veg. Foss. p. 239, t. 68. f. 2).

The specimens of this plant are well preserved and highly characteristic, agreeing precisely with those from the coal-fields of North America. The specimens in my collection were found, as I was told, in the mountains above Servoz; those which were shown to me by M. Pictet, in the museum of Geneva, were from the mountains near Martigny in the Valais. One fragment has the leaflets so broad and round, that it might be referred to *N. rotundifolia*, but I have observed a similar variation in English specimens of *N. flexuosa*.

Neuropteris flexuosa is a very general and very abundant fossil in the North American coal-fields, especially in those of Pennsylvania and Cape Breton. In Europe it seems to be less frequent, but I have seen specimens from Pembrokeshire and from Somersetshire, and it is recorded from Bohemia.

4. Neuropteris?

Very like *N. conferta* of Göppert (Syst. Fil. Foss. p. 204, t. 40), but the specimen is not perfect enough for satisfactory determination, and in particular I cannot ascertain whether the main stem is winged with decurrent leaflets,—one of the essential characteristic marks of that species. I saw nothing similar to this among the specimens from the Tarentaise.

5. Neuropteris alpina (Sternb.)?

(Göpp. Syst. Fil. Foss. p. 204?)

Several of the specimens from the Col de Balme seem to belong to this species, though none of them are sufficiently perfect to display its characters in a thoroughly satisfactory manner. It is very likely that some of those from the Tarentaise, which I placed doubtfully under *N. tenuifolia*, may also belong to this, for, owing to the manner in which the specimens are encrusted with talc, it is often difficult to determine whether the leaflets are really *adnate* to the rhachis or not, and the venation is generally very obscure. Judging from those examples in which the veins are best shown, I should think that this species is not well placed in *Neuropteris*.

6. Pecopteris —— ? (allied to *Cyathea*).

Identical with No. 7 of my Tarentaise list. The leaflets are shorter and broader in proportion than in any of the forms of the *Cyathea* group figured by Brongniart; they vary somewhat in outline in the same specimen, being sometimes nearly round, sometimes more of a square form. The main stalk is always remarkably thick in proportion to the stalks of the pinnæ which proceed from it.

7. Pecopteris —— ? (allied to *Plukenetii*).

Identical with No. 9 of the preceding list. It is perhaps as nearly allied to *Sphenopteris latifolia* of Brongniart (*Aspidites latifolius*, Göpp.) as to *Pecopt. Plukenetii*; at any rate it is one of those forms which might almost equally well be referred either to *Pecopteris* or to *Sphenopteris*. Venation quite undistinguishable in my specimen.

8. Pecopteris pteroides?

The same with No. 8 from the Tarentaise; but the species is very doubtful.

9. Calamites —— ?

Very probably one of the forms of *C. Suckowii*, but the species cannot be determined.

10. Asterophyllites —— ?

Apparently identical with No. 12 of the preceding list. It can hardly be distinguished from some of the specimens from the coal-field of Cape Breton, which I have taken for *Asterophyllites foliosa*.

---

2. *On the Geology of the neighbourhood of* Oporto, *including the Silurian Coal and Slates of* Vallongo. By Daniel Sharpe, Esq., F.G.S.

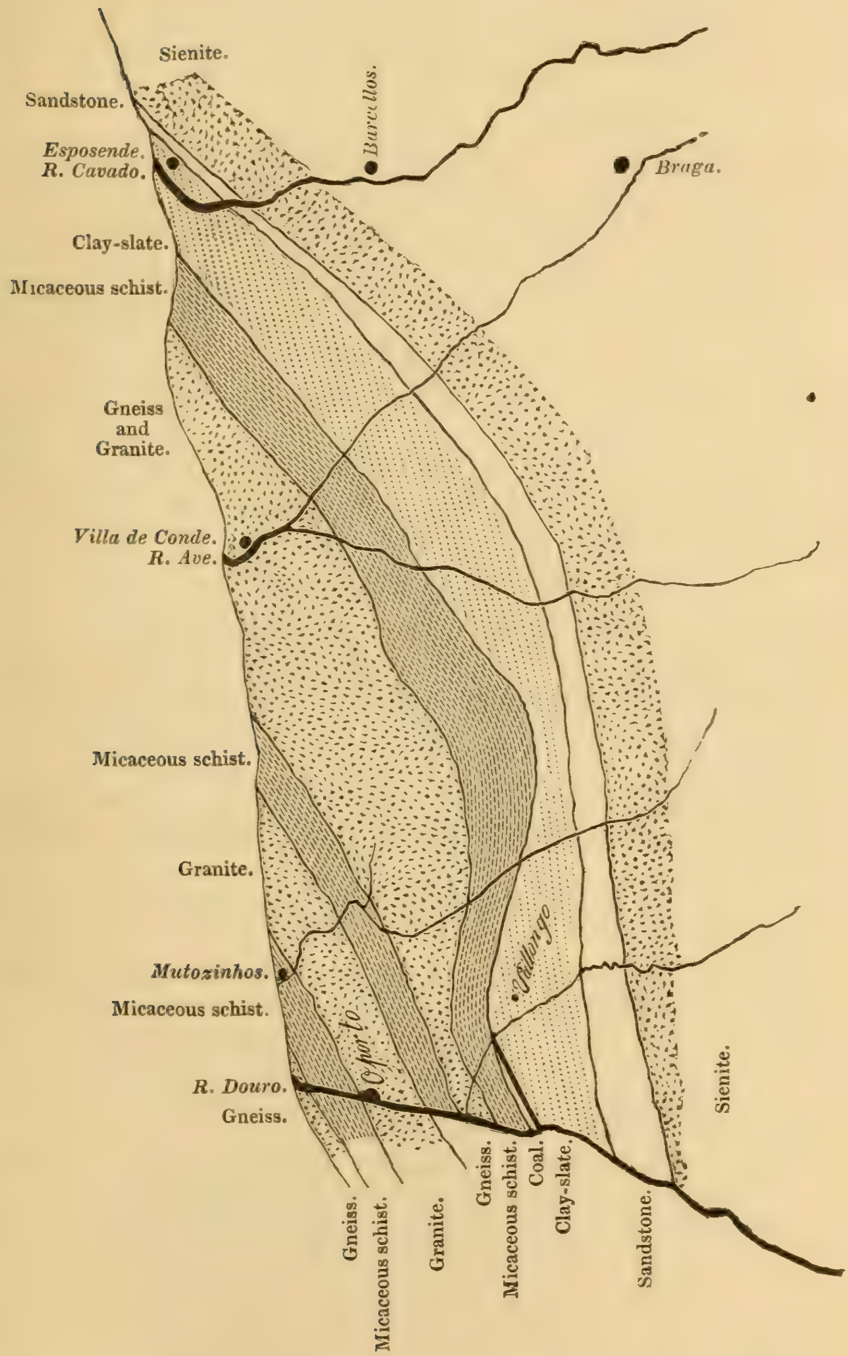
On the 11th of April, 1832*, I laid before the Society a short notice of the rocks of which the following is a more detailed account: since that period I am not aware that anything more has been published respecting them; but the recent discovery of shells and trilobites in the Vallongo slates has given a fresh interest to the subject.

(A.) *Crystalline Rocks near Oporto.*

The town of Oporto stands on a band of granite four or five miles wide, which forms the axis of the neighbouring rocks, with a general direction of about N.N.W.; it is enclosed on each side by a belt of brown micaceous schist with quartz veins, to which succeeds on each side a line of granitic gneiss alternating with and passing into micaceous and chloritic schists, which are overlaid both to the north-east and south-west of the district of crystalline rocks by clay-slates of sedimentary origin. In some places granite is found (as at San Cosme and elsewhere) in the place of the gneiss, and there are, on the

* Proceedings of the Geological Society, vol. i. p. 395.

Fig. 1. *Map of the district North of Oporto.*



south of Oporto near Grijo and Villa da Feira, some peaks of sienite which interfere with the regularity of the series; but notwithstanding these and other irregularities, there is an approach to parallelism in the position of the various members of this system of crystalline rocks, the granite of Oporto appearing to be the lowest member, and to be overlaid on both sides by micaceous schists, gneiss, and micaceous or chloritic schists. The district to which the above remarks apply is about twenty miles wide, measuring it from S.W. to N.E., at right angles to the strike of the rocks.

The foliation both of the schists and the gneiss usually strikes about N.N.W., that is, parallel to the principal axis; but it dips in contrary directions on the two sides of the axis, being usually to the S.W. on the S.W. side of the Oporto granite and to the N.E. on the N.E. side of it; therefore in each case the foliation dips away from the granite as if in the form of an arch or saddle. On the western side of Oporto, the space occupied by micaceous schists and gneiss, between the granite and the Atlantic north of the Douro, is about two miles wide, so that only a small portion of the western side of the arch of the cleavage-planes is here seen; but on the eastern side of the granite the foliation and cleavage dip to the N.E. for a width of about ten miles, ending with a line of perpendicular cleavage in the middle of the clay-slates about two miles east of Vallongo: thus the cleavage and foliation appear to form an irregular arch over the band of granite, of which the diameter if fully seen would be about twenty-five miles. Beyond the line of perpendicular cleavage, the cleavage-planes again dip S.W. and belong to another elevation. These phænomena coincide in principle with those which I have described in Wales, Cumberland, and Devonshire; and help to confirm the rule that the planes of cleavage are arranged in a sort of arch over the axis of elevation of the rocks of the district.

On both sides of the granitic axis the angles of dip of the foliation vary from 60° to 80° with much irregularity. In the gneiss the foliation is frequently wavy or even violently curved; but viewed on a large scale, its direction is parallel to that of the foliation of the schists.

Most of the quartz veins in the micaceous schists are parallel to the foliation of the schists; and where the mineral character of the schists varies, the line of change is usually parallel to their foliation.

Where the sedimentary slates rest on the crystalline schists at the edges of the district of igneous rocks, the cleavage of the slates is parallel to the foliation of the schists.

Thus we find a general approach to parallelism in the foliation of the crystalline rocks, in the direction of the majority of the quartz veins, in the line of change in the minor mineral characters of the schists, and in the cleavage of the sedimentary slates, the whole of which correspond in strike with the line of the granitic axis of elevation of the district. A similar parallelism has been pointed out by Mr. Darwin in various parts of South America, between the planes of foliation of the gneiss and mica schists and the planes of cleavage of the slates*.

* Darwin, Geological Observations on South America, chap. 6.

(B.) *Lower Silurian Formation.*

The series of crystalline rocks just described is overlaid on its eastern flank by a band of rocks of sedimentary origin, of which clay-slate is the principal feature. This band of slates commences northward on the coast near Esposende, about thirty miles north of Oporto, from which place it runs to the S.S.E., meeting the Douro at Jeremunde, about twelve miles above Oporto; here it crosses the Douro and continues to the southward, where I have not followed it.

On the north of the Douro the band in question varies from four to eight miles wide, being bounded eastward by granite and sienite, which form the greater part of the province of Entre Minho e Douro. The most interesting part of its course is to the south of Vallongo, from which place to the Douro the slates overlie a carbonaceous deposit containing several beds of anthracite, which have long been worked at the village of San Pedro de Cova, about eight miles E.N.E. of Oporto, and two miles S.S.W. of Vallongo, and five miles north of the Douro.

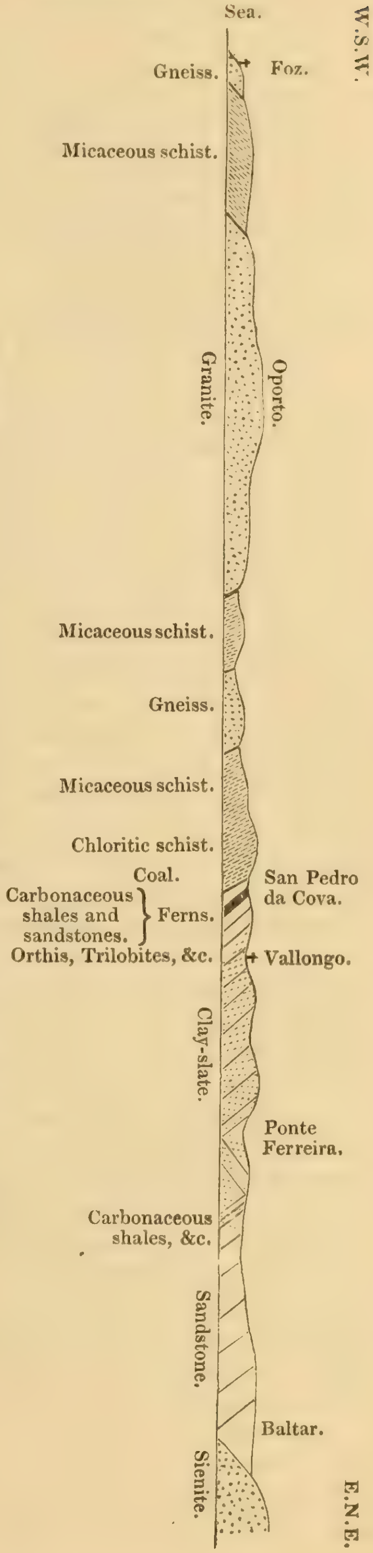


Fig. 2. *Section from the mouth of the* Douro *to* Baltar *(15 miles).*

(a.) *Vallongo Section.*

The slate formation is developed on a larger scale at this part than it is farther to the north: the Amarante road traverses the formation from its eastern boundary near Baltar, where it abuts against sienite, and crosses the beds in a descending order from E.N.E. to W.S.W.: this is nearly the line of this section, fig. 2. The series is as follows in descending order:—

1. Micaceous sandstone usually of a yellowish colour, with some beds near its base of grey carbonaceous sandstone; usual dip E.N.E.

at a high angle; the lower beds dip in that direction 60°. This series is of great thickness.

2. Black carbonaceous slate lying conformably below the micaceous sandstone and alternating with dark clay-slate; with the exception of some local undulations the beds dip N.E. 60° to 70°, and the cleavage of the beds of slate dips N.E. 70° to 80°. Among the shales are numerous beds three to six inches thick of indurated ferruginous clay passing into clay iron-stone. The appearance of these carbonaceous shales accompanied by clay iron-stone is exactly that of the shales of our coal-fields. Several small trials have been made for coal among the black shales, but none has been found. This series is of considerable thickness.

3. Clay-slate, usually dark grey or black, and hard, but occasionally soft, chloritic, and of a pink or yellow colour. The upper beds of slate lie conformably under the carbonaceous shale, dipping N.E. 60°, with a cleavage which dips N.E. 80°; a little farther westward the same beds dip W. 30° S. 25°, the cleavage dipping W. 30° S. 65°; this dip continues to Ponte Ferreira, west of which the slates regain their usual direction, dipping S.E. 45°, and the cleavage S.W. 80°. About 1½ mile east of Vallongo the cleavage is perpendicular with a strike of N. 30° W., which is the mean direction of the strike of the beds and cleavage-planes: the slate at this spot is of a light colour and contains chlorite. Thence to Vallongo is a hard dark roofing-slate of the finest quality, dip N.E. 45°, dip of the cleavage N.E. 60° to 70°. These slates are extensively quarried near Vallongo for slabs and flags, but have not yet been applied to roofing, which throughout Portugal is made of tiles. The lowest beds of this series are soft, of light colours and chloritic. The thickness of the slate series must be very considerable, but owing to several undulations of the beds it is difficult to estimate it. The lower beds of the dark grey slate, and all the beds of the lighter soft slates at the base of the series, are rich in organic remains, which I collected to the north, south, and west of Vallongo; but I found none to the eastward of that village, nor in any of the beds above the fine roofing-slate. Most of these fossils are of new species, but they are all of forms common in the Lower Silurian rocks of the north of Europe, and all the known species among them belong to the Lower Silurian formation.

The following species were found:—

Calymene Tristani, Brongniart, Tril. pl. 1. fig. 2.
————————, another species; specimens imperfect.
Ogygia Guettardi, Brongniart, Tril. pl. 3. fig. 1.
Isotelus Powisii, Portlock, Londond. pl. 6. fig. 1.
Illænus Lusitanicus, n. s.
Chirurus; fragments of an undescribed species.
Beyrichia or *Cythere*; a small species, abundant.
Orthis Noctilio, n. s.
—— *Miniensis*, n. s.
—— *Duriensis*, n. s.
—— *Lusitanica*, n. s.
——, fragments of several other species.

Orthoceras remotum, Salter, MSS.

———, a fragment, $2\frac{1}{2}$ inches in diameter.

Bellerophon Duriensis, n. s.

Graptolithus Murchisoni ?, Sil. Syst. pl. 26. fig. 4.

Besides the above, I saw many shells and trilobites too imperfect to be determined ; the fragments of trilobites are very abundant, and many of them are remarkable for their size ; one crushed specimen measures seven inches across the body. Many impressions of the tails of trilobites were seen between six and nine inches across, but all much distorted.

Mr. Salter has had the kindness to assist me in determining the species of the trilobites ; and Mr. Morris has helped to fix the specific characters of the shells.

4. Carboniferous series of San Pedro de Cova : this series of beds lies conformably under the slate series just described, and the passage from the one set of beds to the other is gradual ; the following are the details, viz. :—

a. Red sandstone, dip E.N.E. $\frac{1}{2}$ N. 45° ; several hundred feet thick, with alternations of dark carbonaceous beds in the lower part.

b. Coarse conglomerates of different characters alternating with black carbonaceous shales : some of the conglomerates are quartzose and micaceous, others grey with a good deal of carbon ; the whole many hundred feet thick*.

c. Coal ; about six feet thick.

d. Coarse micaceous conglomerate alternating with black carbonaceous shale.

e. Coal ; too thin to be worked.

f. Coarse carbonaceous conglomerate.

g. Coal ; four beds from two to five feet thick, varying in thickness in different spots, and separated by three or four feet of black shale. These beds are all worked from the same galleries, and furnish at present the principal supply of coal. They rest on black shale.

h. Shales containing chlorite, resembling in colour the chloritic schists on which they rest, and from the debris of which they have evidently been formed.

The carbonaceous series No. 4 is probably between 1000 and

* Both in the shales and sandstones impressions of vegetable remains are found, but usually in bad preservation. Mr. Charles J. F. Bunbury has had the kindness to examine the specimens, and finds in them "indications of three species of ferns, all in bad preservation and very indistinct; the best-preserved specimen is in fructification, and seems to have a strong resemblance to *Pecopteris Cyathea*, which is a common fern of the coal-measures. Another is extremely indistinct, but reminds us in some degree of *Pecopteris muricata*. The third resembles *Neuropteris tenuifolia* in the form of its leaflets ; but the total obliteration of the veins makes it impossible to pronounce upon it with any approach to confidence." It thus appears from the note with which Mr. Bunbury has favoured me, that there are in the carboniferous beds at Vallongo several ferns with strong resemblance to certain species known in the coal-measures. Now that attention has been drawn to a circumstance of so much interest, it is to be expected that before long specimens may be brought to light which will show whether the same species of plant existed at two periods so remote from one another.

1500 feet thick: it rests on the crystalline chloritic schists described at the beginning of the paper (p. 144). The dip of all the beds of the carbonaceous series at San Pedro de Cova is E.N.E. $\frac{1}{2}$ N. 45°, which corresponds with the dip of the fossiliferous slates of Vallongo; the country between the two places is a rough mountainous district, with little vegetation; the outcrop of the beds is seen everywhere, and their relative position does not admit of doubt.

The coal is worked by inclined shafts which follow the dip of the beds, the deepest of which in 1844 was about 600 feet; at that time I was informed that about 4500 tons of coal were raised annually, which are consumed principally in Oporto. The prices at the pit's mouth were then about equal to 6*s*. 3*d*., 15*s*. and 25*s*. per ton for the three qualities into which it is sorted: the carriage by land to Oporto costs about 6*s*. 3*d*. per ton.

The coal is an anthracite of very pure quality, containing very little bituminous matter.

The same beds of coal have been opened on a smaller scale on the north bank of the Douro at Jeremunde, about twelve miles above Oporto, and they have been traced from that spot to San Pedro de Cova, but they are nowhere so thick as at the latter place. North of San Pedro de Cova this whole carboniferous series thins away very rapidly, and the beds die out completely about a mile and a half north of that place, thinning off against the crystalline rocks of the Serra de Vallongo, which there project considerably to the eastward of their principal line. Where the Oporto road crosses the Serra de Vallongo, the fossiliferous clay-slates of Vallongo, No. 3, rest immediately on the crystalline micaceous and chloritic schists; and, as far as I observed, the same is the case along the whole course of the formation to the northward of Vallongo. It appears that the carboniferous series No. 4 is a very local deposit, only found to the southward of the road from Oporto to Vallongo, and which attained an unusual development, under some peculiarly favourable circumstances, in a deep bay left in the granitic chain near San Pedro de Cova. It would be interesting to trace out the course and character of the coal-beds on the south of the Douro, but this I believe has never been done.

(b.) *Section along the Braga road.*

The slate formation is developed on a smaller scale to the northward of Vallongo. Where it is crossed by the road from Braga to Oporto, the following series of beds is exposed in descending order:—

Sienite reaching to two miles south of Villa Nova de Famelicao; then,

1. Coarse red micaceous sandstone, which becomes more and more slaty in the lower beds.

2. Black carbonaceous shale, with some beds of coarse grit and also of clay iron-stone: nearly perpendicular with a strike of N.N.W. The spot where the road crosses these beds is called *Terra Negra*.

3. The above pass into a soft grey clay-slate, cleavage perpendicular, striking N.N.W., followed by soft slates of various light colours, with some alternations of slaty sandstone and of indurated ferruginous

clay. These beds reach to the banks of the river Ave at Barco da Trofa, where they rest on a soft chloritic slate; strike N.N.W.: a little south of Venda da Serra this rests on granite.

(c.) The section crossed by the road from Vianna to Oporto presents the same features as the above. It appears that throughout the whole course of the formation the three upper divisions of the formation, sandstone, carbonaceous shale and clay-slate, are everywhere to be distinguished; but that the lower carbonaceous division is not to be found north of Vallongo. There is everywhere to be seen a gradual passage between the beds of the different divisions, which leaves no doubt that the whole are to be regarded as subordinate parts of one formation. And the great similarity in mineral character between the black carbonaceous shales No. 2, in the middle of the formation, with the beds associated with the coal in the lowest division No. 4, farther connects the whole together.

(C.) *Road from Oporto to Aveiro.*

A similar series of Silurian rocks is seen about thirty miles to the south of the Douro, on the road from Oporto to Aveiro: after leaving the granite of Oporto the road crosses brown micaceous and argillaceous schists, the foliation of which strikes N.W., and dips S.W. 80°.

Granite, with occasional peaks of sienite.

Gneiss; dip of the foliation S.W. 30°.

Micaceous schists alternating with gneiss; dip of foliation S.S.W. from 60° to 80°.

Sienite at Villa da Feira.

Micaceous and chloritic schists striking W.N.W., which continue to Ovar, beyond which place the Silurian slates are seen in the following ascending series :—

3. Clay-slate, strike N., dip of cleavage E. 80° varying to S.E. 80°, of considerable thickness.

2. Carbonaceous shale which lies over the preceding near Estareja, and alternates with red slaty sandstone, dip S.E. 60°, dip of cleavage S.E. 80°.

1. Red slaty sandstone.

Beyond Angeja these beds are covered up by a thick deposit of coarse gravel which conceals the strata over the great plain round Aveiro.

From the direction taken by the Silurian slates, they ought to cross the high road from Oporto to Coimbra near the banks of the Vouga; but beyond the southern termination of the micaceous schists near Albergaria Nova, the whole country is completely covered with gravel, which reaches to a red sandstone seen on the banks of the Vouga near Sardão; so that we are left in doubt whether the slates are continued in this direction.

The red sandstone of Sardão is a fine-grained freestone in thin beds separated by partings of red marl, resembling the new red sandstone of our Midland counties; it dips S.E. 5°, and is overlaid to the southward by sands which belong either to the oolitic or cretaceous period. We have no clear guide to the age of the Sardão red sandstone; but from its mineral character and horizontal position, I regard it as of secondary origin, and do not connect it with the Silurian formation of Ovar and Estareja.

I have here described the only beds referable to the Silurian system which fell under my own observation in Portugal; but rocks resembling in mineral character the clay-slates and sandstones of the Vallongo section have been described by Dr. Rebello de Carvalho as forming the high chain of the Serra de Marão near Amarante, and covering the whole of the celebrated wine-district of the Upper Douro, in which all the fine port wines are produced upon the slates; the line of the granitic boundary being the exact limit to the cultivation of the finer qualities of wine*.

Similar clay-slates and roofing-slates, accompanied by slaty sandstones, cover the eastern side of Gallicia according to Schulz†, and are stated by Link to form the greater part of the province of Traz os Montes, both flanks of the great granite chain of the Serra de Estrella, and a great part of the district enclosed between the Zezere and the frontier of Spain‡: and we find similar rocks described in Spanish Estramadura by Le Play§. No one has yet ascertained the exact geological age of these rocks; but on comparing the descriptions given of their position and mineral characters with those of the now-ascertained Silurian formation of Vallongo, it becomes highly probable that future observers will find the Silurian system largely developed throughout these parts of the Peninsula.

Description of the Organic Remains.

Isotelus Powisii? (Portlock, Londonderry, &c. pl. 6. fig. 1).

The specimen consists of the tail and a portion of the last joint of the body, and is not enough to determine the species with certainty. It differs from the specimen figured as *Asaphus Powisii* in the 'Silurian System,' pl. 23. fig. 9, but agrees well with Captain Portlock's figure; if the latter prove a distinct species, the Portuguese trilobite must be classed with it.

Found in slate at Vallongo near Oporto.

Illænus Lusitanicus, n. s.

Glabella broad anteriorly and contracted posteriorly; very convex. Eyes placed nearer the back than the front of the head, about one-third of the length of the head from the back.

Body of ten rings divided into three nearly equal parts by two deep furrows; the central portion very convex.

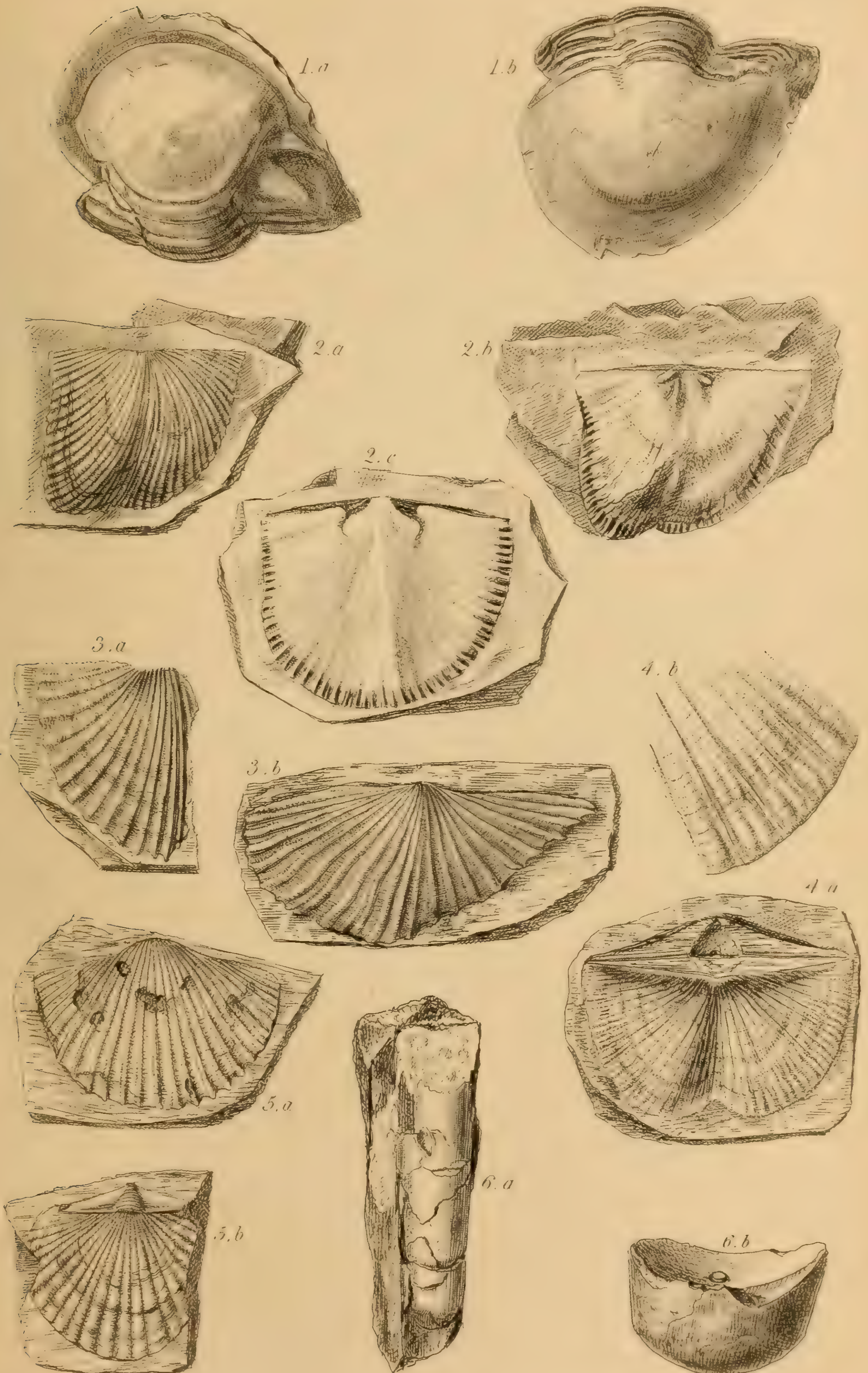
* Considerações geraes sobre a constituição do Alto-Douro. By Jozé Pinto Rebello de Carvalho. 1848.

† Descripcion Geognostica del Reino de Galicia por Don G. Schulz. 1835.

‡ Geologische und Mineralogische Bemerkungen auf einer Reise durch das südwestliche Europa, besorders Portugal. Von H. F. Link. 1801.

§ Observations sur l'Estramadure et la Nord de l'Andalusie. F. Le Play. Annales des Mines, 3me série, vol. vi. p. 297, and pl. 6. 1834.

From the Lower Silurian Slates of Vallongo.



1. Illænus Lusitanicus.
2. Orthis Noctilio.
3. Orthis Miniensis.
4. Orthis Duriensis
5. Orthis Lusitanica
6. Orthoceras vagans

J. De C. S. fecit

Tail convex, very broad, considerably wider than the head, and projecting far beyond the sides of the head when the animal is rolled up ; its anterior margin lobed, with a waved outline ; furrows marking the axis very faint ; axis very small ; its length equal to about one-third, and its breadth only equal to two-sevenths of that of the tail.

Length of the animal about 3 inches.

Head : length 1 inch ; greatest breadth $1\frac{1}{8}$ inch.

Tail : length $1\frac{1}{8}$ inch ; greatest breadth $1\frac{3}{8}$ inch.

Found in slate at Vallongo.

Unfortunately the head of the specimen has been crushed in at the sides, which makes it doubtful how far the triangular outline it now presents is natural ; and the general condition of the specimen does not admit of a good description of the species.

The most marked peculiarity seen is the great breadth of the tail, both compared to the head and to its own axis, which occupies little more than one-fourth of the breadth of the tail.

The *I. giganteus* of the Angers slates, Burm. t. 3. f. 10, is the only described species to which this can possibly be related, having the same narrow caudal axis ; but the Portuguese trilobite has a far broader tail than is shown in the only figure yet published of that species. Unfortunately the *I. giganteus* is so little known and so slightly figured, that we have not the means of any certain comparison with it.

Fig. 1 *a*. Pl. VI. head and part of the body.

Fig. 1 *b*. Pl. VI. tail of the same specimen.

Orthis Noctilio, n. sp.

Shell nearly flat ; outline semi-ovate with sides nearly straight ; length about two-thirds of the width ; thickness inconsiderable.

Dorsal valve slightly convex, with an elevated mesial ridge.

Ventral valve nearly flat, with a mesial furrow corresponding to the ridge of the dorsal valve.

Hinge-areas narrow, slightly produced beyond the sides of the shell.

Surface covered with fine concentric lines, and ornamented with narrow unequal ribs which bifurcate several times, being about 15 in number near the hinge, 50 at the middle of the valve, and between 60 and 70 at the margin.

Interstices wider than the ribs.

Interior margins of the valves strongly crenated.

Length $1\frac{1}{2}$ inch ; width at the hinge $2\frac{1}{4}$ inches.

Found in slate near Vallongo.

The elevated ridge on the dorsal valve connects this species with the *O. bilobata*, Sow., and *O. vespertilio*, Sow., which are found in the Lower Silurian rocks of this country : it is distinguished from both those shells by coarser, simpler and less numerous ribs.

Fig. 2 *a*. Pl. VI. Ventral valve, from the cast of a distorted specimen.

Fig. 2 *b*. Ventral valve ; interior of the same specimen.

Fig. 2 *c*. Interior of dorsal valve.

Orthis Miniensis, n. sp.

Shell rather flat; outline nearly semicircular, with the greatest width at the hinge.

Dorsal valve moderately convex, with a slight mesial elevation.

Ventral valve flat, with a faint mesial depression.

Valves covered with well-marked concentric lines and ornamented with 20 to 30 narrow rounded simple ribs, reaching from the hinge-area to the margin, and separated by broad flat interstices. At the middle of each valve short narrower ribs are inserted between the others, giving that part a more crowded appearance than the sides of the shell: these intermediate ribs vary from 4 to 8.

Length $\frac{7}{8}$ of an inch; width $1\frac{1}{2}$ inch.

Found in slate near Vallongo.

Fig. 3 *a*. Pl. VI. Dorsal valve, from the cast of a fragment in which the shell is rendered narrower by compression.

Fig. 3 *b*. Dorsal valve, from a cast: in this specimen the width of the shell is exaggerated.

Orthis Duriensis, n. sp.

Shell concavo-convex; outline nearly semicircular; greatest width close below the hinge.

Ventral valve slightly concave, with a broad, shallow mesial sinus; ornamented with about 50 delicate, slightly raised ribs, all reaching from the hinge to the margin, and separated by wide interstices. Before they reach the middle of the valve a narrow furrow is impressed upon each rib, this grows a little wider and deeper, and finally divides the rib into two faint rays, which run on together to the margin, which they reach in regular pairs. Hinge-area very narrow.

Dorsal valve; hinge-area broad and longitudinally striated. Another specimen, which appears to be the dorsal valve of this species, is regularly convex, without any mesial elevation.

Length $\frac{7}{8}$ of an inch; width $1\frac{3}{8}$ inch.

Found in slate at Vallongo.

Fig. 4 *a*. Ventral valve, from a cast.

Fig. 4 *b*. Ribs of the same specimen magnified.

Orthis Lusitanica, n. sp.

Shell concavo-convex; outline rather exceeding a semicircle, with the angles at the end of the hinge-line rounded off; greatest width a little below the hinge.

Dorsal valve regularly convex, the greatest elevation being about the middle of the valve; hinge-area twice the breadth of that of the ventral valve.

Ventral valve somewhat concave; hinge-area narrow.

Valves covered with fine concentric lines, and ornamented with 24 to 30 narrow rounded simple equal ribs, all reaching from the hinge-line to the margin, and separated by broad flattened interstices.

Length $\frac{7}{8}$ of an inch; width at the hinge $1\frac{1}{4}$ inch; greatest width $1\frac{3}{8}$ inch.

Fig. 5 *a*. Dorsal valve.

Fig. 5 *b*. Impression of ventral valve.

The present shell is distinguished from all the published Lower Silurian species of Orthis having simple ribs by the concavity of its ventral valve. This is a rare character in the genus, and connects it with *O. semicircularis*, Eichw. and *O. carinata*, Conrad, Ann. Rep. 1839, p. 64. Nevertheless I do not feel sure that this may not ultimately prove a variety of *O. callactis*, Dalm., a species which unfortunately has never been published with sufficient detail.

Orthoceras vagans, Salter, MSS.

Smooth; long tapering when young, more conical when old: septa broad elliptical, oblique on the longer axis, moderately distant in the young shell, distant by more than the diameter in mid-age, and by less than one-fourth of the diameter when old, deep cup-shaped; siphuncle nearly central.

This species differs from *O. distans*, Sow., in its smaller size, and in the more central position of the siphuncle. *O. interruptus*, Münster, is most like our species, but the septa grow more distant with age and are more oblique, and it has a slight swelling of the shell between the septa.

This species is abundant in the Lower Silurian rocks of Wales and Westmoreland. J. W. Salter.

Found in slate at Vallongo near Oporto.

Fig. 6 *a*. A young specimen.

Fig. 6 *b*. One septum of an older shell.

Bellerophon Duriensis, n. sp.

Shell nearly globose, umbilicated, smooth; aperture two-lobed, divided in front by a deep angular sinus; the lobes produced, their outline nearly triangular with the apex rounded off.

Diameter about 1 inch.

Found in slate at Vallongo.

This shell nearly resembles the *B. bilobatus*, Sow., from which it differs in the angular form of the sinus, and the triangular outline of the lobes of the aperture which are bounded by two lines nearly straight, and only rounded at their extremities. It is also closely allied to *B. elongatus*, Portl. pl. 29. fig. 4.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

November 1st to December 31st, 1848.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

American Journal of Science. Second Series, vol. vi. nos. 17 and 18.

Annales des Mines. Quatrième Série, Tome xii. liv. 5 and 6; and tome xiii. liv. 1 and 2.

Athenæum Journal, November and December 1848.

Boston Society of Natural History, Journal. Vol. v. No. 4.

China Branch of the Royal Asiatic Society, Transactions, 1847.

France, Société Géologique de, Bulletin. Deux. Série, tome iv. feuilles 4–78, and tome v. feuilles 9–28.

———, Bulletin. Deux. Série, tome iii. feuilles 23–30. *From J. P. Pratt, Esq., F.G.S.*

Indian Archipelago, Journal of the. Vol. ii. No. 9.

Irish Academy (Royal), Proceedings. Vol. iii. part 3, and vol. iv. part 1.

Liverpool, Literary and Philosophical Society of, Proceedings. No. 4, 1848.

Philadelphia, Academy of Natural Sciences of, Proceedings. Vol. iv. no. 4.

Philosophical Magazine. *From R. Taylor, Esq., F.G.S.*

Tyneside Naturalists' Field Club, Transactions. Vol. i. parts 1 and 2.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by the Authors.

Bartin, François-Xavier, Oryctographie de Bruxelles, ou Description des Fossiles tant naturels qu'accidentels découverts jusqu'à ce jour dans les environs de cette ville. *From G. B. Greenough, Esq., V.P.G.S.*

D'Archiac, A. Histoire des Progrès de la Géologie de 1834 à 1835, tome ii. part 1.

Davidson, T. Mémoire sur les Brachiopodes du Système Silurien Supérieur d'Angleterre.

Dillwyn, L. W. Materials for a Fauna and Flora of Swansea.

Dufrénoy et Élie de Beaumont. Explication de la Carte Géologique de la France, tome ii.

Élie de Beaumont, L. Note sur les Systèmes de Montagnes les plus anciens de l'Europe.

Göppert, Prof. Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Kultur im Jahre 1847.

Gygax, Dr Report on the Geologi cal Formation of the Island of Ceylon. *From the Right Honourable Earl Grey.*

Joly, N., et Leymerie. Mémoire sur les Nummulites.

Portlock, Lt.-Col. Aide-Mémoire to the Military Sciences. Part 1, vol. ii.

Richardson, Joshua. On the Prevention of Accidents in Mines.

Zoology of the Voyage of H.M.S. Samarang during the years 1843–1846. Nos. 1, 2 & 3. *From Messrs. Reeve.*

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 13, 1848.

Thomas Josiah Lang, Esq., and Charles Brumell, Esq., were elected Fellows of the Society.

The first part of the following communication* was read:—

1. *On the Geological Structure of the* Alps, Apennines *and* Carpathians, *more especially to prove a transition from Secondary to Tertiary rocks, and the development of Eocene deposits in* Southern Europe. By Sir Roderick Impey Murchison, F.R.S. G.S. L.S., Hon. Mem. R.S. Ed., R.I. Ac., Mem. Imp. Ac. Sc. St. Pet., Corr. Mem. Ac. France, Berlin, Turin, &c. &c.

Introduction.

The numerous mineral distinctions of the various rocks composing the Alps, and their separation into more or less crystalline masses, were the chief objects of the researches of the illustrious De Saussure; and some time elapsed before it was thought possible to bring these mountains into anything like a comparison with the sedimentary deposits of other parts of Europe, the determination of which

* Part second was read on January 17, 1849.

had been established by their normal order of position and their imbedded organic remains. As soon however as Brochant (1808) declared his belief, that large crystalline masses of the Central and Savoy Alps, which had previously been considered of primary age, belonged to the earlier sedimentary or transition period, a new field of research was prepared; and Dr. Buckland made a still more important step, in a very able essay, wherein he boldly synchronized, in a general manner, the so-called transition rocks of Brochant, with our secondary British types*. Stimulated by such examples, and also by the researches of Brongniart, Von Buch, É. de Beaumont, Boué, Lill von Lilienstein and others, Professor Sedgwick and myself published our views in a memoir in the Transactions of the Geological Society†, accompanied by a general geological map of the Eastern Alps. Since that period, however, much progress having been made, by applying to this chain the more accurate knowledge of the order of equivalent formations, I had the strongest desire to revisit my old ground, to compare it with those regions of the Alps formerly unexplored by me, yet rendered classic by the discoveries of my contemporaries, and to correct any erroneous views I might have entertained. The great stimulus to my researches was, however, that I could not reconcile some of the phænomena I had formerly seen with the view of succession adopted in nearly every work and map of modern times, which represent the so-called cretaceous deposits of the Alps and Italy as being succeeded at once by the younger tertiary strata, almost to the entire exclusion of the eocene or older tertiary. One small tract only (the Vicentine) was supposed by some authors to be of lower tertiary age, whilst others even classed it with the chalk. I felt as certain as when we wrote our memoir, that however Professor Sedgwick and myself might have erred in regard to the age of the Gosau deposits, there were still good evidences of the transition from secondary to tertiary on which we had insisted, and which could not be put aside nor overlooked. For example, I was convinced, that there could be no mistake in the sections on the flank of the Venetian Alps near Bassano, which I presented to this Society before I explored the Austrian Alps,—sections that pointed out in the clearest manner the passage from the surface of the chalk into the *oldest tertiary* strata, and from them into newer deposits with subapennine

* See Annals of Philosophy, an. 1821, vol. xvii. p. 450. It is also but justice to the late Mr. Bakewell, to state that in examining the Alps of Savoy and the Tarentaise in the same summer as Dr. Buckland, he arrived at a similar conclusion (see Travels in the Tarentaise and various parts of Grecian and Pennine Alps, vol. ii. p. 410). In relation to my own researches I may now state, that in the year 1829 I went along the Maritime Alps, and afterwards, by Turin, to the Vicentine, with Sir C. Lyell. In the autumn of the same year I made the Bassano section and traversed the Tyrolese Alps. In 1829 Professor Sedgwick and myself examined the Eastern Alps, Styria and Illyria. In 1830 I returned alone to the Eastern Alps, and did not revisit them until 1847. In 1843 I made an excursion from Cracow to the Carpathian chain with Professor Zeuschner, and in the years 1847 and 1848 I was chiefly occupied in collecting data for this memoir.

† Vol. iii. Second Series, p. 301; and Phil. Mag. and Ann. of Phil. N. S. vol. viii. Aug. 1830.

shells*. These indisputable data were in fact the groundwork of the opinion afterwards applied to the Austrian Alps in natural sections, amidst some of the interior valleys, as well as upon their northern flank. Again, it was impossible to consider the shelly deposits of the Vicentine in any other light than older tertiary deposits, as laid down by Brongniart; and if they were of that age, they must, we argued, have equivalents in other parts of the Alps. In relation, even, to the deposits of Gosau, we then recognized, that their lower shelly beds were cretaceous by their fossils; but influenced both by the presence of an overwhelming quantity of associated gasteropoda, which usually abound in tertiary deposits (said to be of that age by conchologists), and also by the facies of the soft and incoherent deposits, which were so strikingly contrasted with the subcrystalline secondary rocks on which they reposed, we concluded that the upper shelly portion of the group also represented a transition from cretaceous to supracretaceous rocks, analogous to that seen on the flank of the Venetian Alps. My last visit to Gosau in 1847† has convinced me that my former view must be abandoned. I now believe that the marly and earthy fossiliferous beds of that valley are the equivalents of the gault, upper greensand and lower chalk‡. But if the shelly portion of the Gosau deposits proved to be cretaceous, the sections of Bassano and Asolo remained, as well as those of Untersberg and Kressenberg, to establish the existence of other and superior strata. And even when I say, that the Gosau deposits are essentially cretaceous by their fossils, I must guard against the inference that the overlying sandstones and schists of that valley are also of that age. The principal change of classification I have to make, is in respect to the comparison formerly suggested (though then not without considerable doubt), that the great band of green sandstones, impure limestones, and calcareous shale, &c. which occupy the external zone of the north-eastern Alps under the name of "Flysch" or Vienna sandstone, was the representative of the greensand and chalk of England and France. It is needless now to explain all the reasons for having embraced an opinion, which my colleague and self shared in common with other geologists of that day. In the absence of fossils, we could not, indeed, avoid being somewhat guided by mineral characters, particularly in the Eastern Alps, where the whole of this green sandstone zone abruptly succeeds to masses of what was then termed the "Alpine Limestone," the higher portion of which was considered by our precursors to represent the Upper Jura.

Once impressed with the conviction that the great greensand group succeeding to the supposed jurassic rocks was cretaceous, and finding nummulites associated with it, we naturally concluded that these

* See Phil. Mag. and Annals, with coloured sections, June 1829, and Proceed. Geol. Soc. Lond. vol. i. p. 137.

† On this occasion I was accompanied by M. de Verneuil.

‡ M. Boué argued that the fossil beds of Gosau were of the age of the lower greensand, whilst my colleague and self considered that these beds were both cretaceous and lower tertiary. M. Boué, as well as myself, now considers the nummulitic and flysch rocks as supracretaceous.

fossils were connected with both the older tertiary and the younger secondary deposits; an opinion from which I entirely recede. I am now persuaded that no form of the genus *Nummulina* (D'Orb.) occurs in the Alps in beds below the surface of the chalk, or its equivalent. Geologists must recollect, however, that at the period when we wrote, the development of the lower portion of the cretaceous system in Southern Europe had not even been commenced. The Neocomian formation was unknown, and no one dreamt that the thick outer coat of the subcrystalline alpine limestone, then considered to be of the age of the upper oolite, would prove to be the equivalent of the slightly coherent beds of sand and shale known as English "*Lower Greensand*!" The few secondary fossils we could then detect, in any rocks above strata containing liassic and jurassic species, were typical of the cretaceous epoch, and thus, putting aside dislocations, we supposed that the anomalous group called "flysch," containing so much greensand, and which as a whole was interpolated between the supposed jurassic rocks and the known tertiary deposits, might be of the same age as other sandy marls and calcareous bands, often also charged with green-earth, in which we found cretaceous fossils. Portions of the deposits of Gosau, as well as those on the northern flank of the Untersberg, had also to a great extent the characters of "flysch," and hence we supposed that such patches as contained cretaceous fossils were simply "oases" in a great secondary greensand succession.

I have now satisfied myself, that the great mass of the so-called flysch is the superior portion of the nummulitic "Terrain," and that the lowest beds with nummulites are completely above all those rocks which are the equivalents of the white chalk of northern Europe. In demonstrating this by absolute sections, I will further show, that between the representative of the chalk and the lowest nummulite limestone, there are beds, sometimes of considerable dimensions, which, whether marls, green sandstones, or impure limestone, exhibit that true transition I formerly insisted on as occurring between the secondary and tertiary rocks of the Alps.

The application of this classification to the Alps, Apennines and Carpathians, in all of which similar nummulitic limestones and sandstones occur, is loudly called for, seeing the discordant opinions which prevail respecting such deposits. In the valuable general map of Von Dechen, for example, the zone which is occupied by the flysch in the Eastern Alps is placed as the equivalent of the lower cretaceous rocks, without any representative of the chalk; and in defining the secondary boundary through Switzerland, the cretaceous system is omitted, the molasse being represented as in contact with the jurassic rocks. Yet this is the very region in which a most copious development of the *whole cretaceous system occurs*, overlaid by vast thicknesses of nummulite limestone and flysch. In the same map the deposits of the Vicentine are classed as lower tertiary, whilst they are, in truth, a peculiarly shelly portion only, of the same vast series of the supracretaceous rocks which embraces the nummulite limestone and flysch.

In Austria a new map of that empire has been published, in which the flysch of the very zone in question, or a large portion of it, is represented as Keuper. On the Italian face of the Alps and in the Apennines, some deposits, that I believe to be the same, are coloured as cretaceous, and are grouped (in the new map of Collegno) with all the deposits down to the lower greensand or Neocomian inclusive. This has been, indeed, the systematic view of most of the continental geologists. It has been chiefly adopted in pursuance of the opinions of M. Élie de Beaumont and M. Dufrénoy, who have coloured their admirable map of France on this principle. The conclusion of these authors is based upon the fact, that the nummulitic group, including the flysch of the Alps, has undergone all the movements which have affected the subjacent cretaceous rocks. Fully admitting that such are the physical relations, I nevertheless contend, that we cannot establish a comparative geological chronology between the strata of the north of Europe and those of the south, if after the evidences about to be submitted, we do not admit, that the group in question is truly lower tertiary, inasmuch as it lies above all rocks containing cretaceous or secondary fossils, is charged with an eocene fauna, and is succeeded in ascending order by formations filled with younger tertiary shells.

In the first portion of this memoir I give a general description, in ascending order, of the sedimentary rocks which constitute the whole chain of the Alps. After describing in succession the palæozoic and secondary formations, I point out the leading changes they have undergone in their range from the eastern to the western portion of the chain. The relations of the cretaceous and nummulitic rocks will then be discussed at greater length, followed by some data on the age and relations of the younger tertiary deposits of Switzerland; and this part will be concluded by descriptions of some of the principal fractures, inversions and contortions which these sedimentary strata have undergone.

A short sketch will give my present views of the succession on the north flank of the Carpathians, and explain the anomalies of the so-called Carpathian sandstone.

The third part, referring chiefly to Italy and the Apennines, will be terminated by a review of the organic remains and the order of the strata which establish the true age of the nummulitic group, not only in the south of Europe, but also in Egypt, Asia, and those vast regions of the globe over which it extends. A general *resumé* concludes the memoir.

Part I.

General Structure of the Alps.

It is now eighteen years since Prof. Sedgwick and myself pointed out that the chain of the Eastern Alps, when considered only in a general point of view, was of simple structure, in exhibiting a symmetrical succession of deposits from a crystalline centre through transition rocks now termed "palæozoic," flanked by grand secondary zones chiefly calcareous, which were externally environed by masses representing certain members of the tertiary deposits*. We stated, however, that when the geologist grappled with the detailed features of this chain, this apparent simplicity usually vanished, chiefly owing to the great movements of elevation and dislocation which it had undergone, and which frequently caused the younger formations to dip, or appear to dip, under those of more ancient date. But notwithstanding these difficulties, we then separated these Alpine rocks into a series of natural groups, admitting of at least a general comparison with the principal geological groups of England and other countries. Now, nearly all the general classification, as given in our Map, is still correct, and may stand at the present day. The examples, however, selected as proofs of the cretaceous and supracretaceous relations are inaccurate in the north-eastern Alps; and hence, though the legend or order of colours is on the whole right, its application to parts of the map must be changed, together with some essential portions of our reasoning.

Crystalline and Palæozoic Rocks of the Central Axis.—It was in this great group (to which the term palæozoic has since been applied) that we noted the presence of abundance of Encrinites in the talcose and chloritic limestones of the Tauern Alp. We also specially adverted to the presence of species of British carboniferous Producti in the old rocks near Bleiberg in Carinthia †. In short, we showed the existence of those fossils in strata which on the one hand were connected with masses in a crystalline state, and on the other with younger fossiliferous formations. The glimpse which we then obtained of this phænomenon has been matured into certain induction by additional recent discoveries in respect to other and older palæozoic strata ‡. Fossils have been recently discovered by M. Erlach at Dienten near Werfen in a portion of these transition rocks, which M. v. Hauer has noticed. On these fossils being shown by that gentleman to M. de Verneuil and myself when we visited Vienna in the summer of 1847, we identified one of the forms with the *Orthoceras gregarium* and another with *Cardiola interrupta*, both well-known British Upper Silurian fossils, associated with the *Cardium gracile* (Münster), a shell which occurs at Feugerolles in the Silurian rocks of Normandy.

The limestones of the environs of Grätz, near the eastern extremity of the chain, contain fossils of Silurian or Devonian age; perhaps of both formations. Having inspected, in company with M. de Verneuil, a portion of this ground immediately adjacent to the city of Grätz, particularly as seen in the adjacent hill of Plautsch, it appeared to us that the mountain, having a chloritic sandy limestone for its base, passing upwards through sandstone and grits and limestones of dark grey and reddish colours, with separating courses of chlo-

* Trans. Geol. Soc. Lond. vol. iii. New Series, p. 301, and Phil. Mag. and Annals of Phil. vol. viii. Aug. 1830.

† See Phil. Mag. and Annals of Phil. vol. viii. Aug. 1830.

‡ The exact position of which is indicated in the new geological map of M. A. Morlot, entitled 'Geologische Uebersichtskarte der Oesterreichischen Alpen.'

ritic schist, is capped on the summit by dark grey, white-veined, fossiliferous limestone, on the surfaces of which many corals weather out. These corals are, *Gorgonia infundibuliformis*, *Stromatopora concentrica*, *Cyathophyllum explanatum*, *C. turbinatum*, *C. hexagonum*, *C. cæspitosum*, *Astræa porosa* (Goldf.), *Heliopora interstincta* (Bronn), *Favosites polymorpha* (var. *ramosa* of the Devonian rocks), *F. spongites*? &c. As most of these polypifers range from the Upper Silurian into the Devonian, it might be difficult to class the limestones of Plautsch by reference to them only. The rock also contains, however, *Pecten grandævus* (Goldf.), *Cyathocrinites pinnatus* (Goldf.), *Inoceramus inversus* (Münster), *Orthoceras regularis*, and *Goniatites*. We also detected a very striking large bivalve, which is not only seen in the slabs of the pavement of Grätz, but which we also found on the summit of the Plautsch, and which we had at first sight believed to be a Strigocephalus. A better specimen, however, led us to think it might prove to be a Pentamerus not remote from the *P. Knightii*. Until, therefore, more clear specific forms be found and examined, it is not possible at once to say whether the palæozoic limestone of Grätz be Lower Devonian or Upper Silurian. In extending researches from that immediate district to the surrounding country, in which M. Rosthorn has, I am told, already made discoveries which will soon be communicated to the public, Silurian fossils like those of the tract south of Werfen may also be detected; and as the presence of carboniferous Producti has long been known near Bleiberg in the Carinthian Alps*, we shall then have the exhibition at intervals along both sides of the chief watershed of the Eastern Alps of sufficient reliquiæ of the palæozoic deposits to convince us of the former existence of considerable masses of sediment of that age. In the meantime, we have ample data to affirm, that large portions of the tract, coloured purple to indicate transition rocks on the map of my coadjutor and self, are occupied by rocks of true palæozoic age, which in many parts have passed into a crystalline state.

When, however, the geologist follows these palæozoic rocks upon their strike to the W.S.W., he perceives that the action of metamorphism has been much more developed in them. Already to the west of the Gastein Alps and the Grosse Glockner, the masses lying between the granitic or gneissose centre and the flanking walls of secondary limestone are found to be chlorite, talc and mica schists, in none of which have any traces of fossils been yet detected. In travelling in 1847 through portions of the mineral axis both to the east and west of the meridian of Innspruck, in company with M. Leopold von Buch and M. E. de Verneuil, I was forcibly struck with their great change in mineral succession, as compared with the more eastern range of the same masses; for chlorite and mica schists, assuming in parts almost the characters of gneiss, range up to the secondary limestones with scarcely any place for intermediate strata.

* A collection of the Bleiberg fossils having been shown to M. de Verneuil and myself at Vienna in 1847, we recognized therein not less than eight or ten species as belonging to the true carboniferous system of the palæozoic deposits.

These crystalline schists in the gorge of the Fünster-Münster Pass are seen to be permeated by thin courses of brilliantly white dolomite*, seeming to indicate, that in the great metamorphism to which these rocks had been subjected, thin courses and veins of limestone which were subordinate to them, had been transformed into a network of dolomite.

In following the watershed of the Alps from Austria into Switzerland and thence into the Savoy Alps, it becomes apparent that the zone of metamorphism widens. Not only is the place of those rocks, which in their eastern prolongation are palæozoic, taken by crystalline masses, but the metamorphism† has so extended, if I may thus speak, laterally from centre to flanks, as to affect in numberless instances the middle and even the younger secondary deposits, and in one or more tracts, as will be hereafter shown, has even converted into a crystalline state the strata called flysch, which I now consider to be of tertiary age.

No vestige of any fossil palæozoic animal has yet been brought to light in the Western Alps,—a fact, indeed, which accords with the phænomenon on which I am insisting, viz. that on the west the Alps have undergone a more intense degree of metamorphism than on the east. I shall have occasion to return to the consideration of this subject in speaking of those rocks of Savoy which contain belemnites and coal-plants.

In thus briefly touching upon the palæozoic rocks, in order to show that they have a distinct and indisputable existence only in the Eastern Alps, I ought to add that even there no traces have yet been discovered of the uppermost portion of such palæozoic series. The Permian system, so copiously developed in Northern Europe and especially in Russia, seems, in fact, never to have been deposited in Southern Europe.

The Trias.—The group, which crops out at various points from beneath the great mass of secondary limestones of the Eastern Alps, and is interposed between them and the palæozoic rocks above-mentioned, was correctly placed by Professor Sedgwick and myself in the parallel of "Keuper, Muschelkalk and Bunter Sandstein ‡." For this,

* These veins, though so white on fracture, weather yellow under the atmosphere and the action of water.

† I have no intention of going into any details respecting the extension of metamorphism from centre to flank in the Swiss and Savoy Alps. I had the great advantage of making an excursion last summer with M. Studer, who pointed out to M. P. Merian, M. Favre, and myself, the lateral extension of this phænomenon in the mountains which encase the glacier of Grindelwald. They have been called "coins" or corners of gneiss, that wedge into and invade the jurassic limestone which they overlap at great altitudes. The appearances conveyed no idea of wedges of any *pre-existing* crystalline rock of higher antiquity than the limestone, having been forced into the latter; but on the contrary were plain proofs to my mind, that an action of metamorphism ramifying laterally had invaded and altered the jurassic strata *in situ*.—See M. Studer's communication, Bull. Géol. Fr. vol. iv. p. 209.

‡ See the foreign synonyms of the legend attached to our Map. M. Morlot is in error in attaching to this red zone the name of "Rothliegendes?"—for that rock, which is a part of the Permian system, does not, as already stated, exist in the Alps.

however, we had no other grounds than that the mass was inferior to lias, and that besides salt and gypsum, it also contained a bivalve resembling forms known to us in strata of that age. Recently, however, this point has been satisfactorily established in respect to the Alps of the Tyrol, and I will here offer a few evidences of the age of the formation which fell under my notice in the autumn of 1847, when I accompanied MM. von Buch and de Verneuil to St. Cassian and the adjacent tracts, and also when we explored the same series around Recoaro, north of Vicenza.

The trias of the South Tyrol with which I am acquainted, consists of a group of sandstones, marls and limestones, the latter rarely in the state of dolomite, which ranges from E.N.E. to W.S.W., between the transition and crystalline rocks of the central axis (Brunecken, Brixen, &c.) on the north, and the great masses of alpine limestone (liassic and jurassic), which to the south, for the most part in the state of dolomite, range from the Ampezzo Pass to Botzen. This trias is peculiarly well exhibited in the Grödner valley to the east of the great road between Botzen and Klausen. The portion of this tract which lies around the little mountain village of St. Cassian*, at the limit of the German and Italian Tyrol, is that which has afforded the great variety of fossils first made known to naturalists by Count Münster, and since described by M. Klipstein. A great number of these forms being of new and unknown species, considerable doubt hung over the precise age of the deposit. This obscurity has been principally cleared away by an excellent short memoir of M. Emmerich, who, working out the details of a district rendered classical twenty-five years ago by the researches of Leopold von Buch, has clearly exposed the order of the strata, thus leaving little or no doubt, that the chief and peculiar group of fossils of those Alps belongs to the trias. Still the subject required confirmation, and M. von Buch being as desirous as myself of re-examining the tract, I had the good fortune to accompany him and M. de Verneuil thither. Ascending from the Eisach Thal at Atzwang, we passed under the grand dolomitic peaks of the Schlerns mountain, by Seiss and its bosses of melaphyre, to Castel Ruth. The plateau which there constitutes the base of all the overlying masses of limestones and marls, is a spotted red and green or true bunter sandstein, a very good building-stone, with strong courses of subordinate white sandstone. At St. Michael we examined the collection of fossils made by M. Clara, the venerable clergyman of that hamlet, in the strata which form slopes beneath the lofty escarpments of Paflatsch Berg, a promontory of the Seisser-Alp, to the south of his residence. Among these fossils we at once recognised the well-known *Trigonellites pes-anseris* of the muschelkalk (Myaphora or Trigonia) with many fragments of the stems of the lily encrinite, together with certain forms of Avicula and Posidonia†, and we were therefore at

* St. Cassian is upwards of 5000 English feet above the sea and near the head of the transverse valley, whose waters flowing from south to north fall into the Rienz west of Brunecken.

† The most remarkable of the Posidoniæ has been named by M. Emmerich *P. Claræ*, after the venerable pastor, who had discovered the *Trigonellites pes-*

once convinced that they had been derived from a band of true muschelkalk. As the fossils were procured from the band of limestone and shale which surmounts the red sandstone of the plateau upon which we stood, we had therefore already before us two members of the trias. In these valleys the muschelkalk is, however, not only based on red sandstone, but is associated with, and surmounted by red marls representing the Keuper, as seen in the face of the Mittag's Kogel and along various parts of the Schlerns and the Seisser-Alp, and near St. Ulrich in the Grödner-thal, where the whole of the trias is further overlaid by other limestones chiefly jurassic.

In proceeding from the Grödner-thal to Colfosco, by St. Christina through the pass of S[ta] Maria, the geologist cannot avoid being struck with the grand pyramidal and towering peaks of fantastic shape which the dolomite there assumes in the Lang-Kogel and other mountains*. The great vertical fissures and joints which traverse that rock must not, however, be confounded with the lines of true bedding, which are often more or less horizontal and undulating only, and which, though with difficulty observed by an unpractised geological eye, were visibly delineated before us by wreaths of snow which fell during an autumnal storm on the peaks and escarpments around St. Cassian. The pass of Colfosco, which shows clear sections of muschelkalk on the west, is further remarkable in affording fine examples of buttresses of black porphyry (melaphyre), which in one situation, west of Colfosco, is observable in absolute contact with highly dislocated, amorphous, pure white dolomite. I presume that some of this dolomite is of the age of the muschelkalk, because it is associated with certain beds of triassic grit called by M. Emmerich "Halobian sandstein." In descending the valley from St. Cassian by Stern and the Abtey-thal or to the north†, the trias

anseris since M. Emmerich's visit. The *Ammonites Johannis Austriæ* (Von Hauer) from the lower limestones of Halstadt has also proved to be one of the fossils of this deposit in the Tyrol.

* The peaks on the south side of this pass are termed Pissada Spitz, Masons Spitz, &c.

† In his work entitled 'Uebersicht über die geognostischen Verhältnisse Südtyrols, 1846,' Dr. H. Emmerich distinguishes the following Neptunian deposits in ascending order in this region:—1. Red sandstone. 2. Posidonia limestone, which he considers the same stratum that contains the *Trigonia vulgaris*, *Terebratula trigonella*, *Gervillia socialis* and *Encrinites liliformis* at Recoaro, and is the true muschelkalk. 3. Hornstein-führender kalk, a small and local deposit observed by M. Fuchs. 4. Halobian strata (black sandstone and calcareous schist). This rock (which has been termed grauwacke) is the lias of Klipstein, the Wengen deposit of Wissman, and the dolerite sandstone of Fuchs. 5. St. Cassian beds usually united with the Halobian sandstone. 6. Upper limestone with corals and brachiopods, in which, according to M. Fuchs, the fossils of St. Cassian occur at Sotto di Sasso, about 8000 English feet above the sea. Above all these come the jurassic dolomites. As to the *Halobian sandstone*, so called from the occurrence of the genus *Halobia*, it appeared to me to be a rock formed either during submarine volcanic action or out of the detritus of a plutonic mass. It is evidently a local deposit, of which there are no traces near Recoaro and Schio, where it is doubtless represented by other sandstones. The intermixture of fossils under the head of "St. Cassian" is accounted for by the fact, that they are collected in the rivulets which descend through jurassic as well as triassic deposits.

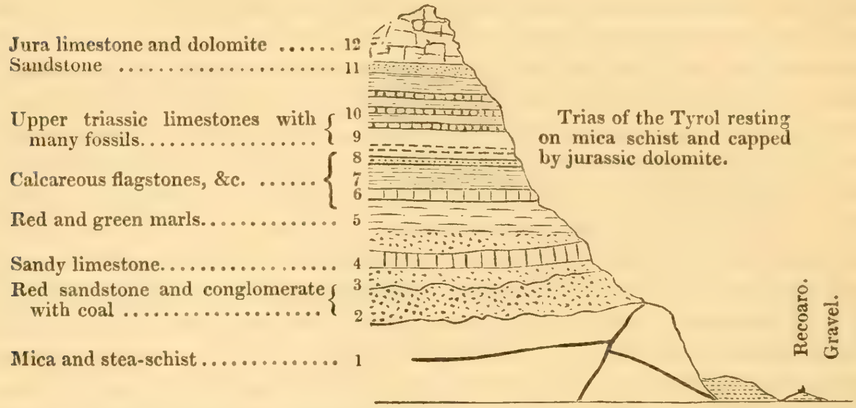
group is first clearly exposed with the dark grey or blackish "Halobian" sandstone, rising out from beneath the dolomitic rocks of the Heilige-Kreutz, and then is exhibited in several flexures along the sides of the gorge which leads to St. Martin. In this gorge, particularly near Poderova, vertical walls of muschelkalk throw off red marls occasionally gypseous, and pebbly conglomerates with many curvatures and flexures; the red ground being usually interlaced and associated with limestones. Lastly, the system is flanked to the north of St. Martin by crystalline schists (here very micaceous) which occupy the place of the transition and metamorphic rocks of the Central Tyrol, and range to the left bank of the river Rienz; for, on the right bank of this stream near Sonnenburg is seen the western end of one of the finest of Leopold von Buch's so-called ellipsoids of granite, the eastern extremity of which constitutes the striking Iffiger Spitz near Meran. The protrusion and juxtaposition of this grand mass of granite accounts, indeed, for the highly crystalline condition of the schists between it and the trias.

Trias of Recoaro and the adjacent tracts.—Between the zone of trias which occupies the valleys of Grödner, St. Cassian, &c., and the southern edge of the Tyrolese Alps, there are other ellipsoids of crystalline rock, which in their elevation have exposed considerable thicknesses of sedimentary deposits around them. The chief of these is the Cima d'Asti with its central granite and its accompanying crystalline formations in the Val Sugana, which I traversed rapidly on a former occasion. Further to the S.S.W. are other elliptical masses, as seen in the valleys of Leogre, Posina and Recoaro, which exhibit fundamental rocks of mica schist covered by an ascending series, in which the trias is the prominent formation. By the valley of Recoaro, I do not simply mean the gorge in which the baths and village of that name are situated, but also all the undulating district embracing Rovegliano and Communda, as well as both sides of the "Valle de Signori," on which the road from Schio and Rovereto proceeds by the pass of Corneto*. He who has but little time at his disposal may rest satisfied with the very clear exposition of the triassic strata which are exposed on the side of the Spitz mountain, immediately south of the village of Recoaro; where ascending from a base of mica or stea-schist traversed by trap dykes, some of which run almost horizontally with the strata, the observer will recognize the following ascending order, as exposed in the annexed woodcut (fig. 1).

Some doubt may exist as to the age of the bottom stratum (2) resting on the mica schist (1). It is a red and white spotted, micaceous sandstone with patches of coaly matter and carbonized vegetables, and some geologists may be disposed to consider it carboniferous. But it

* Having walked over this district by the mountain tract from the Corneto Pass to Recoaro, I afterwards revisited it, as well as the adjacent districts of the Venetian Alps, in company with the chief members of the Geological Section of the Venetian meeting of the "Scienziati Italiani," including not only my previous companions Von Buch and De Verneuil, but also the Marchese Pareto, M. de Zigno, Major Charters, M. Parolini, and Mr. Pentland. M. Trettenero explained the details at Recoaro, and M. Pasini became our leader in the region around Schio and in the Setti Communi, of which hereafter.

Fig. 1.



contains no plants on whose forms reliance could be placed, and it may prove to be a lower portion of the "bunter sandstein." Indeed, the whole stratum is of too feeble dimensions (not exceeding 40 to 50 feet) to require more illustration. It graduates upwards through calciferous sandstones (4) into red and green marls (5), which unquestionably belong to the trias, as proved by fossils found in them. The overlying beds of trias are various bands of limestone (6, 7, 8), one of which is slightly oolitic, which alternate with red marly and sandy beds; and whilst certain bivalves, such as Myacites, &c., occur in the lower flagstone strata, the upper masses (9, 10) have afforded the greatest number of good and peculiar muschelkalk fossils. It was in this band that Professor Brünner, jun., in a previous year, detected the beautiful Encrinite since named *E. gracilis* by V. Buch. From this band we also collected many fragments of the *E. liliformis* with *Terebratula vulgaris*, &c., as well as forms common to the lower strata of the group. Above this are sandstones (11) and jurassic dolomitic limestone (12).

In the deep ravines which lie to the north and west of Recoaro, similar successions of red sandstone, limestone and marls are observed. Fossils occur most abundantly in the ridges of shelly limestone east of Rovegliano (Communda Pass) and at Civelina, where slabs of flaggy limestone are absolutely covered with Trigoniæ (Trigonellites), with *Terebratula vulgaris*, *Myacites*, and other characteristic fossils of the muschelkalk; the deep denudation frequently exposing the same descending order. In one of the lower fossil beds of yellowish earthy limestone associated with reddish layers, our clever guide detected the *Spirifer fragilis* *.

With these very clear proofs of the full development of the trias in the localities already cited, there is every reason to believe, that the equivalents of the system (not, however, always fossiliferous) may be traced continuously along certain zones throughout the Eastern Alps, and particularly where red rocks and limestone rise out from beneath the great masses of alpine (lias and Jura) limestone, and repose upon

* This guide, Castellan, is recommended to geologists as an expert finder of fossils.

the transition or palæozoic rocks. In the general map before alluded to, I roughly sketched such a zone both on the north and south flanks of the transition rocks, and its presence has since been laid down in greater detail by M. Morlot in his useful general map of the Austrian Alps*; though I cannot admit his suggestion that such red rocks can be equivalents of the Rothe-todte-liegende.

The red sandstones (occasionally with certain yellowish limestones and also with salt and gypsum), which my colleague and self described in precisely the same geological position in the northern portion of these Alps, are, I have no doubt, of similar age to those described in the South Tyrol and Venetian Alps.

The researches of the palæontologist in the associated limestones have, indeed, to a great extent set that question at rest. M. von Hauer, jun., of Vienna, has shown that some of the fossils in the Salzburg Alps are identical with those which occur in the South Tyrol in the environs of Castel Ruth, St. Ulrich and St. Cassian; thus establishing the existence of true muschelkalk types in the northern zone, where they had not before been recognized. Among the fossils common to both tracts is the *Ammonites Johannis Austriæ* (Hauer).

Whether any true triassic plants occur in strata of that age in the *central* escarpments of the north-eastern Alps, is unknown to me. But the discovery of them in certain places near Waidhofen and Steyer, either in the middle of the area occupied by the secondary limestones or at their northern edge, has led to a classification on the part of the eminent mineralogist Haidinger, which, with every respect for him, I would suggest is not founded on a sound geological basis. The *Calamites arenaceus, Pterophyllum longifolium*, &c. (identified as such by Dr. Unger of Grätz) have, indeed, been found in a sandstone which dips under the liassic and jurassic limestones of the chain, and such keuper plants are therefore incontestably in their right position. Now, as this sandstone resembles some of the sandstones with impure limestones, that constitute a great zone geographically external to the whole of the alpine limestone, and to which the name of "flysch" has been applied, and of which the "Wiener sandstein" is the prolongation, M. Haidinger has identified the one with the other, and in consequence has recently coloured as "keuper," the whole of the flysch†. This zone of rocks is that which, often affected by great longitudinal faults, appears to dip under the alpine limestone, and had been classed as the uppermost secondary mass of the Alps. It is this very zone to which I am about presently to call attention in detail as belonging to much younger deposits. If the enormous thick accumulations of grits, limestones and fucoid schists to which I now allude, had a real existence beneath the lias where the strata are not inverted, then surely such rocks would somewhere be seen in the well-exposed natural escarpments near the base of those secondary rocks which lie in their normal positions. Such, indeed, is the position of the trias above described.

* See also the octavo volume accompanying the map by the same author, "Erlauterungen zur geologischen Uebersichtskarte der Nordöstlichen Alpen, von A. v. Morlot."

† See the new Geological Map of the Austrian Empire.

The view of M. Haidinger is, I apprehend, to be accounted for by an attempt to identify rocks by mineral resemblances, and by comparing strata in broken and inverted positions with others (supposed to be the same) which lie in their normal state. Finding certain sandstones which resemble the "Wiener sandstein" really plunging under the alpine limestone and lias, and containing keuper plants, and further seeing that the great mass of the Vienna grits external to the chain which are of similar appearance also *seem* to plunge under the same limestone ridge, a conclusion has been arrived at which I apprehend my distinguished friend M. Haidinger will abandon, as applied to most of the large and widely spread masses in question. For, if all the Vienna grits so intercalated between the great masses of secondary and tertiary rocks, be the representatives of the keuper, then all the "flysch" of Switzerland, the grits and sandstones on the flanks of the Carpathians, and the upper macigno of the Italians, may on such reasoning be similarly grouped. Now, although a band of true keuper sandstone with plants may crop out in the localities cited, it is *physically impossible* that all the great external zone to which I have alluded, and which, as I shall presently show, truly forms the last member in ascending order of the great chain of the Alps, can be referred to the keuper, a natural system which is now well understood in the Eastern Alps, and not one of whose fossils has ever been found in that external zone of Vienna sandstone, which forms the continuation of the Swiss and Bavarian "flysch" on all preceding maps*.

In the extension of the trias westward through the North Tyrol, its presence is only as yet recognizable to a very limited and doubtful extent. In short, it may be stated, that no discoveries have been made, either in the central Swiss Alps or in Savoy, which can lead us to think that the trias has had any existence there. Still, judging from the analogy of the Eastern Alps, it *is possible* that a spot or two may be found where the limestone is so little penetrated by metamorphic action as to have left some intelligible evidence of the triassic group. Leopold von Buch inclines, I believe, to the opinion that such a group will be detected.

* M. Morlot's map of the North-Eastern Alps is, as I conceive, quite correct in representing these Vienna grits to be a prolongation of the "flysch" of Switzerland, and in placing them in their true overlying position. But since its publication, M. Morlot has abandoned that opinion, and has adopted the view of M. Haidinger. See a brief notice (Sulla Conformazione geologica dell' Istria, Giornale dell' Istria, Nos. 61, 62, 1847). Again, in a communication to M. Haidinger on the position occupied by the "Wiener sandstein" or fucoid grits, he endeavours to show, that in following it from Istria into the interior of the Alps up the valley of the Isonzo, that formation is seen near Raibl to take, as he says, "its place between the lower muschelkalk (?) and upper alpine limestone," and thus represents the Keuper (Reports of the Meetings of the Friends of Science, Vienna, Haidinger, vol. iii. Oct. 1847, p. 334). Whilst these sheets are passing through the press, the author has received M. Morlot's detailed memoir and map of Istria, "Naturwissenschaftliche Abhandlungen, vol. ii. p. 257." His descending order is,—1. Eocene or nummulitic rocks; 2. Chalk; 3. Tassello. I have some difficulty in reconciling this order either with some of the sections or with the colouring of the map of Istria by M. Morlot.

Lower and Upper Alpine Limestones.

Liasso-Jurassic and Oxfordian.—Following the classification of M. Lill von Lilienbach, Professor Sedgwick and myself considered the alpine limestone of the Salzburg Alps as divided into two great masses, separated by shale, sandstone and limestone with certain saliferous deposits. In differing from some of our contemporaries in assigning a portion of the lowest of these fossiliferous limestones at Admet, to the age of the lias, I still believe we were correct. But, as before said, in the accurate determination of all the members of these lower secondary rocks, a portion of which is now ascertained to be triassic, so much depends on the researches now in progress by the Austrian palæontologists, that I forbear to enter upon a further consideration of the relations of that tract. Looking on the Alps as a whole, however, we have obtained sufficient proof that the lias and equivalents of the inferior oolite occupy a considerable thickness of the lower portion of what was called alpine limestone. This fact has been clearly established by the presence of fossils in the Venetian, Tyrolese and Milanese Alps. There are indeed tracts in which the *Gryphæa incurva* and several true liassic ammonites occur in rocks of this age, whilst in Switzerland and the Western Alps the zone has been traced and identified by Studer, Élie de Beaumont, Sismonda and many geologists.

In following these lower jurassic limestones from the Eastern into the Swiss and Western Alps, great changes in their mineral character are observable. In the first region they are very frequently light-coloured limestones often in the state of dolomite. In the west they are for the most part dark and even black. As, however, the chief strata in many parts of the Tyrol occur in the form of ordinary limestones, and as these can be followed in the strike until they are found to be transformed into dolomites, so this simple fact seems to me strikingly to corroborate the general view of M. von Buch, that the dolomites of the Alps have been produced by a modification or metamorphism of the original strata. Whatever may have been the proximate cause of this great metamorphosis—whether by certain hot vapours or gases, which rose from beneath during one of the revolutions which the chain has undergone, or by any other agent,—it is certain that this cause has acted not only vertically and obliquely, but in many instances horizontally over very large areas; thus transforming the superior strata and leaving comparatively unaltered those beneath. If the crystalline dolomites of the Eastern Alps were the result of original deposit like the magnesian limestone of England, as some geologists aver, then we should not see the irregular and, if I may so say, capricious diffusion of the dolomite, which far from affecting any one set of strata in their horizontal extension, is absent or present in rocks of various ages and at different horizons.

Whilst the great masses of dolomite are peculiar to the Eastern Alps, and are most striking in the tracts of the South Tyrol which have been penetrated by porphyries and other igneous rocks, their place is to a great extent taken in the Western Alps by copious masses of gypsum. In like manner, as the dolomite is the metamorphosed limestone, the lines of bedding and fossils of which are frequently left in the transformed masses, so are the great accumulations of gypsum apparently deposits of carbonate of lime which have been changed into the sulphate of lime. Whether on the highest part of the route over Mont Cenis, or in the deep gorges of the Tarentaise or the Maurienne, or in the Allée Blanche, the valley of Cormayeur and other tracts around Mont Blanc, the same lesson is invariably to be read off; viz. that great bands of limestone have been here and there, and often along zones of some length, converted into gypsum. For, the stratification and even the colours of the original mass so remain, the thick and thinly laminated beds of various tints of white and brown and grey limestone are so preserved, that I have frequently walked up to a rock under the persuasion it was a continuation of the limestone of an adjacent escarpment, until my hammer undeceived me. Whilst expressing my own belief, I must say that it is chiefly a development of the view entertained by the deceased Mr. Bakewell, who as early as 1820, when residing at the baths of Brida in the Tarentaise, came distinctly to the conclusion, that the great limestones of Savoy belonged to the upper secondary strata, and that the gypsum, whether anhydrous or granular, was subordinate to and interstratified with them. That author had also the merit of remarking how these subcrystalline rocks of secondary age were associated with talc schists and mica schists, and were all connected with the alterations due to the action of heat and the formation of granitic rocks*.

I will not here enter at greater length into the question of whether these masses of stratified gypsum, which sometimes occupy entire mountains, were contemporaneously deposited with carbonates of lime. If the presence of such thick accumulations of anhydrous gypsum be not due to metamorphism, I would ask those who entertain the opposite view to explain, how they can suppose that in the very same sea and at the very same period, carbonates of lime should have been deposited along many leagues of the sea-bottom, and that all at once the same laminæ of deposit should have been formed of sulphate of lime? How dovetail the one into the other? On the other hand, nothing is so natural as that the evolution of heat and gas in a region permeated by igneous rocks should have converted the original carbonates into sulphates in one tract, and have left the limestones unchanged in another.

Fortunately, indeed, nature still exhibits in the Alps of Savoy the process by which this conversion may have been effected. The well-known thermal waters of Aix, which rise from a great line of fissure, and contain a notable quantity of sulphur, do now actually change the ordinary jurassic limestone into the sulphate of lime, wherever their hot vapours charged with sulphuric acid have access

* See Bakewell's Travels in the Tarentaise, &c., vol. i. pp. 276 *et seq.* and pp. 289 to 311. Showing, according to M. Charpentier, that the granular gypsum of the Alps is simply the decomposed anhydrite, Mr. Bakewell points out the existence of a carbonaceous stratum in the heart of a thick band of gypsum.

to that rock*. We have only, therefore, to suppose, when some of those powerful changes occurred to which the Alps were subjected, that the more copious transmission of such hot springs and gases, operating on a grander scale and with much more intensity, produced commensurate changes of the carbonates into sulphates of lime, even throughout mountain masses, and also disseminated flakes of sulphur at intervals (as we find them) in the gypsum of the Alps. The conversion of ordinary limestone into the sulphate is usually accompanied in the Alps by other phænomena which forcibly bespeak metamorphism. The limestones situated near deep cracks and fissures (in some of which hot springs still exist, as at Moutiers) are frequently in the condition of a cellular hard tufa, sometimes siliceous, which is known in Savoy under the name of "Cargneule." No one can view this rock and not believe that it is the result of an action in which much heat and gas were evolved.

Although I have introduced the subject of these metamorphisms of limestone whilst speaking of the lias and lower oolite, I am by no means prepared to say, that the same transformation in the Western Alps has not also been applied to strata both of older and younger date; just as limestones of different age in the Eastern Alps have been changed into dolomites. But however this may be, great masses of gypsum are certainly of about the age I speak of, inasmuch as belemnites and ammonites and other shells of the lias, including the *Gryphæa gigantea*, have been found in the associated strata at Bex by M. Lardi. Wherever certain ammonites, such as the *A. Walcotti*, and belemnites, or the *Gryphæa incurva*, *Plagiostoma gigantea*, &c., occur in the strata which occupy the lower zone of the alpine limestone, no one will dispute that such is about the horizon of the lias, whatever may be the mineralogical character or colour and structure of the rocks.

In some tracts saurians have recently been found in the limestones, as near Admont in the Austrian Alps, and at Perledo near Laico in the Milanese; but the small and peculiar forms from the last-mentioned locality do not afford such sufficiently clear testimony concerning the age of the deposit†. I am not aware that any fishes of the liassic age have been detected in the Alps. M. Heckl of

* M. Joseph Bonjean, in an elaborate analysis of the mineral waters of Aix (Annales des Mines, vol. xvi. Third Series, p. 299), whilst treating of various effects produced by their acidulous vapours or gases, says—"Quelle que soit la nature des corps soumis à l'action de cette vapeur (gas acide sulfhydrique), ils sont tous rongés et détruits dans un espace de temps plus ou moins long. *C'est ainsi que les pierres calcaires, dont se composent les murs, se convertissent assez promptement en sulfate de chaux* à leur surface," p. 342. The intelligent physician of the baths, M. Despine fils, showed me the effects of this process, and gave me specimens in which limestone several inches thick had been so metamorphosed. This phænomenon of conversion of carbonate of lime into sulphate is also clearly described by Professor Mousson of Zurich, in a very able memoir on the district around Aix and Chambery. The subject of the occurrence of thermal waters along lines of dislocation is still more fully developed by this author in his sketch of the geology around Baden in Switzerland.

† See Memoir by M. Giuliano Curioni, Giornale dell' Instituto Lombardo delle Scienze, tom. xvi. p. 170.

Vienna, an excellent ichthyologist, showed me indeed a small round fish with a heterocerque tail from Perledo near Laico, the same tract in which the small saurian occurs, and which might lead to the belief in the existence of a still older deposit in that region. He also pointed out to me specimens of ichthyolites from bituminous schists associated with the limestones between Adelsberg and Zircknitz in Illyria, which are chiefly of the genera Lepidotus and Palæoniscus, and much resemble the fishes I formerly collected at Seefeld* in the North Tyrol, the strata of which, according to the present view of their succession, must be the equivalents of the lias and lower oolite. In Illyria, however, the above fishes are associated with a species of the genus *Thryssops*, which has not yet been found at Seefeld, but occurs at Solenhofen. These fishes indicate then the existence of jurassic rocks in that region.

In tracing the lias and Jura limestone through Savoy, I shall say little more than that, in following out the researches of M. Élie de Beaumont, Professor Sismonda has detected the presence of a sufficient number of fossils to characterise the liasso-jurassic and overlying Oxfordian groups, fossils of both of which are to be seen in the museums of Turin and Chambery.

Rocks containing Belemnites and Coal Plants in the Savoy Alps.—I may now allude to the much-agitated question of the plants of carboniferous species† being associated with belemnites. M. Élie de Beaumont and M. Sismonda contend that these plants (which are doubtless true carboniferous species) are interstratified with belemnites, notably at Petit Cœur in the Tarentaise, and that in many other parts of Savoy zones of similar plants occur, which are, in truth, prolongations of liassic or jurassic deposits, in which the well-known animal remains of those periods prevail. This opinion has met with antagonists, and the greater number of geologists, being naturally averse to what they consider an anomalous collocation, the recognition of which is attended with great difficulties, are disposed to receive with favour every effort which has been made to explain the phænomenon by reversal or plication. Until I visited the Savoy Alps, I confess that I was of this number; for the theoretical sections of M. Favre of Geneva, showing the possible curvature of beds the ends of which have been truncated, and the opinions at which other geologists had arrived, that a true representation of the carboniferous system existed in the Savoy Alps, and that the plants of Petit Cœur formed a part of it, had strongly predisposed me to coincide with such views. After an examination, however, of the case of Petit Cœur, I know not how to arrive at any other conclusion than that adopted by M. de Beaumont and M. Sismonda, the grounds for which I now proceed to explain.

* See Phil. Mag. and Ann. of Philosophy, 1829, vol. vi. p. 36. At that time, long before the days of Agassiz, I suggested that these fish might be of the age of the Thuringian schists. They are however clearly of liasso-jurassic age.

† Mr. Bunbury has recently shown that all the species of plants from these localities, examined by him at Turin, are true carboniferous forms—thus confirming the dictum of M. Adolphe Brongniart (Journ. Geol. Soc. vol. v. p. 130).

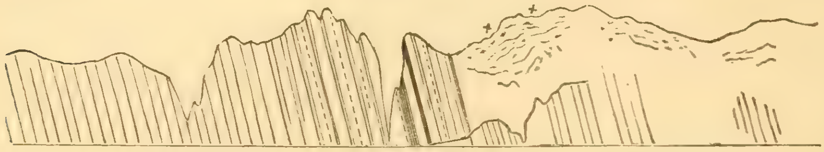
The chief natural feature which influenced me in relation to this question was, that wherever I turned my steps in the Savoy Alps, whether into the Maurienne or the Tarentaise, or towards the environs of Mont Blanc, I uniformly observed that beneath a zone distinguishable as lias by its fossils as well as by its intimate relations with overlying Jura deposits, there was (with the exception of a certain conglomerate and sandstone, often associated closely with such lias) no sufficient development to represent any of the inferior formations *from the trias inclusive downwards*; all the lower strata being in a metamorphosed and crystalline condition. In other words, it seemed to me that between the inferior crystalline rocks and the stratum with belemnites (often itself much altered), there was no adequate representative in space or time for the carboniferous rocks; which if ever they existed, must, therefore, I inferred, have been merged in the great metamorphosis which all the central portion had undergone. Nor could I avoid the query, if the schistose deposits in which true and beautifully preserved coal species occurred, were of the old carboniferous date, why no vestige of any palæozoic *animal* had been ever detected in the Western Alps, whilst in the Eastern Alps there are, as has been stated, animal remains of the triassic, carboniferous, Devonian and Silurian ages?

Let us now appeal to the facts of the section of Petit Cœur. On inspecting the map of Savoy, it will be seen that at Conflans or Albertville, the river Isère having hitherto flowed tranversely by Moutiers in a deep valley across the ridges of the Tarentaise, or from S.W. to N.E., makes a sudden bend and thence trends south-westward to Montmelian and Grenoble. This latter part of its course is, in fact, determined by mountains of jurassic limestone, which have the same general direction, and which constituting the outer zone of the Alps, are composed of the equivalents of the Oxfordian and upper oolites, together with the overlying cretaceous deposits hereafter to be alluded to. In ascending the transverse gorge of the Isère from Albertville to Moutiers, the geologist has no sooner quitted that outer calcareous zone and passed to the opposite side of the valley, than he finds himself immersed in talcose crystalline schists, in parts highly quartzose, and in parts having somewhat of a gneissose aspect. I do not pretend to describe every variety of these rocks, but it is worthy of remark, that in this narrow transverse gorge, whether they be talcose, micaceous, felspathic or quartzose, the strata in their central part appear to wrap over an ellipsoid of granite and granitic gneiss, which is in parts porphyritic*. As far as dip can be marked, these crystalline rocks between Albertville and the zone of granite are vertical; whilst to the S.E. or higher up they incline away from the granite. At all events, when the gorge widens and you approach to Petit Cœur, a village on the right bank of that river, the dip of the crystalline mass is decisively to the S.E. A coarse quartzose

* See the clear and copious account of all these phænomena in the narrative of the excursion of the geologists assembled at the meeting of Chambery in 1841, by the Abbé (now Canon) Chamousset, as well as M. Virlet's note on the porphyritic granite of La Batie (Bull. Soc. Géol. Fr. vol. i. New Series, pp. 166 *et seq.*).

conglomerate is here intercalated in the talc schists and dips with them. A little above or N. of Petit Cœur a mountain rill descending from N.E. to S.W., waters the highly inclined faces of these talc schists, or rather occupies a deep gorge in them, to the east of which these same beds are seen to graduate up into and to be surmounted by others which contain belemnites and plants, the whole in perfectly conformable apposition and at angles from 70° to 75°, as expressed

Fig. 2.



1. Talc schist with sandstone.
2. Black slates (Belemnites).
3. Talc schists with anthracite.
4. Grits, sandstone, &c.
5. Jurassic schists, &c.
†† Coarse detritus and blocks.

in the woodcut (fig. 2). The upper portion of the inferior or crystalline strata is a light-coloured talc schist used in the mountains for the covering of cottages. It is called "ardoise blanche" by the quarrymen, and forms the floor of the quarry (1). Immediately upon this, and perfectly parallel to it, lies another stratum (2) of fissile calcareous flagstone of dark indigo colour, called "ardoise noire," in which the belemnites occur. I could detect no slaty cleavage in these beds, whilst both the shining or talcose, and the dull black or calcareous flagstones strike N.N.E. and dip together 70° to 75° E.S.E. They are further connected by certain bands of hard sandstone occasionally coarse and gritty, with which the dark flags alternate towards their base. In the lower quarry (there being several openings in the line of strike in order to procure the black calcareous flagstone), these belemnitic beds are seen to be surmounted by another band of talc schist (3), as conformable to the belemnite flags or slates (2) as the latter are to the inferior talc schist (1). The uppermost of the three beds is that in which a certain portion of anthracite has been detected, the exploration of which has led to the discovery of numerous plants. These plants chiefly lie in the floor of the anthracitic schist, and therefore within a few feet of the belemnite flags (2), and they are strikingly distinguished by the brilliant white relief of the framework of the vegetables due to the dissemination of the talc upon the dark ground of the schist or flagstone. Much pyrites in single crystals and bunches occurs throughout the rock.

This carbonaceous schist with plants, several yards thick, is surmounted by strong beds of dark grey hard grit that weathers to a rusty colour, and which alternates several times with dark-coloured schists. And here it is to be observed, that the sandstone (4) above the coal plants is not to be distinguished from the band beneath the belemnite flagstone; or in other words, both the belemnite and the plant beds form parts of the same geological mass, the upper and lower parts of which are of similar composition, the talc schist and the sandstone being repeated. In fact, I cannot imagine how any geologist can look at this section and not declare that the whole of these strata form one natural group of very small dimensions. In tracing these beds up the hill-side I further convinced myself, that the belemnite flags (the belemnites most abound in the upper quarries) have there exactly the same relations to overlying and underlying grits, the whole resting, as in the lower quarries, on the white talc slates and also in perfect conformity. In these sections there can be no ambiguity, for you can absolutely follow the line of strike of each bed nearly a mile up the mountain-side. No traces of folding or contortion are observable ; and as belemnites have been found within a foot of the coal-plant bed, it appears, that however we may endeavour to explain them, the physical facts are clear and decisive.

It is true, that in ascending the hill the anthracite thins out from four feet to a few inches, whilst the black belemnite flags are more expanded in the higher than in the lower quarries ; but this phænomenon, so well known to every working geologist, is not worth mentioning, were it not necessary to allude to the minutest circumstance in this singular collocation. The whole group is affected by the same lines of joint or division, and all the beds exfoliate parallel to the laminæ of deposit, the more calcareous portions showing a tendency to assume flat concretionary forms, which produce small undulations in the upper quarries.

Above Petit Cœur the dip to the S.S.E. is continuous for a short distance, and there is therefore a certain amount of ascending order ; but in the parallel of Moutiers the succession is checked by one of those grand transverse dislocations so frequent in the Alps, accompanied by the evolution of hot springs.

According to M. de Beaumont and M. Sismonda, the belemnites, shales and flagstones of Petit Cœur are a portion of certain adjacent jurassic groups in which many ammonites and other fossils occur. These fossils are found in strata of dark shale and schist, which appear on the strike of these beds as they range across the valley of the Isère and appear in the passes which traverse the mountains that separate the Tarentaise from the Maurienne. It is probable that the same strata are several times repeated by fractures if not by undulations ; for it seemed clear to me that the whole of the series exposed between St. Michel and St. Jean de Maurienne, *i. e.* the dark shale and patches of coaly matter underlying or associated with jurassic rocks, represents the succession seen between Petit Cœur and Moutiers in the Tarentaise. The ammonites and other fossils I now present were taken from the broken slopes of the Col de la Madeleine, or rather from the elevated depression immediately to the S.S.W. of Aigues blanches, where they were collected by M. Ansenet. They appear to be in great part the same as those already collected in the tract at the Encombres by M. A. Sismonda, among which that author enumerates the *Ammonites fimbriatus*, Sow., *A. planicostatus*, Sow., *Avicula inæquivalvis*, Sow., *A. costata*, Sow., *Terebratula inæquivalvis*, Sow., *T. variabilis*, with a multitude of belemnites*.

* See a more complete list of these fossils, with specimens from other places in

If the previous statement of the geological relations at Petit Cœur be, as I think, accurate, *i. e.* if the plants and belemnites really lie in the same deposit, as was also concluded by the geologists of the French Society, who met at Chambery, the anomaly is great, and involves us in considerable natural-history difficulties. But are these difficulties insurmountable, and ought geologists to shrink from endeavouring to reconcile them because they interfere with the general distribution of fossil plants ? Excluding for the present all theory, let me say that I cannot admit the presence of certain species of fossil plants to be as decisive of the age of a deposit as that of the remains of any well-known animal. Thus, the *Calamites arenarius* cited by Brongniart as pertaining to the old coal, is found both in the Permian system and in the Bunter sandstein and Keuper, or throughout the Trias, a system in which no one palæozoic animal has been detected. Again, the *Equisetum columnare,* which so abounds in the Brora (oolite) coal, and is most abundant on the Yorkshire coast beneath the Kelloway rock, is one of the most common of the trias plants of Germany. And yet as a whole, both the fauna and flora of the middle oolite and trias are utterly dissimilar. Look, on the other hand, to the weight attached to the presence of belemnites. In no instance has a belemnite been detected in any part of the world below the lias. The trias, of which there is not a trace in Savoy, but now so well known in the Eastern and Tyrolese Alps, affords no sign of a belemnite any more than the same group in other regions ; still less has any one ever heard of a belemnite in an old carboniferous deposit in any part of the world.

In giving the previous description of the section at Petit Cœur, I have done so in opposition, I repeat, to the strong wish I entertained to be able to offer any explanation which might obviate the dilemma in which such a recognition places us. I tried, for example, to account for the phænomenon by an inverted dip, and endeavoured to reconcile the overlying position of the coal plants by a reversal, similar to that which clearly operated on the north face of Mont Blanc : but there the belemnitic strata plunge under crystalline rocks, whilst at Petit Cœur they overlie and are intercalated in them. I could not speculate on the crystalline rocks of the Isère being originally of younger age than the belemnite beds, like the well-known examples on the northern face of Mont Blanc in the vale of Chamonix, and having been metamorphosed by the influence of the ellipsoid of granite before adverted to ; because if so, and that these fossiliferous beds were inverted, other older strata besides the mere bed with coal plants would be found above them, which is not the case ; the same liassic or jurassic group being manifestly developed in considerable force on the line of dip.

Those geologists who have explored the environs of Mont Blanc have long been acquainted with the fact first indicated by Sir Henry de la Beche, that coal plants also appear in the well-known con-

Piedmont, which include other known species of Sowerby, V. Buch, Schlotheim, Agassiz, &c., as given by M. Sismonda, with a descriptive plate of the species from the Encombres (Bull. de la Soc. Géol. Fr. vol. v. New Series, p. 410).

glomerate of Valorsine, and it is fair to state that a very clear and instructive recent section of M. Favre indicates, that this band there forms (Col de Balme) the conformable base of all the liassic and jurassic deposits, whether altered or unaltered, of that highly disturbed tract*.

I do not wish, with my present knowledge, to press the question more closely. Those who have not examined the sections might theorize that the thin anthracitic zone of Petit Cœur was a mere shred, which had been left among the gorges of the pre-existing and crystalline rocks, but it is impossible to apply such a hypothesis to the case; for if the crystalline rocks on the Isère be of anterior date, then we see that the belemnites lie between them and the coal plants; and if they be altered lias and Jura, then it is almost incredible that a few feet of old carboniferous rocks should be so conformably interlaced with these younger deposits. It is just barely possible, that instead of the *vertical* truncated cone theoretically suggested by M. Favre to explain the anomaly†, the older carboniferous rocks may have here been thrown into a very rapid *inverted* anticlinal flexure, leaving a few feet only at their apex, and that jurassic or liassic strata have been conformably folded around this point, the whole having been since altered and denuded. But if so, it is certainly a section more deceptive than any I ever examined; and until I meet with other sites affording a different explanation, I can only repeat my belief, that the relations of the strata sustain the conclusions of M. É. de Beaumont‡.

Upper Alpine Limestone (*Oxfordian, &c.*).—I may remind English geologists, that the parallelism with their oolitic deposits which has been so elaborately worked out by M. P. Merian and other Swiss authorities in the Jura mountains, has, despite of change of mineral character and the much rarer occurrence of fossils, been successfully applied to the French and Savoy Alps by M. Sismonda, and to the Swiss Alps by Prof. Studer and M. Escher. But notwithstanding the former publications of Pasini and Catullo, the clear definition of an equivalent of the Oxfordian group, as established in the Savoy and Swiss Alps, had not been defined in the Southern Alps until M. von Buch demonstrated to the Italian geologists at the Milan meeting that their "Ammonitico rosso" was of Oxfordian age§. This view has since been much extended in respect to the Venetian Alps by M. de Zigno of Padua. In the excursion of the geologists of the Venetian meeting before alluded to, in the mountains of the Setti Communi, my friends and myself were convinced of the accuracy of the fossiliferous distinctions by which that geologist had separated the red ammonite limestone from the lower jurassic rocks on the one hand, and

* Bull. Soc. Géol. Fr. vol. v. p. 263.

† Remarques sur les Anthracites des Alpes, par Alphonse Favre. Tom. ix. Mém. Soc. Phys. et Hist. Nat. de Genève.

‡ The able Memoir of M. Scipion Gras, on the association of the carbonaceous deposits of the Isère, and on their passage into crystalline rocks beneath, and their being clearly separated from all liassic strata above them, is to be taken into consideration in settling this question. See Annales des Mines, vol. xvi. p. 361.

§ See Bull. Soc. Géol. Fr. vol. i. pp. 132 *et passim.*

from the overlying neocomian and cretaceous rocks on the other. In ascending from Pedescala, in the valley of the Astico, to the plateau of the Setti Communi, we passed first over the edges of a great mass chiefly in the state of dolomite, probably representing the lias and inferior oolite, and then over rubbly yellowish earthy limestone; next over other courses of greyish limestone containing Turritellæ, followed by limestone of deep red colour, which from the quantity of ammonites found in it has obtained the name of "Ammonitico rosso." This last is surmounted by the white neocomian limestone. In traversing the lofty plateau of the Setti Communi from Castel Bello by Rotzo and Roana*, we had numerous exhibitions of an ascending order, from grey earthy limestone, with some sandy beds, up into the same red ammonite limestones, and thence into the white neocomian, which is here a purely white indurated rock, and as much loaded with flints as our chalk of Antrim, which it much resembles. Without dwelling on any details, I will simply enumerate the succession of the strata of this tract, as proved from different sections which exhibit the strata more or less inclined, but all conformable, and in this ascending order:—

1. Dolomite, &c., of great thickness, probably representing lias. 2. Compact brecciated marls. 3. Beds of fine oolite, alternating with yellowish marly limestone, containing shells, including Diceras, Gryphæa, &c. 4. Thin-bedded limestone with Nerinæa and univalves. 5. Thin-bedded, dark grey, sandy limestone, with Neuropteris and other plants. 6. "Lumachello grigio," grey mottled limestone with marl, yellow marly beds and grey lumachello with sections of large bivalves. 7. "Ammonitico rosso." This rock is invariably the summit of all the jurassic strata in this region, and clearly represents the Oxford formation. Although seldom more than fifty or sixty feet thick, it is an excellent horizon, since it contains *Ammonites athleta* (Phill.), *A. anceps* (Reinecke), *A. Horneri* (D'Orb.), *A. Tatricus* (Pusch), *A. viator* (D'Orb.), with *Terebratula diphya* and *T. triangulata*. 8. "Biancone," or neocomian with *Crioceras Duvalli* (Leym.), *Belemnites latus* (Blainv.), *Ammonites asterianus*, *A. incertus* and *A. semistriatus* (D'Orb.), with some forms in the uppermost beds resembling those of gault, such as *A. Royerianus* (D'Orb.). In all, this group contains fifteen species of Ammonites, five or six species of Crioceras with Ancyloceras, Aptychus of two species, &c. 9. "Lower Scaglia," of grey colours with fucoids,—lower chalk. 10. "Upper Scaglia," of red and white colours,—upper chalk, &c. 11. Nummulite limestone and grit, with *Cerithium giganteum* and Nummulites of the same lower tertiary age as in the same position at Bassano; of which and of all the series from the neocomian upwards I shall treat hereafter.

In other parts of the South Tyrol, and notably at Trent, M. von

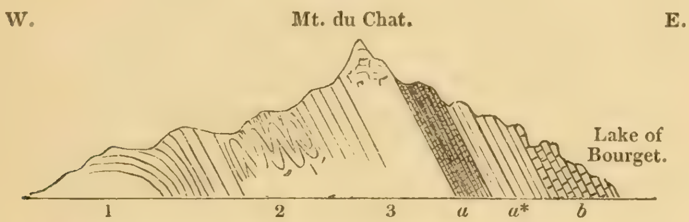
* This is the wild country of the ancient Cimri, and the people still talk a language unknown in any other part of the Alps.

Buch pointed out to me the clear determination of the Oxfordian formation by the presence of several of the fossils above enumerated; and in the grand natural sections between Rovereto and the Corneto pass, I also perceived a fine succession under the Ammonitico rosso.

The same Oxfordian zone has been delineated in Piedmont and Savoy by M. Sismonda. In the environs of Chambery and Aix les Bains, I had the advantage of studying its relation to the superior or cretaceous strata with the Canon Chamousset. That geologist has there divided the great Oxfordian masses into four parts, the lowest of which are marly limestones in beds of about a foot thick. 2ndly, Limestones, deep grey or bluish, with white veins and some ferruginous oolite. It is this band which contains most of the fossils, including the *Ammonites biplex*, &c., with Aptychi, &c. 3rdly, Foliated marls or calcareous flags; and, 4thly, Marly limestone, &c. This zone is overlaid by limestone with many corals, which is paralleled with the coral rag of English geologists, and that again is conformably overlaid by a full expanse of the neocomian formation, which in this region is divisible into three parts.

Not describing all these strata, I here merely annex a general section from the base of the Oxfordian to the summit of the Neocomian, which I made on the western shore of the Lac de Bourget on the sides of the zigzag road from Chambery to Lyons, which traverses the Montagne du Chat†. This Oxfordian group forms the

Fig. 3.



Cretaceous. { b. Upper Neocomian limestone with *Chama ammonia*.
a*. Middle Neocomian with *Spatangus retusus*.
a. Lower Neocomian, greenish ferruginous calc grit with *Ostreæ*, *Pectens*, &c. = base of English Lower greensand.

Jurassic. { 3. Coralline limestone = Coral rag. Summits dolomitic.
1. Oxfordian Jura with Kelloway rock fossils. 2. Schists and limestones.

base of all the outer edges of the Savoy Alps; their summits usually consisting of neocomian limestone, and often covered by still younger rocks. This order is seen around Chambery and the lake of Bourget at Annecy, in the valley of the Arve, both above and below Sallenches, and near Geneva.

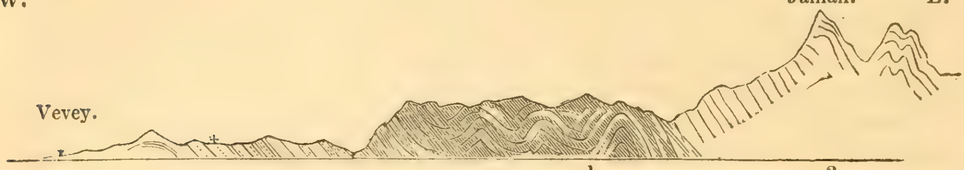
The Oxfordian limestones, but without such a capping, are copiously exhibited in the range of mountains east of Vevey. At Chatel St. Denis, where the limestone is very mottled and concretionary, it is loaded with ammonites and Aptychi‡; and the same rock, subjected to great flexures, rises into the high peak, the Dent

† See Bull. Geol. Soc. Fr. new ser. t. i. pl. 9. fig. 3.

‡ I was directed to these limestones by M. Studer, and M. Collon of Vevey accompanied me thither.

de Jaman*, so well known to tourists, where masses of the mottled limestone with flint nodules repose on dark schists and impure limestones as thus represented. From that peak there is apparently a

Fig. 4.



descending succession through other limestones, as exposed in the gorge of the Baye de Montreux near Glion, down to the black fetid limestones and shale at the bridge of Montreux, which may represent the lias†. Again, when wandering through the Swiss Alps, whether on the lakes of Thun and Brientz, on the upper portion of the Lake of the Four Cantons (fig. 12), or on the northern shore of the lake of Wallenstadt (fig. 14), I came upon calcareous bands, which Studer, Escher, and the best Swiss geologists consider to be of Oxfordian age, sometimes surmounted by limestones the equivalent of the coral rag, and sometimes without them, but invariably covered by the neocomian limestone, as in the Savoy section (fig. 3). The Portland limestone, so copiously developed in the Jura, and so rich in fossils at Soleure, has not as yet, to my knowledge, been found in the Alps‡. It is only indeed by fossils (and unfortunately they are of rare occurrence in the alpine limestones) that the strata can be actually referred to the respective members of the jurassic or oolitic series. Resting upon carbonaceous schists, which in their turn overlie the so-called "Sernft conglomerate" and quartzose talc slate, the upper part of the lower division of the jurassic rocks of the canton Glarus, in parts dolomitic ("Zwischen-bildungen" of Studer), are characterized in their upper member by the diffusion of iron ore in an oolitic matrix. It is this rock which contains the *Ammonites Gowerianus* (Sow.), *A. macrocephalus* (Schloth.), *A. Parkinsonii* (? ?), *Ostrea pectiniformis* (Schloth.), *O. calceola* (Goldf.), and *Terebratula digona* (Sow.), &c.

The overlying stage, or that which immediately succeeds to the ferruginous oolite (the "Hoch-Gebirg's Kalk" of the late M. Escher), as seen in the cantons of Glarus and Appenzell, contains the characteristic forms *Ammonites biplex* and *A. polyplocus*, with belemnites, and is therefore a good representative of the Oxfordian of the Alps§.

* 1872 metres above the sea.

† M. Collon informed me that the *Ammonites Petit Thouars* (d'Orb.), a lias fossil, had been found in the black limestones and schists which are exposed in the gorge above the little bridge, dipping under the mass of the adjacent mountains.

‡ The abundance of tortoises and other peculiar fossils which characterize the "Portlandian" of Soleure, indicate the *local character* of the formation, and the same may, indeed, even be said of the Portland rock of England.

§ For the description of the lithological varieties of these Alpine jurassic rocks, see the Gebirgskunde of M. Arnold v. Escher, included in the general natural-history account of the Canton Glarus by Professor Heer of Zurich.

CRETACEOUS SYSTEM, *composed of Neocomian Limestones=Lower Greensand; Gault; Upper Greensand, and Inoceramus Limestone or Chalk.*—In noting some features of the jurassic or oolitic rocks, as traceable through the Alps, I have already pointed out several natural sections which show, that the rocks which in the ascending order are the equivalents of our oolitic series are conformably surmounted by other limestones, the "Neocomian" of foreign geologists*. In England, as I anticipated it would prove to be, and as we now know through the labours of Dr. Fitton and others, our lower greensand, if not the exact equivalent, represents a large portion, at least, of the neocomian. In the Alps this formation is so linked on to the alpine limestone, that before it was distinguished by fossils, Professor Sedgwick and myself, considering it simply the uppermost member of the great calcareous mass of the Alps, referred it with the geologists of that day to the upper oolite. Our stratigraphical view is, indeed, even now quite correct; for, with a few local exceptions cited by other authors, it seems that in the Alps, as in the Jura, there has been a continuous series of marine deposits in which no general disseverment took place, until after the completion of the supracretaceous nummulitic group (see figs. 12 and 14 in subsequent pages). M. Favre has, it is true, endeavoured recently to show, that in the Alpine tracts around Mont Blanc, the cretaceous system (*i.e.* from the neocomian up to the nummulitic zone inclusive) occurs in more or less horizontal bands, which rest on the convoluted strata of the jurassic age†. It is not in my power to controvert the specific cases which that geologist has cited; but other evidences will presently demonstrate, that even in the same region there are many proofs of the uninterrupted and conformable succession I have spoken of, and which is so clearly seen in the Venetian Alps. No one who has examined the mountains near Chambery in Savoy, or the flexures and contortions to which the whole of the secondary series has been subjected in the little Cantons of Switzerland, and who has seen the manner in which even the supracretaceous as well as the cretaceous beds fold over and conform to the convolutions of the jurassic rocks beneath them, could, I think, hesitate in adopting the conclusion at which I have arrived.

Not, however, to anticipate what I wish to demonstrate by evidence, I may in the mean time say a few words on the general structure and characteristic features of the Alpine cretaceous system properly so called. Its lower member, the neocomian limestone, is by far the thickest and most important cretaceous formation. This deposit has already been adverted to in the Venetian Alps as a hard white limestone with many bands and geodes of flint, and numerous characteristic fossils; and it there dips under the grey, red and white scaglia or chalk. In the Austrian Alps it is the hippuritic lime-

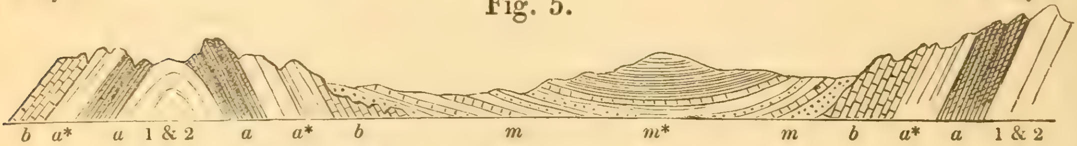
* See my observations on the equivalents of the neocomian at the Meeting of the French Geological Society at Boulogne, anno 1839 (Bull. Soc. Géol. Fr. vol. x. p. 392), and my Address to the Geological Society of London, anno 1843 (Proceedings Geol. Soc. Lond. vol. iv. p. 112). I was not aware, at that time, that Captain Ibbetson had expressed the same opinion at Neufchatel.

† See Bull. Géol. Soc. Fr. vol. iv. p. 996.

stone and marble, of grey, yellowish, and occasionally pink colours, which at Untersberg near Salzburg, around the valley of Gosau, and at numerous other places, plunges under strata of impure limestone, marl and sandstone, charged with fossils of the gault and chalk. In the western parts of Savoy, however, it is more clearly divisible into three zones than at the city of Neufchatel itself, and the diagram of the Montagne du Chat already given, explains the fact (see fig. 3).

In another section west of Chambery, which I made in company with the Canon Chamousset, the order of the strata is exhibited in this diagram (fig. 5). The lowest rocks visible are the Oxfordian

Fig. 5.



Tertiary. { m*. Marine molasse.
m. Freshwater limestone and conglomerate.

Cretaceous. { b. Upper Neocomian (*Chama ammonia*).
a*. Middle Neocomian (*Spatangus retusus*).
a. Lower Neocomian (*Oyster bands*).

1 & 2. Oxfordian Jura and coral rag limestone.

limestones and shale, and the coralline limestone before adverted to (Nos. 1 and 2) which constitute the uppermost jurassic band of this region. On this reposes the lowest neocomian (*a*), which is a hard siliceous limestone with small, sharp-plaited Ostreæ, a small Terebratula, Nerinæa, &c. The middle neocomian (*a**) consists of alternations of bluish grey marly limestone and bands of green-grained calc grit and beds of chert, and in this band most of the fossils occur, including the very characteristic form *Spatangus retusus*. The upper division (*b*) is a whitish limestone, often in a state of marble, which in Savoy contains both Hippurites and the *Chama* (*Caprotina*) *ammonia* (D'Orb.).

For the most part, however, in its prolongation along the flanks of the Savoy, and particularly in the Swiss Alps, the neocomian is divisible into two great subformations only; the lower being dark-coloured and marked by the *Gryphæa Couloni* (Leym.), *Rhynconella* (*Terebratula*) *depressa* (D'Orb.), and *Spatangus retusus* (Lamk.) (Spatangus-kalk, Studer), and the upper being a light-coloured limestone containing the *Caprotina ammonia* (the Schratten-kalk of Escher), is a sure and excellent horizon throughout the greater part of the Alps†.

Cretaceous Greensand or Gault of the Alps. (*Turriliten-Etage*, Escher.)—The largely exposed neocomian limestone of the Savoy Alps supports, as above stated, in various escarpments, a thin zone of dark-coloured marly limestone, occasionally freckled with grains of chlorite, and abounding in fossils. In a collection made by my guide, Auguste Balmat of Chamonix, at the Montagne des Fis, Professor Pictet of Geneva recognized *Ammonites cristatus* (De Luc); *A. Hugardianus* (D'Orb.); *A. Mayorianus* (D'Orb.); *A. inflatus* (Sow.);

† It is worthy of note, that this upper band, as distinguished by the *Caprotina ammonia*, is absent at Neufchatel, as well as the lower part of the formation.

A. splendens?; *Hamites alternatus* (Sow.); *Nautilus*, small species; *Avellana incrassata* (D'Orb.); *Inoceramus sulcatus* (Sow.); *Solarium ornatum*? (Sow.); and a new species, together with various *Echinidæ* (*Discoidea*, *Galerites* and *Micraster*, Ag.).

In laying these fossils before the Society I also present a certain number from Sassonet, near Bonneville, and the Reposoir, which Professor Pictet kindly gave to me. The mere view of these fossils will convince English geologists that the rock of which I am now speaking fairly represents their gault and upper greensand*. A band of this age which I shall indicate in other natural sections in the Swiss and Bavarian Alps containing some of these characteristic fossils, is at intervals traceable far into the recesses of the higher mountains.

Inoceramus Limestone (*Sewer-kalk*), *equivalent of the chalk of Northern Europe.*—When I visited the Savoy Alps, it was still to be ascertained whether they contained any equivalent of the white chalk of Northern Europe, which surmounting the upper greensand was there fairly intercalated between that formation and the great "Terrain à Nummulites." In entering that region last summer I was indeed led to believe, from the first sections I observed around Chambery, that there was little chance of meeting with so full a succession of all the cretaceous strata as would exhibit any equivalent of the white chalk, for there the nummulitic rocks, as above stated, repose at once, as pointed out to me by the Canon Chamousset, on neocomian limestone. Moreover, in his very last memoir†, Prof. Favre had described the nummulitic zone in Savoy as independent of the cretaceous system on the one hand, and of the overlying macigno or flysch on the other. That geologist had doubtless reasons for such an inference, in seeing that the nummulitic rocks, where he examined them, reposed in one place on Jura limestone and at another on neocomian; but such reasoning in a region which has been subjected to many dislocations, is liable to be overturned by the discovery in an unbroken tract of the beds supposed to be wanting. Such, in truth, I found to be the case in a very clear natural section exposed at Thones in Savoy, which I examined in company with M. Pillet of Chambery in a traverse from Annecy by the valley of Thones and the Grand Bornand to the Col du Reposoir, and thence to the valley of the Arve.

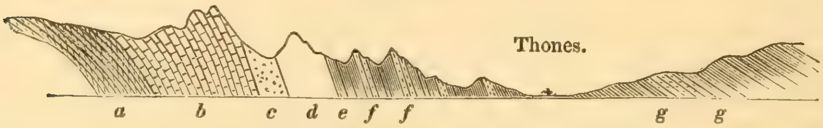
In entering the valley of Thones from the west, I perceived, near

* The fossils given to me by Prof. Pictet from the above localities and from the Perte du Rhone, where the same species occur,—in all three places usually in a bed of a few feet thick only,—are *A. inflatus* (Sow.), *A. Candollianus* (Pict.), *A. varicosus* (Sow.), *A. Mayorianus* (D'Orb.), *A. Lyellii* (D'Orb.), *A. monile* (Sow.), *A. milletianus* (D'Orb.), *A. regularis* (Leym.), *A. latidorsatus* (Michelin), *A. Hugardianus* (D'Orb.), *Hamites rotundus* (Sow.), *H. virgulatus* (Brongn.), *Turrilites Bergeri* (Brongn.), *Avellana incrassata* (D'Orb.), *Inoceramus concentricus* (Sow.), *I. sulcatus* (Sow.), *Cucullæa fibrosa* (D'Orb.), *Arca*, three species, *Terebratula ornithocephala* (Sow.), *T. plicatilis* (Sow.), *Ceromya inflata* (Ag.), with *Micraster* and other Echinoderms. See M. Pictet's excellent work, "Description des Mollusques Fossiles des grès verts des environs de Genève," 1re livr., 1847.

† "Sur la position relative des Alpes Suisses occidentales et des Alpes de la Savoie."—Bull. de la Soc. Géol. Fr. vol. iv. p. 996.

Annecy le Vieux, an ascending succession from neocomian to overlying nummulitic rocks with Pectens; but the broken nature of the banks at this locality, and the little time at my disposal, prevented the tracing of the intermediate strata. On approaching the village of Thones, it was however seen, that after several flexures the upper strata of neocomian limestone with *Caprotina ammonia*, forming a striking ridge on the north side of the valley, and having here a north and south strike, plunged south-east at an angle of 55° to 60°, throwing off on its surface the other strata exhibited in this diagram.

Fig. 6.



f, f. Nummulite limestone. *g.* Flysch.
e. Transition bed.
d. Inoceramus white limestone or chalk.
c. Gault and greensand.
a & b. Neocomian limestones.

On ascending to the little depression above the surface of the upper neocomian (*b*), it was evident that the excavation was due to the beds being less coherent than the hard limestone (*b* & *d*) above and below them. M. Pillet and myself then detected greensand terebratulæ, which, when combined with the position and character of the strata, led me to believe that this band of dark shale, impure limestone, and sandy green marlstone (*c*) was the representative of the gault and upper greensand usually exhibited in these Alps. These beds graduate upwards into yellowish limestone, which is surmounted by a cream-coloured compact limestone with flints weathering white (*d*), in which we found several specimens of Inocerami, the best-preserved of which was the *I. Cuvieri.*

Here then we had under our feet a band (*d*) which by position and fossils must fairly stand for the chalk. In proceeding upon the dip this limestone is seen gradually to change its colour from white to brown (*e*), and in a short space, without the slightest break or unconformity of the strata, the overlying mass is charged with nummulites. The nummulitic strata (*f*) becoming sandier upwards, contain also certain Pectens, and these shelly beds are overlaid by a zone of coralline concretionary sandy limestone, and the latter by a strong-bedded, dark grey, white-veined limestone. This nummulitic group, so intimately linked on to the Inoceramus limestone (or chalk) in its lower beds, is quite as intimately connected with the strata by which it is overlaid, *i. e.* with micaceous sandstones, marls, impure limestones and conglomerates, which represent a portion of the "flysch of the Alps (*g*)." These flysch beds contain certain scales of fishes enumerated by Agassiz, and some casts of shells. They are, in short, identical with the strata which at the desert near Chambery had been pointed out to me as the recognized lower beds of the "flysch" of Savoy, where they equally overlie and are equally connected with bands of nummulite limestone.

In ascending the lateral longitudinal valley of the Borne, which extends eastwards to Grand Bornand, particularly between Thones and St. Jean de Sixt, you have on the left hand a ridge of neocomian and cretaceous limestones overlapped by nummulitic limestone with some of the schist of the flysch, and on the other side of the road superior strata of the same series with hard sandstones in which conglomerates appear. There is no interval except that which has been occasioned by denudation, and all the strata are conformable and highly inclined, dipping to the S.S.E., the angle of inclination decreasing with the distance from the secondary limestones. At La Sommerie, to the east of Grand Bornand and in a deep depression under the Montagne de Four, a lignite has been partially worked, of the same age as that of Entrevernes near Annecy, which is fairly intercalated in the nummulitic group*.

It is therefore evident, that even in the environs of Mont Blanc, there is a connected section, which not only exhibits the whole succession of the cretaceous rocks properly so called, but also their upward lithological transition into beds with nummulites; and further, that the latter are inseparable from the overlying flysch. The independence, therefore, suggested by M. Favre does not exist in this part of Savoy where the natural original relations have not been effaced by dislocations.

Now, these nummulitic and "flysch" strata, which by much more developed natural sections in Switzerland, as well as by a consideration of their fossils, will be proved to be a natural group, distinct from, yet intimately and conformably linked on to the cretaceous system, are copiously exhibited on the summits of some of the highest and least accessible of the calcareous mountains to the north-east, north, and west of Mont Blanc. Thus, rising to vast altitudes, they cap the Dent du Midi and Diableretz, the former 9849, the latter 10,050 French feet above the sea. The fossils of the summit of the latter have been long known to geologists, and besides *Nummulites globulus* (Leym.), the *N. Biaritzana* (D'Arch.) or *regularis* (Rüttimeyer), are the *Cerithium diaboli* (Brongn.), *C. elegans* (Desh.), *C. polymeres* (Leym.), together with *Ampullaria*, *Chemnitzia*, and the *Melania costellata* (Lamk.), three of which are undistinguishable from species of the Paris basin.

In his admirable description of the rocks composing the summit of the Diableretz, M. Brongniart not only enumerated nummulites and several other fossils, and also indicated the intercalation with them of a band of combustible in the condition of anthracite, but he further justly reasoned on the nature of the shells and on the

* This coal of Entrevernes is noticed by Bakewell, Travels in the Tarentaise, vol. iv. p. 186, with woodcut. This author mentions Cythereæ and Cerithia, but does not allude to Nummulites. It was also visited by the members of the meeting of the Geological Society of France which assembled at Chambery, when MM. Chamousset, De Verneuil, Sismonda and Viquenel are reported to have found tertiary shells associated with it. See Bull. Soc. Géol. Fr. 2nd series, vol. i. p. 214. Coal of this age also occurs in the summit of the Diableretz (see next page) and at Pernant on the Arve, where it was observed by Prof. Necker in both situations associated with nummulites. For the latter position see Bibl. Un. de Genève, tom. xxxiii. p. 90.

whole of the evidences as disposing him to view these rocks as being of about the same age as those of the lower strata of the Paris basin. He well distinguished the nummulitic and carbonaceous black limestones from those of the adjacent mountains in which Ammonites, Hamites and other secondary greensand fossils occurred, and was only disposed to doubt his conclusions by the very ancient lithological aspect of the overlying schists and limestones. Such was the influence of mineral character in those days *! Now, however, that representatives of every band of the upper secondary or cretaceous rocks are known to exist in these Alps of Savoy and the Vallais, including even the equivalent of the chalk, we see how sound were the first conclusions of M. Brongniart as to the true tertiary age of the black nummulitic limestones of the Diableretz.

Intending to explore the relations of these supracretaceous strata in the Swiss Alps, where the labours of the geologists Studer and Escher de Linth had already succeeded in developing to a great extent their order, I abandoned further researches on this point in Savoy and the Vallais, being satisfied with having there detected a key to the order of superposition which had escaped previous observers. I further presumed that the limestone with Inocerami, which I had there observed to be intercalated between the greensand and the nummulite rocks of Savoy, would prove to be the same as the Sewerkalk of the Swiss geologists, and future researches completely established this to be the fact.

Nummulitic Rocks and Flysch of Switzerland ("Macigno Alpin" of Studer), with their relations to the subjacent cretaceous rocks.

Having touched upon the cretaceous and overlying masses of the Savoy Alps, I now proceed to describe in greater detail a series of sections specially illustrative of the sections I made chiefly either in the company of Professor Brünner of Berne or in that of M. Escher de Linth of Zurich, in the cantons of Lucerne, Underwald, Schwyz, Glarus, Appenzell and St. Gallen. In so doing I shall necessarily often refer to the underlying cretaceous rocks. As the general view of succession has been already given, it is deemed more desirable, for the better understanding of the subject, that the whole series of strata in each tract which are physically connected with the nummulitic zone should be collectively described, rather than first enumerate all the cretaceous rocks in different districts and then revert many times to the same place to describe the supracretaceous deposits. This would entirely frustrate my object of showing in consecutive sections the inti-

* "J'hésiterais donc très peu (says M. Brongniart), malgré la position de la roche calcaire qui renferme ces fossiles, malgré sa compacité, sa couleur noire, sa stratification concordant avec le calcaire ancien qui est au dessous; j'hésiterais peu, dis-je, à la regarder comme de même formation que le calcaire grossier de sédiment supérieur, si elle n'était recouverte par des roches qui offrent de nouveau le caractère d'homogénéité et de compacité qu'on attribue au calcaire alpin," &c. (Mémoire sur les Terrains de Sédiment supérieur, p. 44.) These overlying blackish, siliceous and micaceous sublamellar impure limestones, and compact scaly limestones with white veins, are parts of the "flysch."

mate connexion of some rocks which must, I conceive, be considered tertiary, with others which are unquestionably of secondary age.

And here geologists will recollect, that when Professor Sedgwick and myself wrote upon the Austrian Alps, the structure of the interior and flanks of the Swiss Alps had not been illustrated by Studer, Escher, and others. M. Studer had then, it is true, published a portion of his excellent work on the Molasse, but his first attempt at a classification of the older formations* had not appeared. Good even as that effort then was, it now requires much revision to bring it up to the state of our present knowledge; and so must it ever be in so complicated and difficult a chain†.

On attending the meeting of the Swiss naturalists at Soleure (after I had passed through Savoy), I was fortunate enough to hear a memoir read on Nummulites and other Foraminifera by M. Rüttimeyer of Berne. On a previous occasion Professor Brünner had described some of these forms as well as their geological position‡; but desirous that the purely zoological portion of this labour should be undertaken by a professed naturalist, he engaged his friend M. Rüttimeyer to join him, and the first result was the memoir I have alluded to, which will be followed by the publication of a joint work. In pursuing my inquiries I induced Prof. Brünner to accompany me in excursions into parts of the little cantons which he had not explored.

In the Beattenberg near Thun a band of coal is associated with the nummulitic deposit, *i. e.* in the strata beneath the flysch. This coal, which is now extensively used in the manufacture of gas at Berne, is therefore precisely in the same geological horizon as the coal of Entrevernes near Annecy, of Grand Bornand in Savoy, and of the Diableretz. In this respect there is indeed a close analogy between the northern and southern flanks of the Alps; for, as will hereafter be shown, coal is pretty largely extracted from the lower strata of the nummulitic rocks of the Vicentine, between Vicenza and Recoaro, and at Monte Bolca, in a region where these deposits unquestionably overlie everything cretaceous.

The nummulitic rocks of the Beattenberg (*f*) at once repose on the neocomian limestones (*b*), and are surmounted by flysch (*g*),

* See Transactions of the Geological Society of France, 1834.

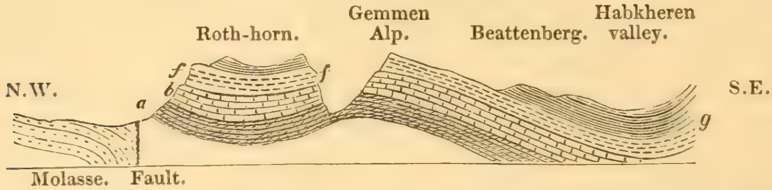
† No one is more aware than M. Studer of the necessity of frequent revisions and corrections of all the older sketches or attempts to map geologically any portion of the Alps before the organic remains were developed. In reference to his own small map of the region around Berne, he candidly explained to me, that the legend attached to it must now be much changed.—See Trans. Geol. Soc. Fr. vol. iii. p. 379.

‡ See Professor Brünner's memoir, "Beiträge zur Kenntniss der Flysch und Nummuliten Formation," Mittheilungen der Naturforschenden Gesellschaft zu Bern, 1847. In this memoir Professor Brünner compares the nummulitic strata to the north of the lake of Thun with those of the Diableretz, the *Nummulites globulus* (Leym.) being common to both. In both are species of Cerithia, Chemnitzia, &c., whilst the *Neritina Fischeri* (Brünner) of the Thun district is scarcely to be distinguished from the *N. lineolata* (Deshayes) of the Paris basin.

M. Rüttimeyer has since published an extract from his work in the Bibliothèque Universelle de Genève.

(fig. 7). In the countries, however, to which Professor Brünner and myself extended our researches, we perceived the relations of the de-

Fig. 7 (*by Professor Brünner*).

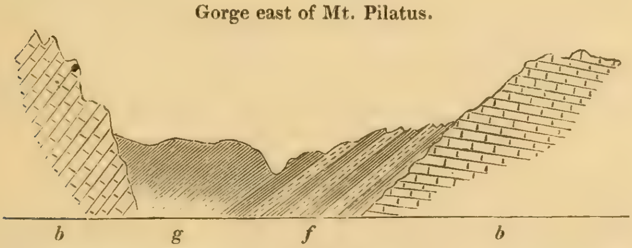


posit to the subjacent rocks to be much more copious and clear than what he had previously known, and more in harmony with my section at Thones in Savoy. Finally, meeting M. Escher de Linth, I found that this excellent field-geologist had (with the exception of a peculiar band of passage on which I lay great stress) come to the same conclusion as myself concerning the true position of the nummulitic zone, as being invariably above the inoceramus limestone or representative of the chalk.

The great zone of limestone, containing Nummulites, Orbitolites and Operculinæ, with certain shells, and surmounted by vast accumulations of "flysch," *i.e.* impure limestone, sandstone and schist, extends from the Beattenberg and Habkheren to Alpnach, trending parallel to the major axis of the Swiss Alps, viz. from W.S.W. to E.N.E. It is, in fact, an elevated trough between the great calcareous chains of Hofgant, Sernberg and Pilatus on the N.W., and the ridges which flank the lakes of Brientz and Sarnen, the Stanzhorn forming the south-eastern "pendant" to the Mount Pilatus. The depression occupied by the Alpnach branch of the Lake of the four cantons has been essentially formed in the softer schists or marly shale and sandstones of the "flysch" deposits, whilst the hard calcareous rocks on the flanks of the trough constitute the Pilatus on the one hand and the Stanzhorn on the other. I do not pretend to have so examined Mount Pilatus as to be able to give a detailed description of its structure and relations. I ascended it from Alpnach to the south flank of the Thumli-horn, and thence by a valley, leaving the Eck-horn on the right hand, to the summit, called the Esel, about 6000 feet above the sea, devoting the short time at my disposal to the examination of the nummulitic strata and the rocks on which they rest. The chief masses of the mountain are certainly composed of upper neocomian limestone (with *Caprotina ammonia*); and between the Thumli-horn on the one hand, and the Rustiger-wald on the other, I perceived a brownish sandy limestone which strongly contrasted with the white neocomian limestones of the flanking mountains. I saw no traces of gault, upper greensand, or inoceramus limestone, but judging from the analogies on the eastern shore of the lake of Lucerne, hereafter to be described, it is probable that such may be found on one of the unbroken shoulders (if such there be) of this remarkably bold and highly dislocated mountain. From a spot near the Esel summit, where I observed nummulites*, I perceived that there was an ascending section, with a rapid dip to the S.S.E., through beds of impure limestone into highly ferruginous strata, which in parts became a strikingly green calcareous grit (in parts small pisolitic), in which were casts of Pectens and other shells, similar to those associated with nummulites in many other parts of Switzerland. These green sandstones and calc grits there dipped rapidly under a vast thickness of schists, micaceous sandstones and bastard limestones; in short, under the "flysch." It was thus clear that the nummulitic and flysch rocks, though perfectly united and conformable within themselves, and clearly forming one natural division, were at this high gorge unconformably enclosed between two walls of the older neocomian limestone, as exhibited in this diagram. In my rapid survey

Fig. 8.

Gorge east of Mt. Pilatus.



g. Flysch of great thickness.
f. Ferruginous greensand with Pectens (part of the nummulitic group).
b. Neocomian limestone (upper).

I did not visit the adjacent flanks of the mountain in which a sequence might be found; and I have only to observe, that in the great masses of finely laminated marly and sandy schists which descend rapidly on the face of the older limestones into the lake, I found some of the same small foraminifera which MM. Brünner and Rüttimeyer have recognized in the environs of Thun.

On the whole, however, the nummulitic and flysch rocks of the Pilatus have the appearance of having been upheaved in a highly broken and elevated trough, the sides of which rest on the edges of the neocomian limestone, which latter presents to the north one of the finest mural precipices along the whole outer edge of the Alps, to the lower and undulating country of molasse and nagelflue, which here range over the canton of Lucerne.

The eastern end of the lake of Alpnach is almost barred in by a tongue of land, composed of subconical and undulating hills, which

* The species of nummulite I found in the Pilatus was small, but it is well known that large forms of this genus are there also present. In reference to these organic remains, I ascertained, when in the company of Professor Brünner, how much the species of Nummulites and other Foraminifera differ in the same region at different localities, and yet, as will hereafter be seen, the very same characteristic species reappear at spots very widely distant from each other.

having been examined by M. Brünner, proved to form a very instructive trough, as expressed in figs. 9 and 10, the lowest rocks on either side being the upper neocomian (*b*), surmounted by the Sewer-kalk (*d*) or equivalent of the inoceramus limestone, and this by a basin of nummulitic limestone and flysch (*f*, *g*)*.

Fig. 9.

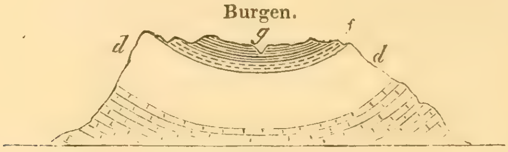


Fig. 10.

g. Flysch.
f. Nummulite limestone.
d. Sewer-kalk or chalk.
b. Neocomian (upper).

The lowest of these diagrams, fig. 10, represents the general relations at the south-western end of the promontory, between Stansted and Stanz, where the nummulitic rocks are squeezed up, whilst fig. 9, on the strike of the same strata to the W.N.W., shows how the basin of nummulitic and flysch rocks expands and becomes regular.

The Orbitolites, which occupy beds of considerable thickness in the mountains of Ralligstock and Beattenberg, near Thun, are here contained in a green calcareous sandstone of a few feet thickness only, whilst the *Nummulites millecaput* (Boubée), or *polygyrata* (Desh.), is much developed, and seeming, according to Brünner, to replace in this spot the small *N. rotularis* (Desh.), or *N. globulus* (Leym.). The first-mentioned large and striking species, which is so extensively distributed over the globe, reappears in many other tracts to the north-east, as will be hereafter detailed†.

* When M. Brünner examined this promontory he had not had his attention called to the thin band of secondary greensand or gault which we afterwards found so usually intercalated (as in Savoy) between the upper neocomian and the inoceramus limestones; and in a rapid examination, looking chiefly to the great relations and general symmetry of the trough, a few feet of greensand may he thinks have escaped him. (See fig. 10.)

† In my tour I necessarily used the specific names given to the Nummulites and other Foraminifera of the Swiss Alps by Rüttimeyer and Brünner; but on comparing the forms I collected, M. D'Archiac, to whom I referred them, identifies several of them with species previously named and described in France. Thus, whether the following names, as given in Italics, be finally adopted or not, their equivalents being here mentioned, no misunderstanding can arise. The fact which

In following our formation into the valley which extends from Brunnen to Schwyz, on the eastern shores of the lake of Lucerne, we found that the intermediate succession between the neocomian and the flysch became much more regular and distinct. Situated between the Rigi (that grand accumulation of nagelflue and molasse) on the one side, and the great masses of contorted secondary rocks of Altorf on the other, the valley extending from Brunnen to Sewen and Schwyz is another of these troughs, the sides of which are composed of the secondary limestone, dipping, on both banks of the river, under the nummulitic and shelly deposits. On the northern side the symmetrical order of succession is very clear, as exhibited in this diagram (fig. 11). Commencing the ascending section on the edge of

Fig. 11.

Relations of Cretaceous and Nummulitic rocks at Sewen.

Eocene. { g. Flysch (denuded). f. Nummulit ic rocks. }

Cretaceous. { e. Passage beds obscured. d. Sewer-kalk (Inoceramus limestone). c. Gault and upper greensand. b. Upper Neocomian limestone. a. Lower Neocomian. } (b, a: Lower greensand.)

the lake of Lowerz to the north of Sewen, the dark-coloured lower neocomian limestone and shale (*a*) is overlaid by the light-coloured, crystalline, thick-bedded upper neocomian limestone (*b*), in which we detected not only numerous sections of the *Caprotina ammonia*, but also *Hippurites Blumenbachii*, with corals and Echini. Immediately above these is a narrow depression (*c*), in which are softer beds, the equivalents of the gault and upper greensand, with small ammonites and other fossils*.

The next mass which succeeds is the Sewen limestone of the Swiss geologists. This sewer-kalk (*d*) thus resting on upper secondary

is of paramount importance is, that the following species occur in the south of France, the Pyrenees and the Alps, thus identifying the group :—

1. *Nummulites millecaput*, Boubée = N. polygyratus, *Desh.*
2. ———— *planospira*, Boubée = N. assilinoides, *Rüt.*
3. ———— *Biaritzana*, D'Archiac = N. atacica, *Leym.*, N. acuta, *Sow.*, and N. regularis, *Rüt.*
4. ———— *globosa*, Rüt. (var. *Biaritzana*, D'Arch.) = N. obtusa, *Joly et Leym.*
5. ———— *rotularis*, Desh. = N. globulus, *Leym.*
6. ———— *placentula*, Desh. = N. intermedia, *D'Arch.*
7. ———— *lævigata* (Lam.).

1. *Orbitolites discus*, Rüt.
2. ———— *patellaris*, Brünner.
3. ———— *stellaris*, Brünner = Calcarina stellaria, *D'Arch.*

Operculina near to *O. ammonea*, Leym.

* Several fossils of the greensand have been found here by Studer and Escher. The latter geologist was we believe the first to name the overlying limestone Sewer-kalk, and to show how a similar limestone occupied a similar place in the canton of Appenzell, and on the lake of Wallenstadt.

greensand, is a whitish grey rock, in which limestone of conchoidal fracture and light colour, forms small and flattened concretions in a light grey earthy base, or rather the shale of this colour wraps in thin coatings over the calcareous undulations, the whole splitting into flagstones six to eight inches thick, and occasionally into much stronger beds. Like the greensand and neocomian limestone on which it rests, this rock seems here to be the exposed portion of a dome, which, as far as can be seen, dips to the N.E., E., S.E., and S.S.E. To the east it is denuded along the bank of the little river, and is extensively quarried as a building-stone. We were fortunate enough to discover (we believe for the first time) Inocerami in this sewer-kalk, fragments of which fossils are to be detected by those who will carefully look for them, even from the lowest beds which rest upon the greensand, to the upper portion of the quarries. The dominant species (two or three specimens of which I brought home) seems to be the *Inoceramus* or *Catillus Cuvieri*. In following these beds as they fold over to the S.S.E., and where they descend into the Muotta-thal at about 25°, there is a hidden space of about fifty paces only, in which the succession is not observed (*e*), but they are then succeeded in perfectly conformable apposition by beds (*f*) of sandy greenish-grained limestone, abundantly charged with nummulites, chiefly the *Nummulina planospira* or *assilinoides*, which alternate with marly shale, which becomes sandier and more flag-like upwards, and are finally surmounted by sandy marlstone charged with Orbitolites, Pectens, &c.

The broad valley watered by the Nieten and the Muotta streams has evidently been excavated in the soft beds of flysch and sandstone superior to the nummulite bands; for after traversing to Ingolboldt, on the external slope of the opposite mountains, the first strata met with at that village, are the very same beds of sandy rotten marlstone with large Orbitolites, Pectens, and casts of other fossils, which there occur in highly inclined strata dipping to the north, and thus form a portion of the opposite side of a trough, as seen in the general section (fig. 12). The flank of the ridges extending from Brunnen up the left bank of the Muotta is much obscured by woods, fallen cliffs, and vegetation; but there are spots in which portions of the nummulitic rock are also seen to be underlaid by the sewer-kalk, greensand, and by upper and lower neocomian, the latter forming the nucleus of the great dome-shaped calcareous mountain Morschach, on the east side of the Altorf branch of the Lake of the four cantons, immediately to the south of Brunnen (fig. 12)*.

Reserving for another part of this memoir the consideration of the enormous flexures and breaks to which this whole series of rocks, together with the jurassic limestones, have been subjected at the upper extremity of the Altorf lake, I would now merely remark, that the woodcuts figs. 11 and 12, the one detailed, the other general, clearly indicate that the Sewen limestone (*d*), with its Inocerami, lying between

* Near the spot called Gumpisch, this lower neocomian dark limestone is loaded with *Gryphæa Couloni*, *Rhynconella* (*Terebratula*) *depressa* (D'Orb.), and *Spatangus retusus*.

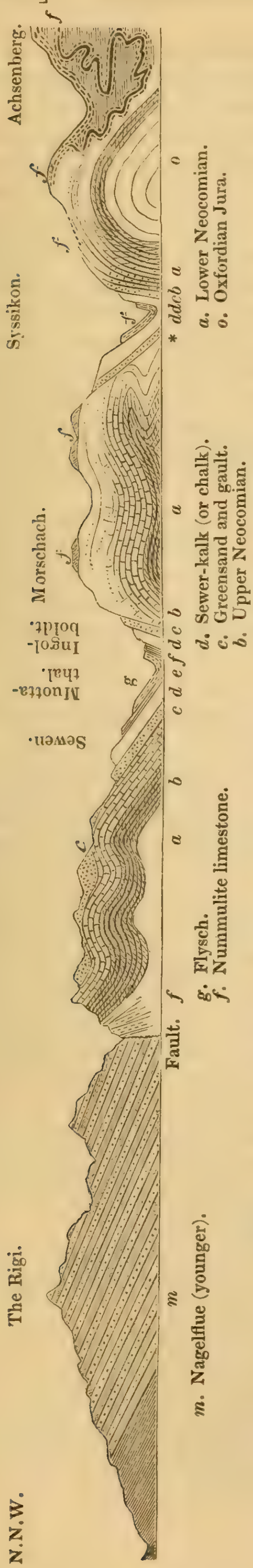


Fig. 12.

the upper greensand (*c*) and the nummulite rocks (*f*), is precisely in the same place as the inoceramus limestone of Thones in Savoy before described, and that both are clearly representatives of the white chalk of Northern Europe.

This sewer-kalk rises up on nearly all sides of the beautiful valley of Schwyz. I refer to it the grand red and white peaks of the Mythen*, which overlook the town of Schwyz, so well known to all lovers of the picturesque. These masses of red and mottled grey and white limestone strongly resemble the scaglia or Italian equivalent of the chalk, and have no sort of resemblance to any other known limestone in the Swiss Alps. They also clearly overlie all the older limestones, jurassic and neocomian; I therefore unhesitatingly refer them to the white chalk; and the more so because they are linked on to the superior nummulitic and flysch formations. On the northern flank of the smaller peak, in ascending to the Hacken pass, we crossed over masses of schist and impure limestone with white veins, which formed the external envelope of the slope, and next over green-grained calciferous grits with *Nummulites planospira, N. rotularis, N. Biaritzana,* and *Orbitolites discus*; the thick shells of the latter resembling little layers of calcspar; but we also detected a specimen of Inoceramus in the fragments of limestone which had fallen from the cliffs. The upheaval, however, of the Mythen has been accompanied by so much dislocation around it, and such enormous subsidences have taken place on the taluses, that no regularity of succession can be detected; nor could the above order be stated if the adjacent rocks when in their normal positions (as before cited in fig. 11) had not afforded us a true key to the structure of the tract. There is, in fact, just the same appearance of a general inversion of the formations on the

* We passed the Mythen on the north by the Hacken pass in our route to Einsiedeln and returned by Brunnen and the Holzeck pass. The latter is the grandest scene, and is the point from whence the summit is alone accessible.

eastern shore of the lake of Lowerz, as on its western banks. The great accumulations of nagelflue and molasse of the Rossberg in the one case, like those of the Rigi on the other, instead of dipping away from the Alpine centre, plunge towards it; the younger tertiary rocks seeming to be the oldest by their order of superposition; whilst the nummulitic and flysch formation is broken and squeezed up against the cretaceous rocks of the Mythen. In stating my belief that the *summits* of the Mythen are of the age of the chalk, I would not, however, infer that the lower part of the mountain is also of this age; for at the eastern face, when examined from Brunnen, in the valley leading to Einsiedeln, it presents a great succession of underlying massive terraces, the lowest of which are highly altered, siliceous rauchwacke limestone, with partial dolomitic veins not unlike the "cargneule" of Savoy. In the vertical faces of the limestone beneath the red peaks, the lines of stratification are obscurely perceptible, seeming to pass to the S.S.W.; whilst the whole is traversed by highly inclined joints resembling a rude cleavage, the planes of which plunge 70° to the N.N.W. As this mountain is to a great extent inaccessible, and as the lower portions of it seem to have undergone great modification, it is one of the countless examples which the Alps offer, of the difficulty of defining with precision the downward limits of formations.

Nummulite and Flysch Rocks of the Environs of Einsiedeln.

Vast masses of flysch* lie between the Mythen and the valley of Einsiedeln; and to the west and south of that town, terraces of nummulitic limestone rise out from beneath the chief masses of such flysch, and are seen, at the same time, to be strictly united with them.

I have already stated that in Savoy, the only passage from the chalk upwards with which I am acquainted, shows a gradual change in the colour and texture of the rocks from the white limestone with inocerami into the brown sandy nummulitic rock; there being there, as far as I could see, but one band charged with nummulites. Again, in the section near Sewen, as we have seen, there is an apparent passage between the uppermost beds of the inoceramus rock and the nummulitic strata above them.

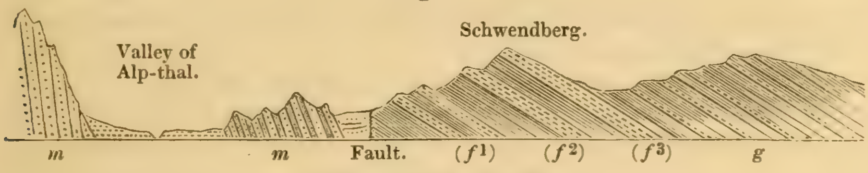
In the environs of Einsiedeln, however, the thickness of the lower portion of the nummulitic group increases, and in subsequent pages it will be shown how such development becomes still more striking in the canton of Appenzell, and in the Bavarian Alps.

The Schwendberg to the west of Einsiedeln consists of several buttresses of hard brownish nummulitic limestone dipping south (fig. 13).

* I need not repeat the mineral description of the flysch, except where it offers some new features. The generic word applies to the group associated with and overlying the nummulitic rocks, which is chiefly composed of thin-bedded, impure, dark grey limestone with white veins, schists, both argillaceous and calcareous, marls, micaceous sandstones, sometimes green-grained, but more frequently diversified by small black grains, with fucoids and a few casts of shells and fishes' teeth in its lower parts.

In the lower mass, composed of a greenish limestone (f^1), nothing but nummulites are visible, chiefly the *N. millecaput* (Boubée); then come greyish blue bands (f^2) with other species of nummulites; next a considerable thickness of marls, sands, &c. (flysch), surmounted by strong reddish and greyish nummulitic limestones (f^3). In short, from the bottom to the top of the nummulitic portion of the series, there were intercalations of strata having all the characters of flysch. The great overlying mass (g), however, has been alone styled such by Swiss geologists, and it here spreads in vast thickness over the adjacent mountains.

Fig. 13.



m. Upper molasse and nagelflue.
Eocene. { *g.* Flysch. *f.* Nummulite limestone alternating with flysch.

In ascending the little valley of the Sihl from Einsiedeln the same relations of ridges of nummulitic limestones and flysch are still more clearly exposed to the east and west of the village of Gros, where they have also a dip S.S.E. The Sattel mountain on the east side of this valley exposes on its flanks three or four prominent bands of the nummulitic rock, all dipping to the S.S.E., separated from each other as well as overlaid by considerable thicknesses of flysch (*i. e.* of sandstone, limestone, shale, and schist).

The lower nummulitic limestones visible are dark grey, reddish, and greenish grained, in which occur the large echinidæ of Kressenberg, together with ostreæ, small nummulites, and large orbitolites. Then intervenes a great mass of shale and sandstone, followed by a second nummulitic limestone and another zone of flysch, and that again by a third nummulitic limestone. In this last-mentioned mass I was much struck with the strong coincidences between some of the coarser nummulitic limestones and the limestone of the so-called "flysch" of many parts of the Alps. They were, in fact, precisely the same thin-bedded, dark grey, sandy limestones with white veins, and occasionally with so many grains of green earth as to become a green calcareous grit; the only difference being that the flysch was void of the nummulites and fossils which distinguish the other. These strata, covered by thick beds of grey limestone, pass upwards through shale into fine micaceous flaggy grey sandstone, and thence up into the great series of the so-called "flysch." A similar intercalation and association is indeed quite as instructively seen just above the village of Gros on the west side of the valley.

The chief fossils of the nummulitic bands of this district are the *Nummulites planospira* (Boub.) or *assilinoides* (Rütt.); *N. millecaput* or *polygyrata* (Desh.); *N. Biaritzana* (D'Arch.) or *regularis* (Rütt.); *Operculina,* apparently a large new species; *Orbitolites discus,* and *O. parmula*; Pectens, large Ostreæ, and some few univalves, and occasionally the large *Conoclypus conoideus* and other Echinoderms that characterise the deposits of Sonthofen, Kressenberg, and other places in Bavaria and Austria.

All the dips of the rock-masses in this tract are inverted; for the molasse and nagelflue of Einsiedeln being the eastern prolongation of the Rigi and Rossberg equally plunge S.S.E., and seem absolutely to be overlaid by its older neighbour the nummulite limestone and "flysch;" the latter formation being in its turn so thrown over that its younger member lies against or dips under the secondary rocks. In this manner the oldest portion of the nummulitic group is in contact with the tertiary conglomerates (fig. 13), which I shall hereafter prove are the upper part of a great series containing some marine shells of existing species!

Nummulitic Rocks and Fish Slates of Glarus.—Nummulitic limestones reappear in broken troughs at various other points throughout the little canton of Schwyz; but in following them into the canton Glarus, the associated strata, or rather the beds immediately overlying the zone characterized by nummulites, presents a striking zoological feature. The bands of flysch above the nummulites, indeed, as in many other places, contain fishes' scales and teeth, particularly certain dark schists and marls of Savoy and various parts of Switzerland. In Glarus, however, and notably near Engi in the valley of the Sernft, where these black beds have undergone much induration, they are largely quarried under the name of Glarus slates, and are well known to collectors for the numerous fossil fishes they contain. On visiting the quarries I found them totally void of any slaty cleavage; the so-called slates being true calcareous flagstones with a few diagonal veins of white calc spar. They dip away 30° and 40° E.S.E. from the face of the ridge of the most ancient rock of this tract, usually called the Sernft conglomerate. At the spot on the west side of the valley, where the fish beds are quarried, there is no visible relation to any nummulitic rock; but the same calcareous flagstones with white veins, and which are clearly one of the numerous varieties of "flysch," can be followed up the valley of the Sernft to heights of 1000 feet and more above the water-course; and to the east of Elm they are associated with and overlie strong bands of nummulitic limestone. This position was clearly seen by M. Escher and myself as we ascended from Elm to the high pass of Martin's-loch. In treating of some of the contortions, inversions, and breaks of the Alps, I shall have occasion hereafter to return to the consideration of this very remarkable tract; but whether the strata be there overthrown "*en masse*" or not, has nothing to do with the present question; for the calcareous flagstones identical with the fish beds quarried as Glarus slates, and which are in truth a direct prolongation of them, are fairly dovetailed between two courses of nummulite limestone, in the lowest of which I perceived the large *Nummulites millecaput*, and in the other a greenish-grained deep-coloured siliceous limestone with another and smaller nummulite, both of which occur in numerous places in association with all the other fossils of the group and regularly overlying the cretaceous rocks.

These Glarus slates were formerly considered, from their mineral character, to be of high antiquity, and great was the surprise of most geologists when in the work of Agassiz the species of fishes contained in them were classed with so new a formation as the chalk. I now go farther, and assert that, by geological position and association with the nummulitic strata, they are certainly eocene, and possibly not of older date than the lowest portion of the London clay. Nor is there any evidence in the characters of the ichthyolites of Glarus to contravene this inference, but on the contrary much to sustain it. The Palæorhynchum, Acanus, Podocys, &c., are, it is true, extinct genera, but they are also peculiar and unknown in any cretaceous deposits; whilst the Fistularia, Vomer, Osmerus, and Clupæa* have not only never been found in any secondary rock, but are absolutely living genera. Even then, if we had no geological or stratigraphical evidence, one might be fairly led, by the identifications of Agassiz alone, to conclude that a formation including smelts and herrings (there being three species of the latter) was of tertiary age, by the approach of its fauna to the present order of things. The palæontological inference is further sustained by these slates or flagstones containing the bird *Protornis Glariensis*, Herman v. Meyer, and the tortoise *Chelonia Knorrii*, Her. v. Meyer.

In fact there need be no more difficulty in viewing these fish beds of Glarus as tertiary, than the black carbonaceous hard limestones and schists and flysch of the Diableretz.

Nummulite and Flysch Rocks in the Grisons.—M. Studer has shown that large portions of flysch in the Grisons have been converted into a crystalline gneissose rock; but I would now state, that whatever be their irregularities of position in the interior of that canton, and to whatever metamorphisms they may there have been subjected, they unfold themselves with symmetry and regularity in their normal order between the valley of the Rhine and the baths of Pfeffers. In the gorge of the Tamina, to the south of these baths, a clear succession is seen through Oxfordian, Neocomian, and upper cretaceous rocks, which latter pass under nummulite rocks; the baths being situated in vast masses of flysch interlaminated with nummulites, as seen in a section which I made in company with M. Escher. Here again many of the black flags are absolutely identical in mineral characters with the so-called slates of Glarus, and although no entire ichthyolites have been discovered in them, they contain the teeth of fishes.

Sections of the Cretaceous and Nummulitic Systems on the north side of the Lake of Wallenstadt, and in the Hoher Sentis of Appenzell.—Whilst the section of the Tamina and the baths of Pfeffers show the ascending order from the cretaceous rocks up into the nummulitic limestone and flysch, by far the largest and clearest exhibitions of the whole succession in Switzerland are displayed on the plateaus on the north bank of the lake of Wallenstadt†, and in the environs of the

* See Agassiz, Poissons Fossiles, General Table, tom. i. p. xxxiii, where forty-two species of fishes are named.

† When in the Tyrol with M. von Buch in the previous autumn, he assured me

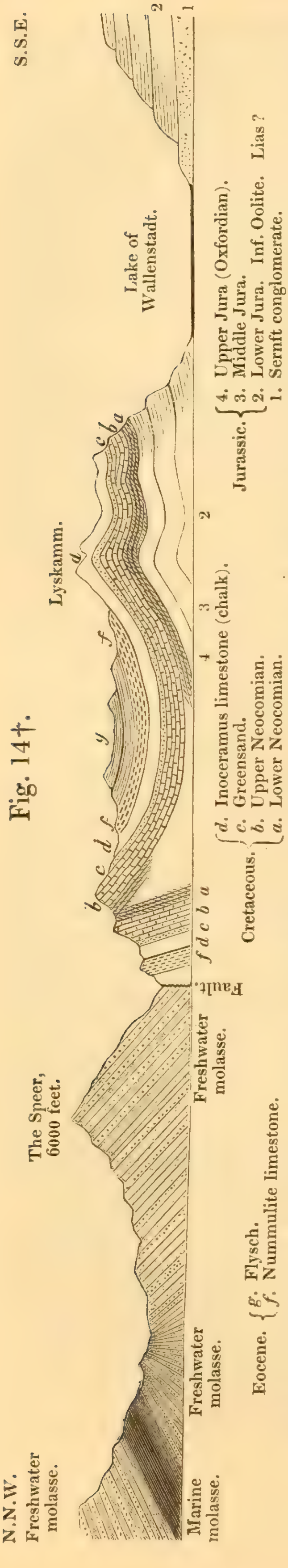


Fig. 14†.

still loftier Hoher Sentis and the high tracts of Appenzell; a district which is rendered classical in geology by the recent labours of M. Arnold Escher de Linth. We have there not only that series which has been already so much dwelt upon, from a low horizon in the Jura limestones through the neocomian to the cretaceous series including the inoceramus limestone, but also a very complete exhibition of nummulite rock and flysch. Seeing that M. Escher had so fully made himself master of all the dislocations as well as all the regular successions both of the plateau of Wildhaus and of the Hoher Sentis, I could only pretend to offer one, I trust not unimportant addition to his valuable contributions, by bringing to his notice a band between the inoceramus and nummulite limestones, which I consider to be of value in demonstrating a lithological transition from the cretaceous system, properly so defined, to that which overlies it. I also urged him to adopt my method of classifying the nummulitic and flysch rocks as lower tertiary, and no longer to include them in the cretaceous series*.

In travelling from Mells near Sargans to Wallenstadt and Wesen, a clear ascending order of the strata is visible, from the "Sernft" conglomerate (the most ancient rock of the region) at Mells (fig. 14). This

by reference to his well-filled note-book, that this would be found the grandest and clearest of all the Swiss sections in explaining the true overlying relations of the flysch and nummulites to the cretaceous rocks.

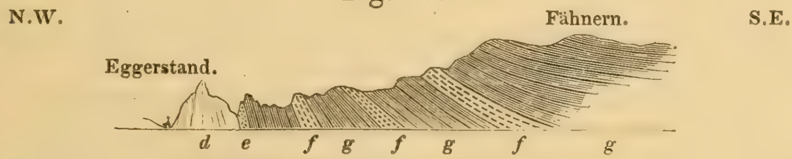
* In the tabular view of his memoir entitled 'Gebirgskunde,' appended to the description of the canton Glarus by Professor Heer, M. Escher gives the following names in ascending order of all the strata of the "Kreide-bildungen":—1. Spatangus kalk (Studer) or Lower Neocomian. 2. Schratten kalk or Upper Neocomian. 3. Turriliten-Etage or Gault. 4. Sewerkalk or chalk. 5. Nummuliten Etage. 6. Flysch and Dachschiefer von Plattenberg.

† Although this diagram, from the pencil of M. Escher, exhibits a thin course of it only, the zone of gault or upper greensand exists in full force around the Sentis. In the valley of the Rhine, and extending to Eichberg, it appears in insulated hummocks charged with Turrilites, *Inoceramus sulcatus* and other fossils, which with many forms gathered from the different overlying rocks around the Hoher Sentis, Prof. Brünner and myself examined in the rich museum of the Rev. Mr. Rechsteiner of Eichberg.

conglomerate (1), which is in parts a purple and green spotted glossy schist, in parts a millstone grit, passing into a conglomerate with pebbles of white quartz in a talcose base, dips to the north and passes under the limestones which form the great escarpment of the chain called "Kurfürsten." In that escarpment the Lower Jura and Oxfordian formations (2, 3, 4) are surmounted by the three members before cited of the cretaceous system, viz. neocomian with its two divisions (*a* and *b*), gault or upper greensand (*c*) and inoceramus limestone (sewer-kalk) (*d*). The same overlying succession is seen on the northern shore of the lake of Wallenstadt, the mountains in which are a western prolongation of the Kurfürsten. Above all this and to the north is the upland depression or trough of Wildhaus, in which the inoceramus limestone (*d*) is covered by nummulite limestone and flysch (*f* and *g*). The latter deposits rise up to the north of Wildhaus in a basin-shape with a reversed or southern dip, and then equally repose on inoceramus limestone, which is succeeded by the gault and neocomian limestone (*a* and *b*), the latter culminating in the chief summits of the Hoher Sentis. That mountain group, the highest points of which are near 8000 English feet above the sea, and which forms by far the most remarkable promontory along the whole outer zone of the Alps, is highly instructive in the full development of all the cretaceous rocks from the lower neocomian to the inoceramus limestone, as seen in the Alte Mann as well as in the other chief summits.

I shall hereafter advert to its escarpments when speaking of the great flexures and fractures of the chain, where the tertiary nagelflue is apparently brought under the masses of secondary limestone. I will now briefly state, that on the north flank of the Kamor, a north-eastern promontory of this group, and again on the Fähnern mountain beyond it, there are natural sections which exhibit the supracretaceous succession (see fig. 15). The last boss of the sewer-kalk of the

Fig. 15.



g. Flysch, with fucoids.
f, *f*, *f*. Nummulite limestone.
e. Transition bed with *Gryphæa vesicularis*.
d. Inoceramus limestone.

Hoher Sentis, prolonged in a low ridge to the N.E. of Weissbad, constitutes a scarp immediately overhanging the little hamlet of Eggerstand, where, in the form of thin-bedded white scaglia, it plunges rapidly to the S.E., and is immediately covered by slightly micaceous shale and bluish grey impure limestone with white veins. This rock, which already resembles a variety of "flysch," passes up into a sort of sandy marlstone with some green grains associated with a dark indigo-coloured schist, in which occurs the same species of Gryphæa, *G. vesicularis*, to which I shall subsequently call attention in describing the sections at Sonthofen in Bavaria, where it occupies a like place.

The next bed (*d*) is a green calc-grit charged with nummulites and orbitolites. So far all is clearly seen on the sides of the broken ravines descending near Eggerstand. In ascending the Fähnern, or rather in coasting its western face obliquely towards its summit from the ravines above-mentioned, you next pass over a considerable thickness of schists and sandstone or flysch, and then reach another and the chief band of nummulite limestone which ranges along to Schwarzen Eck. This is a very green-grained, sandy limestone, which when bruised by the hammer is rendered grass-green, and contains *Nummulites globulus, N. globosa* and *N. millecaput*, Boubée, together with Orbitolites and several forms of Pecten and the usual fossils of the group.

The inclination of the strata gradually decreasing as the axis of disturbance is receded from, the nummulite bands graduate upwards into other beds of flysch in which no animal forms are visible, and finally towards the summit of the hill into finely laminated, light-coloured calcareous flagstone, on the laminæ of which are numerous impressions of fucoids of at least three species, viz. *F. Targioni, F. intricatus,* and a new species with broad fronds, described by Prof. Brünner as *F. Helveticus**.

In relation to these fucoids, I may here observe once for all, that throughout the Savoy and Swiss Alps, and indeed I now believe generally all along the *northern* face of the chain, they occur in a zone superior to the chief masses of nummulitic limestone. The beds in which they occur are, however, so linked on to the inferior members of the group in numerous natural sections, (there being no instances of dislocations or unconformity between the one and the other with which I am acquainted, except on lines of fault,) that I necessarily consider them to form one natural group with the nummulitic rocks on which they repose. In treating of the flexures and breaks of the calcareous mountains of the Alps, I will hereafter produce a series of transverse sections across the group of the Hoher Sentis, as prepared by M. Escher von der Linth, which in exhibiting the wonderful contortions to which these masses have been subjected will also clearly indicate the order of the strata (see Pl. VII.).

Nummulitic Rocks and Flysch of the Voralberg and Allgau.—Having traced these rocks to the north-eastern extremity of Switzerland, it became highly expedient to traverse the valley of the Rhine above Bregenz and connect them with similar strata, which Prof. Sedgwick and myself had described many years ago. In fact, I could not acquire the knowledge of the Savoy and Swiss succession which has now been detailed, without seeing clearly that our former classification of the nummulitic rocks and flysch of Dörnbirn in the Voralberg, and of Sonthofen in Bavaria, and of various places in Austria, with the cretaceous system and greensand, must be changed.

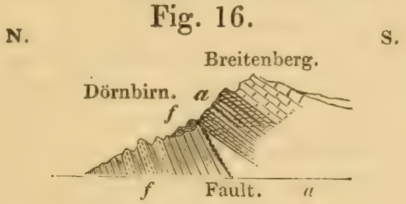
The nummulite beds near Dörnbirn on the right bank of the Rhine have here been correctly described as apparently dipping southwards

* Professor Brünner has also shown that the *Fucus Brianteus* (Villa) of the Briançon on the flanks of the Milanese Alps is identical with a species found in the Gurnigel sandstone or flysch near Berne.

under the great calcareous masses of the Stauffen*. On visiting this spot with Prof. Brünner I found dark greyish, white-veined limestone with schist or shale in the mass now visible *in situ*, which, if the fossils were omitted, would be "flysch," surmounted by other bands of schist or shale and sandy green-grained limestone passing into a grey rock, and again shale and schist with thin stone bands of "flysch." In the lower limestone were small-ribbed Pectens, large Ostreæ, Terebratulæ, Echini, and many Nummulites. The higher portion of the upper band is characterized by *Orbitolites discus* and the *Nummulites globosa*. In the lower mass is the highly ferriferous band formerly worked for iron, which is a perfect congeries of the *Nummulina planospira* or *assilinoides* and *N. placentula* (Desh.). These fossils are precisely those of the Fähnern mountain on the opposite bank of the Rhine; whilst in the association of iron with the nummulites it is clear that it is the direct western extension of the still more ferruginous zone of Sonthofen in Bavaria.

These nummulitic and flysch beds apparently dip under the secondary limestone. The mural escarpment of the Breitenberg, a counterfort of the Stauffen, which seems to be the upcast mass, consists chiefly of neocomian limestone, and in the part to which we ascended with some difficulty through the thick woods we found the *Spatangus retusus* of the *lower* member of that formation. It is probable that there is really an overlap at this junction as represented in this woodcut, fig. 16, and the point will be discussed in the sequel.

Fig. 16.



f. Nummulite rocks.
a. Neocomian (lower).

Sonthofen Iron Mines, and the Grünten Mountain in Bavaria.— The symmetrical order of succession so clearly exposed on the outer flank of the Fähnern and at other points around the Hoher Sentis, and which is obliterated along the great line of fault at Dörnbirn near Bregenz, is strikingly and instructively resumed in the Grünten mountain, situated between Immenstadt and Sonthofen in Bavaria.

Sections of this mountain were published in the communication so often alluded to†, but they were defective in not presenting any well-defined geological horizon either in the inferior or superior strata. It is true that Prof. Sedgwick and myself then discovered greensands with unquestionable British cretaceous fossils, and we stated that these were surmounted by the scaglia or equivalent of the chalk. But the transition downwards from that which really represents the gault and upper greensand into the fossiliferous limestones, now

* Trans. Geol. Soc. Lond. vol. iii., 2nd series, p. 325, and pl. 36. fig. 3.
† *Ibid.* pl. 36. fig. 4.

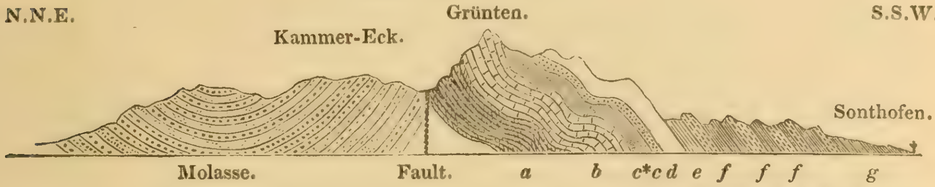
known to be neocomian or lower greensand, was wholly omitted; for, as before said, the neocomian fossils were then unknown, and these rocks were considered to be of jurassic age. On the other hand, the transition upwards from the equivalent of the chalk into the nummulitic grit, and thence into the flysch as an overlying mass, was imperfectly explained. In short, having returned to Sonthofen and the Grünten after an interval of eighteen years, and immediately after I had made a consecutive series of sections in strata of this age throughout the Savoy and Swiss Alps, I looked at the masses with a different eye to that with which I viewed them when the only Alpine bases known to me were the rock-masses (often inverted) on the north flank of the Austrian Alps. Even formerly, however, when treating of the flysch with fucoids of this valley of Sonthofen, Prof. Sedgwick and myself offered our sketch as a provisional arrangement only; stating that a more minute acquaintance with the fossil history of the Alps might hereafter lead geologists to a better-defined subdivision of these groups. Profiting, therefore, by the increase of this very fossil knowledge and by a study of the best types in other parts of the chain, and correcting my former views, I now offer sections which I consider to be as clear, copious and instructive, in explaining the succession from the cretaceous to the nummulitic rocks, as any with which I am acquainted.

The peaked and remarkable calcareous mountain called the Grünten (5923 French feet high), which stands out boldly between Immenstadt and Sonthofen, and there forms the eastern side of the valley of the Iller, has a general direction from N.E. to S.W. This direction, oblique to that of the chain which trends from W.N.W. to E.N.E., is connected with dislocations which affect all this tract. On the north-west face, where the mountain is washed by the Iller, it throws out a spur above the village of Wagneritz or towards Immenstadt; to the north it abuts against a mass of tertiary molasse; on the south-east it is divided into several jagged peaks, the precipitous walls of which preserve a parallelism to the main ridge of summits; whilst on the south-west, or towards Sonthofen and the upper valley of the Iller, round-shaped buttresses diminishing in height expose an excentric arrangement of strata in ascending order. In a word, the general escarpment of the mountain is to the north-west and north-east, and the prevailing dips of the strata to the south-east and south-west. The best general section may be described as that which exposes an ascending order from the elevated escarpment near Rettenberg on the north-east, to the plain of Sonthofen beyond the village of Burgberg on the south-west. As in proceeding upon this ascending section the strata towards the south-west are found to mantle round and overlap the chief nucleus, it follows that lines drawn either to the south or west of the sectional line will exhibit similar successions. Thus, on the south-eastern face of the Grünten, vertical walls of jagged limestone, which diminish in height from the summits of the mountain to the valley of the Starzlach, expose precisely the same ascending order of strata as that which is seen in the masses that fold over at less high angles towards Burgberg and Sonthofen.

A glance at this diagram, fig. 17, will sufficiently explain the case.

Fig. 17.

Right bank of the Iller.



Eocene. { *m.* Molasse and nagelflue.
g. Flysch.
f. Nummulitic limestone alternating with flysch.
e. Transition band with Gryphæa.

Cretaceous. { *d.* Inoceramus limestone or chalk.
c. Green sandstone and gault.
*c**. White quartzose sandstone.
b. Upper neocomian limestone (*Caprotina ammonia*).
a. Lower neocomian limestone.

The lowest visible rocks, as seen in the escarpments on the north and north-east faces of the Grünten (*a* of fig. 17), are shaly, dark grey, thin-bedded compact limestone, with a little iron and nodules of black flint, alternating repeatedly with dark shale. Some of the beds contain so much chlorite, that, like rocks in two other zones higher in the series, they become grass-green when bruised by the hammer, though previously they are simply dull grey calcareous grits or impure limestones with schists. With the exception of an ammonite, M. Brunner† and myself found no fossils in this rock. There can, however, be no doubt that it is the lower neocomian of Swiss geologists, which lithologically it resembles, and like which it graduates up into, and is at once overlaid by, the true upper neocomian, white limestone. The latter rock (*b*), which, as has been stated, forms so clear a horizon throughout large regions of the external calcareous chain of the Alps, is here, as elsewhere, a thick-bedded, compact, light grey limestone, weathering white in the cliffs; the surface being distinguished by innumerable white lines, occasionally defining the segments of the shell of the *Caprotina ammonia* and other fossils. Usually, indeed, these fossil outlines are the hardest portions of the rock, and stand out in the form of chert. Veins of white calc spar also traverse the strata. This white limestone or upper neocomian constitutes the highest point of the double-peaked Grünten, a narrow broken wall of limestone trending from north-east to south-west, the beds of which dip rapidly to the south-west. The consequence is, that in following the top of the crest from these limestone summits to another point called the Hohe Wand, where a cross is erected, and thence down to the highest houses in an upland gorge, called the Gundalpe Hütte, you pass successively from the neocomian above described to other overlying formations. The rock (*c*) immediately resting upon the upper neocomian limestone is a lightish grey, brownish, and even a whitish siliceous or quartzose sandstone. Finding this rock in other sections on the sides of this mountain, as well as upon the summit, and always in this position, viz. overlying the limestone recognised as the upper neocomian of the Alps; and,

† This name has been misprinted Br*ü*nner in the preceding pages.

further, seeing that in all situations it is capped by a zone of dark green, schistose sandstone which contains fossils of the gault or upper greensand, I was induced to think that it might represent the upper portion of our English lower greensand, some parts of which it resembles. It may also be compared with the "Quader Sandstein" of Saxony, except that it is more brittle and quartzose. Whatever the sandstone rock (*c*) may represent (for we found no fossils or casts in it), there could be no doubt as to the next zone, or the dark shale and deep green sandstone (*c**) that succeed, and which, though of no great dimensions (probably nowhere exceeding 50 feet), is the same excellent fossil horizon as in Savoy and Switzerland. In short, it is the band so often spoken of as representing the gault and upper greensand. In it we found ammonites of two or three species, including *A. Mantelli* (Sow.), Turrilites, and the small *Inoceramus concentricus* (Sow.).

Some of these fossils also occur in a lateral spur of the Grünten, towards the village of Wangeritz, and others on the external face of the great dome-shaped mass which, in the ravines to the east of Burgberg, exhibit this dark green sandstone passing up into a thin band of hard, compact, cream-coloured limestone impregnated with chlorite; in short a hard "craie chloritée." The green sandstone is extensively quarried on one of the shoulders of the Grünten to the north side of the great depression called the Vust †, between the mountain and the nummulite ledges (*f*) that run down to Burgberg, and when worked out is really a very striking band. It is a mottled rock, and frequently owes this appearance to branching flattened stems, which may be Alcyonia.

The inoceramus limestone (*d*), with its chloritic base, above alluded to, forms a wrapper of great thickness over the green sandstone or gault, and constitutes the external coat of the mountain on its western and south-western faces. It is largely and clearly exposed in the breaks on the sides of the upland depression of the Gundalpe Hütte, above the Vust ravine, from whence it rises up to the summit called the Hohe Wand, the cross of which stands on it, and very near its junction with the inferior zone of green sandstone. In parts it is of the colour of the sewer-kalk, *i. e.* a light grey or green colour; but above the Gundalpen, or between these châlets and the Hohe Wand, it graduates into limestone as red as the scaglia of Italy, or of the Mythen mountain near Schwyz. Throughout its matrix are numerous fragments, occasionally almost entire shells, of large thick-shelled inocerami. This rock of the Grünten, so clearly in the posi-

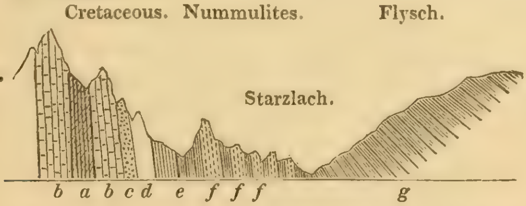
† Many of the fossils, so called, of Sonthofen, collected by the Bergmeister and other persons, have been found in the beds of this broad torrent called the Vust. Now, as the waters which flow into it traverse all the strata in the cretaceous succession, and these flank the nummulitic beds, geologists will readily understand how Prof. Sedgwick and myself were formerly led to believe, by the inspection of such collections, that nummulites occurred in the same beds with ammonites and belemnites and small inocerami, the *green sandstones above and below the equivalent of the chalk often closely resembling each other.* I have now satisfied myself that here, as elsewhere throughout the Alps, nummulites are unknown below the surface of the inoceramus limestone.

tion of the chalk of North Europe and of the scaglia of North Italy, is of very considerable thickness, certainly several hundred feet.

The largest superficies in which the inoceramus limestone is exposed, is around the dome-shaped masses, the external faces of which dip rapidly down into the great ravines north-east and east of Burgberg. In the latter we perceived it to be overspread by a thin course of dark greyish, fatty marl, in which we detected one inoceramus. This band is immediately surmounted by marly and incoherent, slightly micaceous, thin-bedded sandy shale, which here has been largely denuded, and above Burgberg is exposed in a transverse depression between the Grünten mountain on the one hand and the lower nummulitic ridges on the other.

This hollow space (the Vust) between the external face of every stratum to which the terms 'chalk' or 'cretaceous' can rigorously be applied, and the lowest band of nummulitic limestone, is occupied in its lower portion by the small micaceous shale and schist before mentioned, which is succeeded by a greenish sandstone associated with impure greyish limestone and dark grey shale. These beds, particularly the sandy impure limestone, contain the same *Gryphæa vesicularis* which has been remarked as lying between the inoceramus limestone and the nummulitic rocks of the Fähnern in Appenzell. Here, however, this intermediate band of green sandstone, schist and limestone (*e* of the diagram) is vastly more expanded. If the section be made in the regular ascending order of the mountain (fig. 17), as followed from its main escarpment, over its summits, down the Gundalpe, and across the Vust to the nummulitic ridges east of Burgberg, this intermediate group (*e*) is seen to be perfectly conformable to the inoceramus limestone beneath it, and to the lowest nummulitic rock above it. Equally is it conformable if another section at right angles to the above be made from the Grünten to the valley of the Starzlach, a little to the south of the chief mines, and where a rivulet descends from the mountain (see fig. 18). In

Fig. 18.



this section the beds are more nearly vertical, and necessarily occupy very small horizontal spaces. The same order being followed from centre to flank, *i. e.* from the neocomian through the greensand and cretaceous strata, the explorer does not fail to observe a great thickness of bluish grey, slightly micaceous marls, and marlstone associated with a sort of greensand, and beds of impure grey limestone with white veins (*e*), in which we again detected the same Gryphæa as in similar strata in a like position in the other section near Burgberg, p. 205.

The Gryphæa to which I have now so much alluded, is considered by Mr. Morris, M. D'Archiac, and all the conchologists who have examined and compared it since my return to England, to be the *G. vesicularis*, a fossil of the upper chalk of England, and which in the south of France is common to the white chalk and the lowest nummulitic zone. It was either this species or its representative Gryphite, which Professor Sedgwick and myself collected at Matsee, north of Salzburg in Austria, where it occurs in strata similar to those of the Grünten and Fähnern mountains, and where it is equally surmounted by nummulitic limestones with large Echini and Pectens*. If then we are guided by fossils, we ought to group this band or intermediate bed (*e*) with the cretaceous system, although its beds have already assumed to a great extent the lithological characters of the overlying nummulitic greensands and flysch into which they make an imperceptible transition. In the Fähnern mountain, indeed, the same Gryphæa continues to pervade the ascending strata until it is associated with nummulites; whilst in the Vicentine, another species of Gryphæa approaching to the *G. columba*, mounts, as is well known, into strata in which not only nummulites, but many true eocene shells occur. These Gryphites (perhaps two or more species) characterize, therefore, the zone of transition between the secondary and tertiary rocks of the Northern Alps.

Nummulite Rocks and "Flysch."—After a clear exhibition on the sides of the torrents of several courses of the above-mentioned strata with Gryphites, some of which lithologically resemble the flysch above the nummulites, these beds (*e*, fig. 18), dipping 60° to 70° south-east, are seen to graduate conformably into another and somewhat thicker band of limestone of deep ferruginous colour, which is loaded with myriads of nummulites, grains of chlorite being abundantly disseminated in it (*f*). This is the lowest of the several well-known zones of nummulitic iron ore of Sonthofen, and it is charged with the large *Nummulina millecaput* and *N. planospira*, the smaller *N. globosa*, the large Echini with Crustacea (*Cancer Sonthofensis*), Pectens, some Terebratulæ, the *Trochus giganteus*, etc†. On a former occasion it was stated generally, that bands of nummulitic limestone succeeded each other on the banks of the Starzlach, and I would now simply observe, that the overlying schists, impure limestone, and sandstones of the mountain (*g*) are referable to the flysch, or are simply the continuation of one and the same series of strata, however slightly they may be fossiliferous in their upper parts.

* See Trans. Geol. Soc. Lond., New Series, vol. iii. p. 349. The Gryphæa of Matsee is named *G. expansa* by Mr. J. Sowerby. Unluckily the true equivalents of the chalk or limestone with Inocerami are not visible near Matsee. It is now however my belief (though I have not re-examined the country) that all the extensive mass of flysch or Vienna sandstone lying between Matsee, Mondsee, and the walls of secondary limestone on the south, is of lower tertiary age.

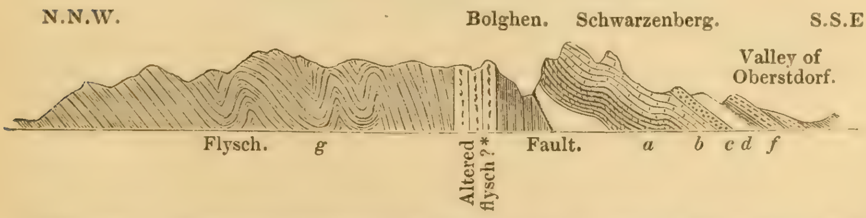
† Trans. Geol. Soc., New Series, vol. iii. p. 332. The genera are Pecten, Terebratula, Spondylus, Plicatula, Astarte, Anomia, Isocardia, with large Serpulæ, the well-known large Echini, and the *Cancer Sonthofensis*. It is in fact the same group, most of the species being undescribed, as that which occurs all through the Swiss Alps.

Returning to the chief section (fig. 17), I specially call attention to the ascending succession, as seen to the south-east of Burgberg, above the intermediate gryphite zone (*e*). As on the east flank of the Grünten (fig. 18), so here we see schist and thin bands of dark flysch with white veins, intercalated between the greensand and impure limestone with the Gryphæa and the lower zone of nummulites. The mineralogical transition is here equally perfect, nummulites are also abundant, together with Pectens, Spondyli, and other fossils of the zone, the beds being also ferriferous, but offering some local peculiarities, such as small cavities in the green sandy calciferous grits. This band (*f*) is overlaid by glossy light grey and dark schists, that have been worn into a small depression, which is followed by a second ridge of nummulitic rock. The mass of this is a greenish, yellowish sandstone, or sandy calc grit, which graduates into a hard siliceous limestone containing large Echini, Pectens, Terebratulæ, as well as Nummulites, and is very peculiar from the small flakes of chlorite which occupy the structural divisions of some of the foraminifera. Shale and thin stone bands recur in another slight depression, followed by another course of nummulitic limestone of grey colour, but also containing iron, whereon an ancient castle stands; then another depression in shale, &c.; and lastly a great band of nummulitic limestone of about 150 feet in thickness, which, being thin-bedded, sandy, and subconcretionary in its lower parts, passes up into very thick beds of hard grey limestone charged with *Nummulina millecaput*, Orbitolites, &c. This limestone, when followed to the Starzlach, plunges under other courses of schist and sandy shale, forming part of the great overlying masses that occupy both banks of the river Iller, between Sonthofen and Ober Maiselstein, but which are denuded in the plain of Sonthofen.

I may complete this ascending section of the formations in the valley of the Iller by stating, that although a consecutive ascending order is observable in the hills to the east, the same order cannot be followed without breaks, curvatures and reversals in the chief depression or on its western side. It is manifest, however, that all the sandstones, schists and bastard limestones, which constitute the flysch on both sides of the valley between Sonthofen on the north and the Schwarzenberg, are parts of that great group the lower portion of which inosculates with the nummulitic limestones. (See fig. 19.)

Fig. 19.

Left bank of the Iller, above Sonthofen.



* The small *Nummulina placentula* (Desh.), *N. intermedia* (D'Arch.), in this band, is, I believe, the same species known in the nummulitic limestones of

This upper and much larger division of the supracretaceous formation, which so rarely exhibits fossils, is chiefly characterized by its fucoids, viz. *Fucoides Targioni* and *F. intricatus*. A little to the north of the turnpike and bridge over the Iller, west of Sonthofen, this "flysch" is in the condition of a light-coloured, greenish grey, micaceous sandstone with black grains, in beds from two to four feet thick, and undistinguishable from strata which I shall hereafter dwell upon as the "macigno" of the Italians; one bed of it, an excellent building-stone, being twelve feet thick, and much resembling the "pietra forte" of the Florentines. Intercalated with some of this "macigno alpin," I detected a thin course of nummulitic limestone, the uppermost limit of the nummulites in this region; for in the still higher masses of "flysch," extending by the Bolghen to the foot of the Schwarzenberg near Ober Maiselstein, no traces of other fossils, except fucoids, have been seen.

It is unnecessary to say more on the mineral characters of the overlying group of sandstones, limestones, calcareous grits, argillaceous schist, and calcareous shale and flagstone, which compose the flysch; and after all the details given, I need scarcely remind my readers, that everywhere in the Swiss and Bavarian Alps, where the order has been preserved, this group passes downwards into, and inosculates with, the nummulite limestones above the inoceramus limestone or chalk. When combined with the nummulitic strata (from which I hold them to be inseparable) they constitute therefore one of the grandest formations of the Alps, often rivaling in thickness the whole jurassic limestones, and being of as great thickness as the cretaceous rocks on which they rest.

Altered Rocks of the Bolghen.

Before I take leave of the valley of Sonthofen, I must explain my present views respecting the phænomena in the Bolghen mountain near Ober Maiselstein, where large masses of crystalline rock (having the character of mica schist, gneiss? &c.) were described* as penetrating the green sandstone, fucoid shales and millstone grits of the flysch series. Judging chiefly from Scottish analogies, I formerly thought that these crystalline rocks, which I then believed to be of primary age, had been partially protruded in wedge-shaped and conical masses through overlying sandstones and schists; and I deemed this view the more probable, as on both sides of the valley of the Iller in this part of the district, the strata are not only much convulsed and set on edge, but are partially penetrated by eruptive rocks, and on the east side of the valley contain many mineral veins. That opinion has been controverted by M. Studer, who believes that those masses of crystalline rock in the Bolghen are in truth transported *boulders*, which were included in the

Mosciano near Florence. Besides the prevalent species of nummulites, viz. *N. planospira*, *N. millecaput*, *N. Biaritzana*, &c., Professor Brunner thought he discovered a new species, which he proposed to name *N. Murchisoni*.

* See Trans. Geol. Soc. Lond. vol. iii. p. 334.

"flysch" during the period of its formation. As he mainly supports that view by the example of certain granitic blocks of the valley of Habkheren near Interlacken, and as the interstratification of such boulders or blocks in strata of that age must be very novel to English geologists, I crave permission to digress from the chief objects of this memoir, in order to discuss a point, which, according to M. Studer, is closely related to the structure of the "flysch."

In the valley of Habkheren, on the north bank of the lake of Thun (as in many interior valleys of the calcareous chains of the Swiss Alps), the flysch is squeezed up in a narrow trough with broken and highly inclined strata, portions of which are exhibited on the right-hand side of the hill road which ascends from Interlacken to Habkheren. That these beds belong to the true supracretaceous flysch is undoubted, because in rising up they overlap the nummulitic limestone at the head of the valley, which rock in its turn surmounts the neocomian limestones of the adjacent chain. These "flysch" rocks, in parts pebbly and gritty, in parts schistose, together with the usual shale and thin-bedded, dark, impure white-veined limestones of this series, are there seen to contain truly intercalated geodes and bands of a granitoid character, which re-occur at intervals in a distance of about 150 paces, much in the manner represented in the diagram (fig. 20), the granitic geodes often imitating

Fig. 20.

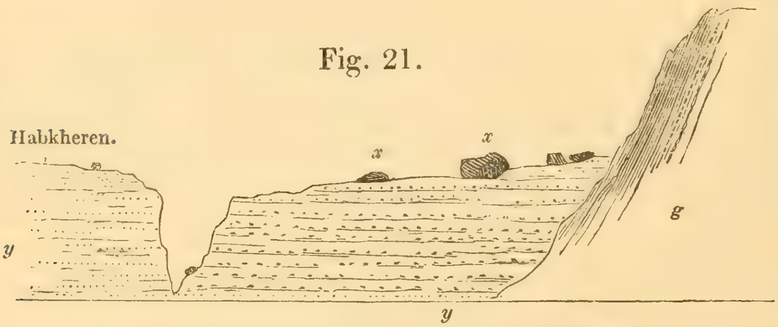
1. Greenish crystalline granitic course.
2. Alternations of schist and impure limestone or "flysch."
3. Granitic geodes.
4. Schist and limestone, &c.
5. Quartzose granitic band.
6. Black schists with calcareous concretions.
7. Schists with granitic concretions.
8. Schists and limestones overlaid by granitoid conglomerates, &c.

in form the calcareous nodules! My attention was first directed to this section by Professor Studer, in company with whom and M. Merian and M. Favre, I visited it. It appeared to me, that the granitoid-like concretions are there intercalated with calcareous nodules, as well as that the thin granitic courses alternate with the schists and impure limestones. The largest of the concretions visible in the course (3) is an oblate spheroid about four feet long by three feet wide; the external zone being more schistose, the interior passing from a paste with large crystals of felspar to a more compact nucleus, one extremity of which seemed almost as if made up of small granite pebbles. The band (5), on the other hand, appeared to be an uniform greenish-coloured granite or granitic gneiss.

I confess that I could not account for such appearances, except by supposing that the granitic matter was evolved contemporaneously with the formation of the sedimentary sandstones and schists which envelope it; the concretionary forms of some of these masses seeming to favour the hypothesis. But whether produced in the same manner as the so-called volcanic or plutonic grits of other regions, by contemporaneous segregation of the igneously-formed particles in the bottom of a turbid sea, or by subsequent partial alteration of the strata through the action of heat and gases, or by transport from other rocks, it is clear that these small developments of granitic matter are contemporaneous with the flysch.

Now, it happens that in the same valley of Habkheren several large granitic blocks also exist, which lying upon the surface of the ancient alluvium, or having been washed into water-courses, have at a distance all the aspect of the usual Alpine erratic blocks, about the transport of which there has been so much discussion*. The largest of these lies on the surface of a boggy meadow, under which is a great thickness of the coarse ancient alluvia on the east side of the rivulet of Habkheren, as explained in the woodcut (fig. 21). This

Fig. 21.



x. Erratic blocks. *g*. Eocene flysch.
y. Ancient alluvium.

block, so superposed to the ancient alluvia, is about 105 feet long by 90 feet broad and 45 feet high (above the marshy meadow), and has therefore a mass of not less than 400,000 cubic feet. As it consists of a peculiar granite†, now unknown to mineralogists in any part of the Alps, Professor Studer believes that, like the very small geodes and courses alluded to, this block was also included in the formation of the flysch, and that during the disintegration of that rock on the vertical sides of the valley, it has rolled down into its present position.

Extending this view, M. Studer accounts in a similar manner for what he calls the blocks of the Bolghen, *i. e.* that they were derived from pre-existing rocks, and were originally encased in the flysch during its formation. After examining both spots, I cannot adopt this opinion, nor can I regard the great block of Habkheren in any

* In this memoir I shall not enter upon the question of the Alpine erratics, it being my intention, at a future day, to give my opinions concerning their transport and their relation to former glaciers.

† According to Studer, this granite is composed of bluish-white and pink felspar, the latter possibly albite, with white quartz, occasionally weathering yellowish, and dark bronze-coloured mica in small crystals.

other light than that of a huge superficial erratic derived from some parent rock, which has either since been lost by subsidence and buried beneath other deposits, or is hidden from sight under those coverings of snow and ice, which necessarily impede observation over so very large an area of the higher Alps. I fully admit that the small bands of granitic rock above adverted to, are fairly intercalated in the flysch, but the presence of geodes, the largest of which is not above four feet long and a foot wide, can never satisfy me that a monstrous block, containing 400,000 cubic feet, was similarly formed; that block not having the slightest appearance of having ever been a geode. Again, no conglomerates known in any part of the flysch of the Alps exhibit pebbles of more than a foot or two in diameter. But, supposing this block to have been part of a conglomerate, and that it was transported from a ridge of crystalline rock into the flysch during the formation of that deposit, by what agency must we suppose it to have been moved? Certainly not either by solid or floating ice; for the period of the nummulites and flysch was anything but one of glacier action, and was in fact one of considerable warmth.

Seeing then no satisfactory explanation of the deposit of a block of this magnitude in finely laminated sandstone and schist (such as constitutes the flysch of the sides of the valley of Habkheren) (*g* of fig. 21), I necessarily reject the application of such reasoning to the Bolghen. On re-examining that locality (see fig. 19, p. 209) I perceived that the rocks which I had described as millstone grits, greensands and schists, have each of them a persistent strike. Thus, quartz grits, passing into highly indurated schists, the former assuming the vitrified aspect of certain quartz rocks, trend from the slopes above Ober Maiselstein to the summits of the Bolghen on the west. They are, in fact, either vertical or dip 70° to 80° north and south. Now, associated with these, and having indeed quartz rocks on both sides of it, the chief boss of mica schist rock protrudes itself. From the conical form of the chief mass, I suggested that it might have been upheaved amidst these sediments, and have tilted them to the right and left. On recently making a transverse section from the summit on the N.N.W. to the gorge of the Schinbergerach on the S.S.E., I perceived, however, that in parts, the black schists of the flysch passed into a sort of Lydian stone, and that perfectly parallel to the higher zone there were other less elevated peaky ridges of altered millstone grit and sandstone, partially in a state of quartz-rock, with here and there a sort of mica schist. These quartz rocks are sometimes indeed in an amorphous state, and often appear like so many dykes of fused or semi-fused matter running through bands of highly altered flysch limestone. With such appearances therefore on all sides, I could not resist the impression, that the so-called gneiss and mica schist, which I had supposed to be upheaved points of older crystalline rocks, are nothing more than certain courses of the "flysch" which have undergone greater change than the others. Besides, the phænomenon occurs in a highly mineralized zone of the chain; and when I add*, that it is immediately to the north of a grand line of fault, by which the whole system of the flysch and nummulite rocks is brought in its southern flank against the neocomian limestone (see fig. 19) (in precisely the same unconformable relations as at Dörnbirn and Haslach, south of Bregenz), there may be less difficulty in adopting this solution. At all events, the conversion of flysch into gneiss and mica schist is, as before stated, a phænomenon in the Grisons insisted on by M. Studer himself, and a partial exhibition of such metamorphism in the Bolghen may therefore reasonably be admitted.

Prolongation of the Cretaceous and Nummulitic zones of Switzerland and Bavaria into the Austrian Alps.

Taking the strata of Appenzell and those of the Grünten and Sonthofen as types, the practised geologist will have little difficulty in adapting to them the descriptions of the sections of the Alp Spitz near Nesselwang, the banks of the Traun, Kressenberg, Untersberg, Mattsee† and Pancratz, as given by Prof. Sedgwick and myself. Thus, at the Alp Spitz, near Nesselwang, to the east of the Grünten and on the edge of the Bavarian Alps, there is clearly a cretaceous succession, the extent and details of which must be hereafter worked out. But in the meantime, and in reference to our former section, it appears clear that the northern flank of that mountain presents an escarpment in which strata, with fossils of the greensand and gault (if not neocomian), are brought into contact with the same tertiary conglomerates as at the Grünten (molasse and nagelflue)‡. To the south, or towards the Alps, the younger strata of "flysch," &c., are thrown off from these greensands and cretaceous rocks, the most southern of which is evidently a representative of the chalk.

In the section of the Traunstein there is pretty much the same expansion of a system of sandstone and shale and impure limestone with several courses of nummulites, &c.§, as that which has

* M. Boué has described the crystalline mining tract east of the valley of the Iller, which is in truth a prolongation of these masses.

† The fossils which I formerly collected at Mattsee having been examined by M. D'Archiac, are pronounced by him to be *Nummulites Biaritzana* (D'Arch.) (*N. atacica*, Leym.), so common in the Lower Pyrenees, the Corbières, and the Lower French Alps; *N. rotularis*? Desh. (*N. globulus*, Leym.), of the Corbières and the Crimæa; *Orbitolites submedia* (D'Arch.) of Biaritz and the Lower Alps; Operculina, n. s.; Echinolampas, probably the *E. ellipsoidalis* (D'Arch.) of Biaritz; and among the Pectens one species closely resembles the *P. tripartitus* (Desh.) so well known in the tertiary rocks of France. Identifying these beds with those of Kressenberg (see the Bulletin of the Vienna Society, 1848, vol. iv. pp. 267, 269, and Leonhard's Jahrbuch, 1849, p. 109), M. Erhlich has cited from them the *Nautilus lingulatus*, *Clypeaster* (*Conoclypus*) *conoideus*, *C. Bouei*, and the *Micraster pulvinatus* (D'Arch.). As I formerly found such Echinoderms at Mattsee, though at that time they were without names, there can be no sort of doubt of the age of the rock; the Gryphæa of the lowest beds being the only secondary form.

‡ Trans. Geol. Soc. Lond. vol. iii. p. 337. plate 36. fig. 5. The section is so drawn that the tertiary conglomerates appear to be conformable to the cretaceous masses. This is an error.

§ Geol. Trans. vol. iii. p. 338–9, pl. 36. fig. 6.

been described elsewhere, and particularly at Sonthofen. In referring my readers to page 338 of the third volume of the Transactions of the Geological Society, I have only to request them to consider the great group of the flysch, nos. 2, 3 and 4 (Miesenbach to Loheim), as overlying the nummulitic strata nos. 5, 6 and 7, and the whole falls into order with Sonthofen and the Swiss types. To make that instructive section entirely coincide with my present views, I ought to add, that between the northern end of the nummulitic grits and the setting on of the tertiary molasse, the grand fault so often alluded to occurs, and is represented by piles of detritus. The truth is, that the great external fault of the Alps here, as in all the other places cited, inverting the flysch and throwing it off to the south, brings up, against strata of pliocene age, the very oldest or bottom beds of the eocene deposit.

This great fault has, however, been moderate in its operation in Austria and on the south slopes of the valley of the Danube, when compared with the gigantic dislocations that accompany it in Bavaria (Grünten), and in Switzerland (Hoher Sentis and Pilatus, &c.), where even the neocomian limestone, or the equivalent of the very bottom of our lower greensand, is thrust up into lofty escarpments, on the upper surfaces of which the overlying cretaceous and nummulitic groups are pitched in towards the Alps, whilst that neocomian or the oldest formation of the whole succession is at once in contact with younger tertiary nagelflue! Thus, whether we appeal to the Austrian, Bavarian or Swiss sections, we perceive (now that we have a true acquaintance with fixed *fossiliferous* base-lines), that there is an ascending order from the point of junction with the younger tertiary, or in other words, that in the valley of the Danube, as in the great valley of Switzerland, or on the shores of the lake of Constance, the underlying members of the series on which in other places the nummulitic group rests, rise up at the very outside of everything alpine, and often throw off the younger portion of the eocene formations into the abnormal position of dipping under the great secondary limestones of the chain.

In regard to the cretaceous group of Gosau, it has been already remarked that it is deficient, both in not possessing any solid limestone with fossils to represent, as in Switzerland and Bavaria, the true equivalent of the white chalk, and also in being void of a distinct nummulitic zone. I have, however, now little doubt, that the sandstone, impure limestone and shale, which there overlie the marls, recognised by their fossils to be cretaceous, are representatives in time of a portion of the nummulitic and flysch series of other parts. In fact, it may be said of Gosau, that the lithological type of the "flysch" there descends not only to the horizon of the inoceramus limestone, to the total exclusion of any limestone to represent the chalk, but also takes possession of nearly all the series of beds which further represent the upper greensand and gault; the first bands of hard and coherent rock being the subcrystalline hippurite limestone, which, like that of the Untersberg, near Salzburg, represents the neocomian formation.

At the Untersberg, the equivalents of the gault, upper greensand and chalk, which repose upon neocomian limestone or hippurite marble, are marls and marlstones, often not unlike malm-rock, and variegated green and red bands, some of them approaching to scaglia, in which Professor Sedgwick and myself found Belemnites and Baculites with *Inoceramus Cripsii* (Sow.) and *Trochus linearis*. Next come sandstone and calcareous grit, with many small nummulites, followed by other strata of sandstone and blue marl, in which other nummulites, with Operculinæ, Dentalia and Serpulæ, are associated with shells having a tertiary aspect. Two or three species indeed of these fossils, such as *Auricula simulata* (Sow.) and *Dentalium grande* (Desh.), have been considered identical with species of the London and Paris basin.

In following the cretaceous rocks from Bavaria into Austria, their upper member or the equivalent of the chalk is no longer to be seen in the form of the white limestone, which is so clear a horizon in Savoy, Switzerland and Western Bavaria. Even at the sections of the Untersberg between Reichenhall and Salzburg, the band containing the chalk fossils is, as above stated, made up of grey, green and red marls and marlstone. In the valley of Gosau, still further to the east, the lithological change is still more decisive; for not only is there no trace of a white limestone, but the group so loaded with fossils, many of which are unquestioned cretaceous species, with many peculiar tertiary-like forms, consists of soft shale and sandy marl, with impure dark-coloured limestones. Reverting however to the sections of the strata above the cretaceous rocks of the Untersberg*, I may affirm, that they exhibit the same general ascending order as at the Grünten, near Sonthofen, and other places, *i. e.* from a true cretaceous zone, (the equivalent of the chalk being in a very different mineral state,) through certain strata of marl and sandstone into masses with nummulites and shells, all of which are unknown in the strata below. On the other hand, it is evident that beds having the characters of the "flysch," are not merely the expanded overlying member of the nummulitic group, but often inosculate with bands of nummulites, and even descend as at Gosau into strata with the true cretaceous fossils. Again, we readily see, that notwithstanding a local dislocation, the highly fossiliferous nummulitic strata of Kressenberg are but a full development of one of these upper bands of limestone, of which I have mentioned many examples.

Not having personally revisited Kressenberg, I can only suggest that the intermixture of a few cretaceous fossils with the acknowledged tertiary types of that locality may be explained† by their having been obtained from the Bergmeister (as at Sonthofen, see p. 206), who may

* The reader must be told, that the true cretaceous rocks with fossils of the age of the gault and chalk, are with great difficulty detected in the slopes between the Untersberg and Reichenhall, owing to the quantity of verdure and detritus which obscure the slopes; but although to a great extent hidden and of no great thickness, they certainly exist in the ravines mentioned by Professor Sedgwick and myself. See Geol. Trans., New Series, vol. iii. p. 346.

† See Trans. Geol. Soc. Lond. vol. iii. p. 344, note.

have collected some of the forms in a truly cretaceous rock. My friend M. de Verneuil, who visited Kressenberg in 1847, has informed me that all the fossils associated with the nummulites are of supracretaceous forms. He has satisfied himself that the matrix of the two sets of fossils is quite distinct, the one containing the gault or greensand fossils being an earthy chloritic sandstone, the other a highly quartzose and ferruginous rock. It is in the latter only, which is surmounted by the flysch, that nummulites occur, including *N. lævigata*, Lamk., and *N. elegans*, Sow., of our London clay, associated with *Orbitoidea*, D'Orb.; *Pygorhynchus Cuvieri*, so abundant in the calcaire grossier of Paris; *Conoclypus conoideus*, which, with other species of that genus, is so frequent in the Alps; and also the *Echinolampas politus*, Ag., common to the Vicentine and south of France.

In a word, there can be no sort of doubt in the mind of any geologist, who has examined the two localities, that the nummulite rocks of Sonthofen are exact equivalents of those of Kressenberg. The flysch at the latter, as at Sonthofen, is thrown in towards the chain, and differs only from that of Sonthofen in the occurrence of a line of fault between it and the beds containing nummulites.

Deferring for the present the general consideration of the fossils of the nummulitic rocks, I may remind the reader that they do not contain any one of the prominently characteristic types of the chalk, such as Ammonites, Belemnites, Hamites, Inocerami, &c. Hence I think that all geologists who classify strata by their animal contents combined with their order of superposition, must admit that the nummulite and flysch rocks of the Alps, Savoy, Switzerland, Bavaria and Austria belong to the older tertiary or eocene age, and can no longer be classed with the cretaceous rocks. The only question, it seems to me, which can be mooted is, where the precise line between secondary and tertiary should be drawn;—for example, whether, as I think, immediately at the base of the lowest band of nummulites, or still lower beneath the flysch-like and greensand beds (*e*) with one or two species of Gryphæa, of which so much has been said. On this point it is sufficient to say, that wherever a true lithological passage and conformable transition occur, the settlement of such line of demarcation must always be somewhat arbitrary.

The opinions of the eminent geologists who have classified the nummulitic and flysch deposits in the secondary rocks, being based upon physical features, I must necessarily defer considering them, until the whole subject of the relations and fractures of this zone be reviewed.

Supracretaceous or Older Tertiary Rocks of the Southern Alps and Vicentine.

The greater part of a century has elapsed since Arduini* expressed his belief, that the deposits of Ronca and Bolca, &c. were of tertiary age, and that Fortis remarked how certain species of fossils from the

* See Arduini's Letters.

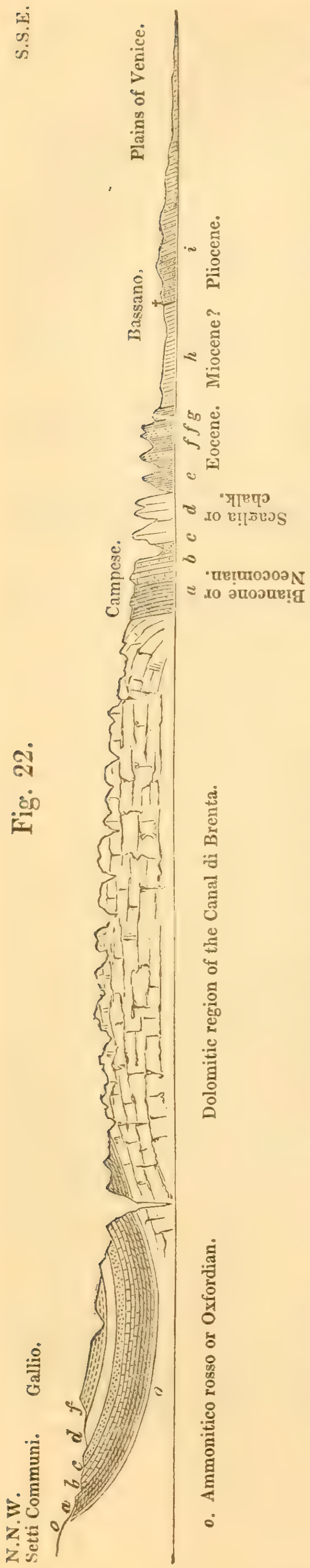


Fig. 22.

Val d'Astico resembled forms published by Brander from the London clay of Hampshire. M. Brongniart*, however, first systematically classified these strata as older tertiary, and described their organic remains, whilst our associate Dr. Buckland arrived, about the same time, at a like conclusion in his general survey of the Alps†. But although there could be little doubt, from the absence of cretaceous fossils, and the presence of a multitude of genera having a tertiary facies, that these shelly masses were younger than the chalk, the great desideratum still remained of natural exhibitions of the true relations of these strata to the inferior or secondary rocks. These were the more called for, as some leading geologists considered all the nummulite deposits of the Vicentine to be of cretaceous age. In our rapid survey of parts of the Vicentine in 1828, Sir C. Lyell and myself, having visited the principal localities described by Brongniart as "calcareo-trappéens," found these shelly deposits so commingled with and interrupted by basaltic and other eruptive rocks, that we were unable, any more than our precursor, to detect an order of succession. It was after my colleague had proceeded on his journey to the south of Italy and Sicily, that in returning to England across the Venetian Alps, I obtained the desired proofs of that order, in the clear and instructive natural sections on the banks of the Brenta near Bassano, and again between Possagno and Asolo. I there saw the same nummulitic and shelly beds as those of the adjacent Vicentine, entirely free from igneous intrusions, reposing conformably on the scaglia or the Italian equivalent of the chalk, and passing upwards into strata of younger tertiary age, the whole upraised in lines parallel to the direction of the Alpine chain.

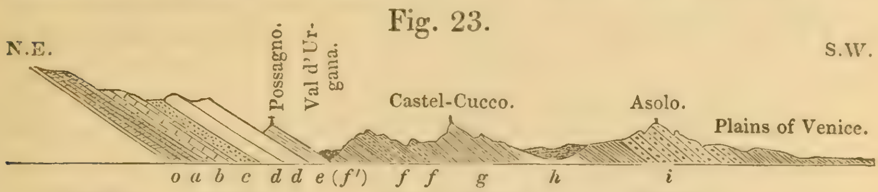
The figures of the remarkable sections near Bassano were published in the 'Philosophical Magazine,' but as that work is in

* Mémoire sur les Terrains de Sédiment supérieurs calcareo-trappéens du Vicentin, par Alexandre Brongniart, Paris, 1823.

† See Annals of Philosophy, June 1821.

the hands of few continental readers, I now reproduce them, with some additions, as woodcuts*, (figs. 22, 23). When these sections near

Fig. 23.



Bassano were described, the new nomenclature of Sir C. Lyell had not been announced, and the groups of shells which there overlie the chalk were simply termed lower and upper tertiary. These two classes of tertiary rocks were shown by me to have been upheaved in parallel lines, and also partially to expose a transition from one to the other. And now that I have revisited the localities, and have examined a much wider range of the Alps, I see more than ever the value of these sections; for as the nummulitic zone is there conformably placed between what I am certain is the true equivalent of the chalk, and a superior zone in which younger tertiary shells occur, the zone so intercalated, and which contains so many true older tertiary forms, must be the representative of the eocene. Nay more, the highly inclined position of the outer or younger tertiary zone would, as I formerly stated, seem to indicate that one of the last great upheavals of the Alps (*redressement*) took place after the accumulation of the sub-Apennine formation. I do not by any means wish to imply that the same elevation which raised the chalk and eocene deposits also raised the younger tertiary deposits. On the contrary, I believe that the latter were thrown up subsequently, but in the same direction as the adjacent older deposits†.

It has already been stated, that a thick mass of compact cream-coloured limestone, with flints and ammonites, called "biancone," now proved by its fossils to be of neocomian age (*a*), reposes on jurassic rocks (*o*), and is surmounted by the whole mass of the scaglia. This scaglia (*d*), containing in parts Inocerami, Terebratulæ and *Ananchytes ovatus*, and being interposed between the neocomian and the group of nummulite rocks with tertiary fossils (*f*, *g*), is demonstrated, like the "sewer-kalk" of Switzerland, to be the equivalent of the chalk. In the headlands between Recoaro on the north

* My last visit to Bassano, Possagno and Asolo was made with the leading members of the Geological Section of the Venetian Meeting of the "Scienziati Italiani," to which I have before alluded. Those who will be at the trouble of consulting my original sections as published in the Phil. Magazine (vol. v. June 1829, p. 401, pl. 5) and those now produced, will perceive that there is nothing essential in the one which is not in the other. The chief alteration is in respect to the flexure or fracture of the cretaceous rocks near Bassano before they come into contact with the nummulitic zone.

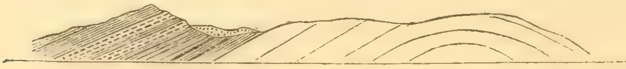
† Although upon the small scale the younger tertiary are drawn conformable to the older in figures 22 and 23, there are parts of the intervening tract between Bassano and Possagno where the intermediate sandstones are broken and reversed. Close research may detect an interval between the older and younger tertiary.

and Vicenza on the south, this scaglia is copiously developed, and may be seen in numerous sections underlying the nummulitic limestones. Near Val d'Agno, to the south of Recoaro, the scaglia with its characteristic fossils is directly overlaid (as expressed in this woodcut) by

Fig. 24.

Relations of Lignite to Scaglia and Nummulite Limestone.

S. N.B. In this figure the north has been accidentally reversed. N.



f. Nummulite limestone. *d.* Scaglia or chalk.
e. Lignite coal shale.

seams of coal worked for use in that neighbourhood, which lie in shales that dip away from the older rock, and pass under the adjacent hills of nummulitic limestone. In fact, these coal-beds occupy the same place as those of Entrevernes in Savoy, of the Diableretz, and of the Beattenberg in the canton of Berne (see p. 189). There are, indeed, other localities in this region where the nummulitic rocks are equally characterized by containing lignites or coal, as at Monte Bolca, and at Monte Viale near Vicenza, where it occurs in the escarpment of the well-known coralline limestone of that insulated mount.

In the tract between Vicenza, Schio and Verona, the various sedimentary deposits are so penetrated by different eruptive rocks, whether porphyries, trachytes, greenstones, basalts or serpentines, and peperino, that the dislocations and interruptions are frequent, and the original order of succession with difficulty observed, particularly around Ronca, Montecchio Maggiore, and other localities noted for their organic remains. To the west of Schio, however, and above

Fig. 25.

f. Nummulite limestone. *d*.* Red scaglia and white.
e. Shelly volcanic grit. *c.* Grey scaglia.

the town of Magra, another instructive section is exposed (fig. 25), the base being composed of the red and white scaglia, in which Inocerami, *Terebratula incurva*, *Ananchytes tuberculatus* and other fossils occur, whilst the summit is occupied by strong bands of nummulitic limestone. The beds being only slightly inclined, a perfect conformity is observable, as well as a transition from one group to the other. There are here no coal-seams, but towards its upper limits the red fissile scaglia (*d**) alternates several times with basaltic trap tuff, some of the highest beds of which above the scaglia are just as much loaded with nummulites as the hard grey nummulite limestone (*f*) which crowns the hill. The manner in which certain bands of these tuffs are thus interlaminated with the nummulitic strata here, and with other shelly strata of this age in the adjacent tracts, induces me to think that they were volcanic dejections formed contemporaneously with the submarine deposits,—a class of strata now too well known to require further illustration†. At the same time I know that this region also abounds in igneous rocks of a truly eruptive character which have penetrated and cut through the whole of the stratified masses. Examples of both these classes of former volcanic or plutonic action are sometimes to be seen in the same hill, as exhibited in the above woodcut. The chief masses or ledges of nummulitic limestone which thus surmount the scaglia, dip on the whole southwards to pass under the marls, tuffs, sands and limestone of the undulating hills of the Vicentine, and thus the nummulitic limestone is fairly seen to constitute the base of that shelly group, even in a tract much traversed by basaltic matter. But in proceeding to the west and south-west of Schio, the igneous rocks so abound, that a regular sequence, I repeat, is not traceable for any considerable distance. To the north of St. Orso near Schio, indeed, the effects of the intrusion of a great mass of porphyry have been such as completely to invert the strata and to fold back the cretaceous rocks and make them overlie first the nummulitic and then the other and younger tertiary rocks‡, as expressed in the diagram (fig. 26). This point will be

Fig. 26.

N.N.W. *Inverted Strata.* S.S.E.

p. Porphyry.

Cretaceous. { *d.* White scaglia. *d**. Red scaglia. *c.* Grey scaglia. *a* & *b.* Neocomian.

g. Sandy limestone (youngest beds).
f. ? Blue marls. *f.* Sand and clay. *e.* Shelly tuff and bone-beds. } Eocene.

reverted to when the dislocations and inversions in the Alps are considered, and I now proceed very briefly to direct attention to the clear and unambiguous sections of Bassano and Asolo (figs. 22 & 23), which have, in fact, proved to be, what I ventured to suggest so many years ago, the best expositions of the true normal succession from the cretaceous to the tertiary rocks which have anywhere been observed on the flanks of the Alps. (See back, pp. 218, 219.)

On the right bank of the Brenta at Campese, a little above Bassano, the neocomian and scaglia, which range in great undulating terraces

† M. Brongniart has described in some detail these rocks, which he has called "calcareo-trappéens." I only differ from my lamented friend in considering some of his "brecciole" as being contemporaneous with the deposits.

‡ In common with all the members of the Geological Section from Venice, I was exceedingly obliged to my able friend, M. Pasini, for the pains he took to make me better acquainted with the interesting tract around Schio, Recoaro, and the Setti Communi, with which he has been so long conversant. The tract which has given birth to Arduini, Brocchi, Fortis, Mazzari Pencati, Maraschini, and Pasini, may well be considered classical in geology. In this region every variety of dislocation is to be seen with much metamorphism of mineral structure; and yet it is here that the best development of the trias is displayed, as well as a copious series of jurassic, cretaceous and tertiary deposits.

over the summits of the Setti Communi within the chain of the Alps (see fig. 22), are brought down by rapid flexures to occupy, as before said, vertical positions on the edge of the lower country *. To the red and white scaglia (*d*) so placed on both banks of the Brenta succeed sandy marls and stone-bands which form the base of the nummulitic group formerly described. Vertical ledges (*f*) of nummulitic limestone follow. This inclination is continued, as far as can be observed, through the whole space occupied by the city of Bassano; for after passing over the edges of a great thickness of marls, impure limestone, sands, &c. (*g*, *h*), few of which are well exposed, the section terminates towards the flat country on the south in the conical hillock of Monte Grado composed of sandstone, calcareous grit and pebbly conglomerate (*i*), the beds of which strike parallel to the rest of the ascending series, and dip 75° to 80° to the south. I have only to add, that the *Ostrea Virginica* and the shells found in the outermost conglomerate are of pliocene age, whilst the nummulitic and lower masses near the scaglia are of the same date as the older tertiary accumulations of Ronca, Castel Gomberto, &c.

The section from the scaglia of Possagno, on the edge of the Alps, to Asolo, at the exterior of the tertiary series of this region (fig. 23), is much more developed in its middle and upper portions, though the junction of the nummulitic strata with the scaglia, so well seen at Bassano, is not exhibited, the strata having been denuded in the Val d'Urgana. I believe that this valley was formerly occupied by the same slightly coherent strata of shale, marl and green sandstone (*e*), which in the Bavarian and Swiss Alps mark this horizon. The lowest tertiary beds visible to the north of Possagno, and quite conformable in strike and inclination to the underlying scaglia, are marls of darkish colour, occasionally ferruginous and sandy, with fungiæ and other polypes, and many of the fossils so well known at Monte Ronca and in the Berici Hills(*f'*). Then follow calcareous grits and nummulitic limestones (*f*) with *Fusus longævus*, which passing up into hard white courses are surmounted by a yellowish subconcretionary impure sandy limestone with blue fossiliferous marls in which pectens first appear. Next come yellow sandy limestone and calcareous grit with green grains, containing pectens and echini. This mass (*g*) is of considerable thickness, and is very similar to some of the calcareous green sandstones of Switzerland, there associated with the nummulite limestones. Overlying this "glauconie grossière" is a small concretionary mottled dark grey and cream-coloured limestone, loaded with foraminifera, in which nummulites sometimes occur. This rock is well exposed at Castel-Cucco, where it has been largely quarried, and the columns of Canova's church of Possagno are built of it. The strata of marl, shale and sand which succeed to the south of Castel-Cucco (*h*) are badly exposed in low undulating grounds with devious dips; but on reaching the outer tertiary ridge of the Asolan Hills, a good, well-defined order is exposed, first, in an escarpment in which blue marls,

* See Bull. Geol. Soc. Fr. tom. iv. p. 56, 7th Nov. 1842, where M. de Zigno confirms my former view of the general relations of the secondary to the tertiary rocks.

very like the subapennine marls of Brocchi, dip under yellow sandstones and pebbly conglomerates like those of Monte Grado near Bassano (*i*). In the marls are the *Venericardia costata*, *Arca Diluvii*, *Pyrula clathrata*, with species of the genera Murex, Natica, &c., which clearly characterize the blue marls of the subapennine strata; whilst the large *Ostrea Virginica* is found in the overlying yellow limestones and conglomerates. Being aware that M. de Zigno, who has already written on the subject, and has sustained my former views, is about to publish a detailed account of all the species in the tertiary fossiliferous strata of the tract between the Brenta and the Piave, I will not attempt to give palæontological details. I will merely now say, that from the order of the strata and from the fossil shells which our party collected, and also from those we inspected in the museum of M. Parolini of Bassano, I still entertain no doubt that the sections afford an ascending series from the surface of the chalk up into deposits of the subapennine age. M. Ewald of Berlin*, an excellent palæontologist, who in common with M. Leopold von Buch, M. de Verneuil and myself, regarded all the lower portion as eocene, thought that the sandy bands and calcareous grits, which there lie above the nummulitic group, might prove to be the equivalents of the miocene.

But it is with the nummulite group that we are now occupied, and I must leave to local observers the future details and exact delimitation of each tertiary subdivision. It is enough for me to prove that the cretaceous system is here distinctly and conformably overlaid by true lower tertiary deposits, and that the facts which I announced so long ago have now been amply verified ; viz. that tertiary rocks, both lower and upper, are in this tract parallel to the secondary rocks, and have been upheaved and set on edge by forces which also affected the adjacent Alps. The lower tertiary group is specially characterized between Bassano and Possagno by containing, in addition to nummulites, *Fusus longævus*, *F. intortus*, *Pleurotoma semicolon*, *Turritella imbricataria*, and a whole suite of shells and many corals completely distinct from those of the chalk, and which are either known tertiary forms of Northern Europe, or species peculiar to the localities. In following the same zone westwards into the Bregonze Hills, and the tracts around Vicenza and Schio, or to the interesting, isolated hill called Monte Viale, it is seen to contain all the species enumerated by Brongniart, among which the following

* Highly valued and esteemed by M. von Buch and all the geologists and palæontologists of his country, M. Ewald seems almost to shun publication. The views which he put forth at the Venice meeting were eagerly caught up by all his auditors. He has since written to me, insisting on the indisputable zoological proofs that these deposits are eocene. He has not seen the species of Gryphæa which I collected in the Northern Alps, and which has been named *G. vesiculosa*, but he contends that the species of this genus known in the Vicentine, and published by Brongniart as *G. columba*, is not a known cretaceous fossil. At the same time he admits that the *Terebratula caput-serpentis* rises from the chalk into the eocene deposits. It is to be hoped that M. Ewald will soon be enabled to resume his journeys southwards, and thus complete a catalogue of all the fossils of the nummulitic group, in which he has already made great progress.

fell under my own notice, *Cerithium giganteum*, *Cerithium Maraschini* (Brong.), (which M. Ewald assures me is the *C. hexagonum* (Brug.) of the Paris basin), *Crassatella sulcata* (Sow.), *Nerita conoidea*, *Bulla Fortisii*. Among the conchifera are the *Pholadomya Puschii?* (Goldf.), the *Cardium Theresæ* of Nice, whilst the *Spondylus cisalpinus* (Brong.) and certain Pectens are as common as in the nummulitic rocks of the Northern Alps. The Echinoderms of this tract are equally decisive of a supracretaceous deposit; for they chiefly belong to the genera Schizaster, Scutella and Echinolampas, which are unknown in the chalk, but which also occur in the nummulitic deposits of Switzerland and Bavaria.

In an excursion through the lofty table-land of the Setti Communi, I saw the lowest tertiary beds, containing *Cerithium giganteum* as well as nummulites, reposing conformably on slightly inclined strata of the red and white chalk or scaglia at the height of about 5000 feet above the sea. This position is expressed in the diagram (fig. 22), which shows how the same movements of elevation and undulation which threw the lower tertiary group into a vertical position on the external flank of the cretaceous rocks at Bassano, had raised fragments of it at Gallio, near Asiago, on the surface of similar rocks amid the summits of the adjacent mountains. Again, in the Kalisberg mountain which overlooks the city of Trent on the east, the uppermost cliffs of sandy yellow limestone, which at a distance weather like dolomites, were found by MM. von Buch, de Verneuil and myself to be nummulitic rocks overlying the jurassic and cretaceous systems*. In these strata we collected the *Nerita conoidea* and *Voluta ambigua*, well-known species of the calcaire grossier of Paris, together with the *Lucina Corbarica* (Leym.), and several species of Echini, including the *Eupatagus ornatus* (Desor), the *Echinolampas subsimilis* (D'Archiac) and the *Pygorhynchus subcylindricus* (Ag.), both of Biaritz, and the *Echinocyamus profundus* (Ag.) of the nummulitic rocks of the Swiss Alps. At Sardagna (Trent) on the opposite bank of the Adige, the nummulitic limestone with Echini, Crustacea, Pectens, and the *Spondylus cisalpinus* so well known at Castel Gomberto, &c., also overlies white inoceramus limestone; thus exhibiting precisely the same succession as at Sonthofen and many other places in the North-western Alps. These nummulitic beds, according to M. Perini, occur also at the height of not less than 7000 feet above the sea, in the peak of Monte Bondone, to the south-west of Trent. The same tertiary deposits, therefore, which form mere hillocks on the south flank of the Alps, and which in some places (Bassano, &c.) are raised conformably into vertical walls, flanking the cretaceous rocks, have been carried up to great altitudes within the chain, where they bear the same relation to the cretaceous formation as the nummulitic rocks and flysch of Switzerland and the Northern Alps.

* In the museum of M. Menapace, of Trent, we observed the *Inoceramus mytiloides* and *Terebratula subglobosa* of the chalk, which that zealous collector, as well as M. Perini, who accompanied us to the Kalisberg, assured us were invariably found under the nummulitic rocks. Most of the fossils above cited were found by M. Menapace.

In resuming the consideration of the deposits which in the Vicentine and adjacent countries overlie the scaglia or chalk, I may add that they sometimes consist of strata, more or less sandy, which alternate with marls and graduate up into sandier bands of greenish calcareous grit.

In some tracts so much green earth is disseminated in this series, that near Schio where such is the case, and where the strata have been inverted, as before said, by the porphyry, this band was considered by the older geologists to be the secondary or cretaceous greensand. Professor Catullo has shown, in a recent publication, to what a great extension this zone attains in the Friuli. There it is characterized by a *Pholadomya*, which is scarcely to be distinguished from the *P. margaritacea* of the London clay*. Passing over for the present all the next overlying strata in this section, which the palæontologists of our party believed would prove to be of miocene age when fully examined, I have here only to repeat what I stated in my former memoir of the year 1829, that the highest deposits of the whole series contain many true subapennine shells, and that the beds in which they lie are apparently linked on to those we are now considering.

In regard to Monte Bolca, near Verona, so famous for its fossil fishes, I unhesitatingly affirm that it is of true lower tertiary age. In company with Sir C. Lyell I made sections of it and of the adjacent Monte Postale in 1828, which leave no sort of doubt that the strata are simply continuations of the eocene deposits of the adjacent Vicentine. Marly, whitish and yellowish limestones, occasionally mottled with bluish grey and brown colours, are on the whole subordinate to bands or mounds of peperino, and are also distinctly traversed by dykes of the igneous and basaltic rocks described by Brongniart.

Whilst the latter are certainly posterior, and have in many cases altered the contiguous limestone, the peperino must, I conceive, be viewed as the result of submarine volcanic dejections contemporaneous with the other deposits, the heat attending the evolution of which may have destroyed the fishes of a former well-tenanted bay of the sea, just as on a recent occasion shoals of them were killed on the coast of Sicily when Graham's island arose from the deep. Notwithstanding this abundance of eruptive matter, quite enough, however, of the original sedimentary deposit remains to show, that it is entirely distinct in lithological and zoological characters from any portion of the scaglia or chalk which flanks it on the north. Thus, lignite coal here occurs in the same position as cited in previous pages in the Savoy and Swiss Alps, and at Val d'Agno and Monte Viale in the adjacent Vicentine ; whilst the plants, including dicotyledonous trees, palms, cocoa-nuts, and certain aquatic forms, are pronounced by Dr. Unger to be eocene types†. Nummulites, indeed, occur between the lower and upper fish-quarries, among which I collected the small *N. globulus* and the *N. millecaput*, and with these are associated

* I have mislaid the note which I made concerning the other fossils of this lower tertiary greensand, but besides Ostreæ, I apprehend that it contains a peculiar Gryphæa, like the *G. columba* ? ? of Brongn. of Montecchio Maggiore.

† See also M. Adolphe Brongniart's description of some of the plants collected by his father (Mém. du Mus. d'Hist. Nat. vol. viii. p. 343).

numerous *Alveolinæ*. Whilst mounds of peperino (occasionally however containing nummulites) occupy the upper conical summits of Monte Bolca, overlying the dislocated and variously inclined limestones, true tertiary shells are seen both in the limestones of Monte Bolca itself and of its neighbour Monte Postale. Among these shells are Natica, Fusus, Buccinum, Ostrea and small Avicula, with Teredina closely resembling the *T. personata* of the London clay. We have thus abundant proof of the age of this deposit; but when the fishes are appealed to, they speak the same language still more decisively than those of Glarus in Switzerland. Of the 133 species enumerated and described by Agassiz, many are, it is true, peculiar and unknown elsewhere, but as at Glarus there are genera, and in much greater quantity, which, wholly unknown in any secondary rock, are still living in our seas; viz. Fistularia, Vomer, Torpedo, Lophius, Diodon, Rhombus, Clupæa and Anguilla. The presence alone of many species of *herrings* and *eels* completes the proofs drawn from other sources, that the deposits of Monte Bolca, like all the other nummulitic rocks of the Alps, must be completely severed from the chalk, and be considered a true lower tertiary formation.

Most geologists must, indeed, have been disposed to adopt this conclusion from the tabular arrangement of Agassiz, who, while the subject was still a matter of doubt, prudently placed the ichthyolites of Monte Bolca, together with those of Monte Libanon, as a special group between the cretaceous and tertiary deposits. I now, however, revert to the old opinion of Fortis, and definitively, I hope, class the Bolca deposit as a true lower tertiary rock.

I may terminate this portion of the memoir by saying, that when we compare the Vicentine and Veronese eocene deposits with the nummulitic rocks of the Savoy, Swiss and Bavarian Alps, we find as much assimilation as can be expected to occur in deposits of the same age, but of dissimilar composition, which lie at some distance from each other, and have manifestly been separated by intervening lands. In both, the true equivalents of the chalk are overlaid by limestones, in which some of the same species of nummulites appear interstratified with and overlaid by deposits in which are many of the same shells; whilst the most striking parallelism is marked by the abundant echinoderms of the two regions—all quite distinct from those of the preceding æra. In short, the deposits on the south as on the north slopes of the Alps are proved, by their organic remains and superposition to rocks containing chalk fossils, to be of the lower tertiary age, provided the groundwork of the classification previously adopted by geologists be not entirely changed.

In many natural sections, where the disruptions so frequent in this chain have not interfered, the evidences are complete as to a former continuous deposit from the surface of those strata in which any cretaceous fossils are discernible, through a vast series of strata in which all the vestiges of life belong to a new æra. What then can these nummulite deposits, whether in the Vicentine or in the Swiss Alps, be, but true eocene? If there be geologists who are not swayed by the evidences of organic remains only, still they must surely be influenced by the existence of a great, *conformable* and *continuous* succession of finely laminated strata, the deposit of which being clearly proved to begin after the accumulation of the limestones with true chalk fossils, has gone on uninterruptedly during long ages. The united group of the nummulite limestone and flysch of the Swiss Alps, as well as the great nummulitic and shelly accumulations of the Vicentine, are indeed more stupenduous monuments to mark the lapse of *time* than any of the so-called eocene deposits in Northern Europe. This phænomenon of a fuller eocene development, at least of all its lower part, in Southern Europe, is quite consonant with the facts elicited by the geologist. In Northern Europe a hiatus is very generally seen between the surface of the chalk and the lowest eocene, occasioned doubtless by very considerable disturbance at that æra. In numberless places the surface of the chalk has been abraded by the action of tumultuous waves, and the strata have been dislocated before the tertiary strata were accumulated thereon: not so originally in the Alps. There, the submarine deposits having in many parts been continuous throughout both periods, we are necessarily presented (where subsequent dislocations have not obscured them) with a grander series of strata. In regard to the enormous thickness of "flysch" which overlies the zone of nummulites and other recognizable fossils, and in which very little of organic form, save fucoids and a few fishes' teeth and scales, and an occasional cast of a shell, have been detected, we can scarcely say more than that, from the intimate association and intercalation of these rocks with nummulites, we must presume that they were simply the copious accumulations of a deep sea of that æra in which animal life was scarce. It is however to be noted, that the well-preserved ichthyolites of the Glarus slates, which unquestionably occur in one of the lower bands of flysch, are highly important evidences, and not less so that they are accompanied by the bones of a bird and a tortoise. The fishes of Monte Bolca, their position and their association with nummulites, enjoin still more forcibly the same conclusion. The fucoids of this deposit are indeed of little value in geological classification. For although in the Swiss and Bavarian Alps they mark, as far as I know, the upper portion of the group we are now considering, there are forms said to be similar in the Italian Alps which occur in the grey or lower chalk beneath the red scaglia. And this is just what we might expect; it being almost an established law in the distribution of organic remains, that the higher the organization the more neatly defined is its stratigraphical horizon. Vegetables of so low a class as fucoids, and so adapted for enduring physical changes, may therefore have continued to live on in spite of those grand mutations which may have often interfered with animal life.

It may be objected that the "flysch" of the North-western and Austrian Alps is not obviously displayed in the same mineral form on the flanks of the Southern and Venetian Alps. But even there the yellowish and green sandstone, and bands of marl and schistose limestone which are associated with the nummulite zone, may well be viewed as representatives of the North Alpine flysch. It is, in fact, from the identity of the rocks, and the belief in a similar position of the Italian macigno (upper) and the flysch of the Swiss, that M. Studer has recently styled the latter "macigno alpin." In treating of the Carpathians and Apennines it will, however, be shown to what a limited extent the "grès des Carpathes," and the Italian "macigno," are to be identified with the nummulitic or lower tertiary flysch; for in both these regions it happens, that the same lithological type of sandstones (often green) pervades vast thicknesses of strata, some of which are of upper secondary and others of lower tertiary age.

On the younger Tertiary Rocks of the Alps, and on the extent to which they represent the Miocene and Pliocene of Geologists.

In all parts of the Northern Alps there are evident signs of a marked interval between the last-formed strata of eocene age and the next overlying deposits, which every one has admitted to be tertiary. In contrast with the apparent conformable superposition of the overlying tertiary strata to the eocene on the flanks of the Venetian Alps near Bassano, already alluded to, and in parts of Italy to which I shall afterwards advert, the general phænomenon along the northern edge of the Alps, is that of a grand dislocation between such masses. In other words, it is clear that between the upper portion of the "flysch," and the lower portion of any tertiary formation of subsequent date, there is so great a break and unconformity as quite sufficiently to account for the absence either of the uppermost eocene, or of the lower part of the miocene of other countries.

Professor Studer, who has so long and so minutely studied the molasse and nagelflue of his native country, has as yet in vain sought for any section which exhibits a physical connection between the base of these deposits of molasse and the upper portion of the strata we have been considering. Thus dissevered from pre-existing strata, the molasse and nagelflue conglomerates are constantly thrown up at all angles of inclination, not only to verticality, but beyond it; and on lines usually parallel to the direction which has been impressed on the pre-existing masses of the chain, viz. from W.S.W. to E.N.E. The manner in which many of these tertiary conglomerates and molasse have been so placed against the flanks of the chain will be presently considered. In the meantime, whilst I acknowledge my incapacity to work out the subject completely, let us see what can be gathered from fossil evidences respecting the true age of these deposits.

In Styria* there is, indeed, a general ascending series, from a base

* The account of the tertiary deposits of the Styrian Alps, by Sedgwick and self (Trans. Geol. Soc. Lond. vol. iii. 2nd series, p. 382), has recently received a great addition in the description of their fossil plants by Dr. Unger of Grätz. (See Leonhard and Bronn, Jahrbuch, 1841, p. 505, and Journ. Geol. Soc. Lond. vol. v. Part 2. p. 11.) That author enumerates nearly 150 species from one bed only of lignite at Parschlug, all of which are of lost forms. Besides many Dicotyledonous trees of genera common in Europe, there are genera which require a climate as warm as South America, whilst others resemble the fauna of the United States and table-land of Mexico. On the whole, Dr. Unger believes that these plants,

with partial conglomerates, the whole reposing upon older rocks, and dipping away under the younger deposits of the adjacent lower countries. But when we pass to the north flank of the Alps, particularly in Bavaria and Switzerland, the physical relations are manifestly different.

In speaking of Switzerland I must not only refer to the well-known and excellent work of M. Studer on the Molasse, but also to the valuable additions to it recently made by M. Arnold Escher de Linth*. In the former we have set before us numerous derangements of this great deposit, and also the variations in its composition in different tracts. In the grand pebbly accumulations of the Rigi, for example, several thousand feet of which are clearly exposed, there are pebbles of granite and porphyry whose parent rocks† are now wholly unknown to the mineralogist in the Alps. At the same time it is clear, that the chief heaps of such materials have been derived from the well-known adjacent ridge of secondary limestone, mixed up with an extraordinary quantity of "flysch," which rock has also afforded materials for a large portion of the calcareous sandy matrix of the nagelflue. M. Escher points out that this great system of nagelflue and molasse is divisible into three zones. The lowest visible portion of the inferior zone is exposed along a great axial line, which, according to M. Escher, passes from near Rheineck on the north-east, by Herisau, Watteville, Jonen east of Rapperschwyl, on the north bank of the lake of Zurich, and Hutten on the south-west. Thence it runs between the lakes of Egeri and Zug immediately to the north of the city of Lucerne, whence it is presumed it may be followed further to the south-west, to the west end of the lake of Thun and the valley of the Sulg. Along this line molasse sandstone is seen in vertical or highly-inclined positions, throwing off overlying conglomerates of enormous thickness. If the masses of nagelflue which constitute the Rigi mountain near Lucerne, and the still loftier Speer (figs. 12 & 14, pp. 195, 200) near Wesen be included in one group, their thickness must be enormous, certainly exceeding 6000 or 8000 feet. This axial line trends from W.S.W. to E.N.E., and is, I would remark, perfectly

which I examined in his company in the museum of Grätz, bespeak a Mediterranean climate and a miocene age. It is eighteen years since I furnished M. Adolphe Brongniart with the plants of the Häring tertiary coal deposit in the Tyrol.

* For M. A. Escher's account of the molasse of Eastern Switzerland see Mittheilungen der Naturforschenden Gesellschaft in Zurich, No. 7, May 1847. In this memoir M. Escher states, that although a powerful deposit of marine molasse (not less than 1000 feet thick near Berne) is interpolated between the lower and upper freshwater molasse and nagelflue, he is unaware of any zoological distinction in the two last-mentioned members of this great series. *A warm climate, which permitted the growth of palms and large Cycadeæ, seems to have prevailed during the whole of the molasse period*, and the species of Helix, Lymnea, Planorbis, Melania, appear to be the same in the strata above as well as in those below the marine molasse.

† Professor Studer believes that the parent granite, from whence such pebbles were derived, protruded along the great line of dislocation between the molasse and the chain, and was lost by subsidence *en masse* when the great accumulations of nagelflue were formed.—(Letter to myself.)

parallel to the great band of cretaceous rocks, nummulite and flysch before described, to which the strata of the nagelflue and molasse are entirely unconformable. Nor does this line of dislocation cease at the eastern end of Switzerland. It continues, as before stated, in the same direction, from near Bregenz to Immenstadt in Bavaria, where it affects the huge tertiary masses, often vertical and sometimes dipping both to the north and south, in which Professor Sedgwick and myself have described several transverse sections between Bregenz on the south-west, and the subalpine ridges south of Munich on the E.N.E., in which micaceous sandstones with marls, shales, conglomerates and courses of lignite occur, as in Switzerland. In some Bavarian strata of this age we found freshwater shells, *i. e.* Cyclades and Potamides, mingled with marine forms*. On the whole, however, we detected so very few fossils in these vast accumulations, that, simply connecting these rocks with the molasse and nagelflue of Switzerland, we then said that whatever conclusions Professor Studer or other geologists might establish, by help of fossils, respecting the Swiss formations, might be extended to a portion of the newer Bavarian deposits. Now, in what is called the lower group, particularly as seen in the canton of St. Gallen and along the axial line above cited, no trace having been found of anything organic except lignite with terrestrial plants, and land or fluviatile shells with bones of extinct land quadrupeds, M. Escher justly considers it to be a freshwater formation.

Whatever may be the dimensions of the lower (freshwater and estuary) member of this series, it is overlaid by molasse, sandstone and marls of considerable thickness, which contain a great variety of marine species†. I submit a collection to the Society which I obtained from Professor Deicke at St. Gallen, near which place they abound. In examining the strata there, in company with that gentleman and Professor Brunner, I perceived that the shells chiefly occurred in beds of sandy, micaceous blue marls, which alternate with sandstones, and are intercalated with large accumulations of pebbly conglomerates. The following may be enumerated as among the characteristic fossils which occur at St. Gallen, but more complete lists must hereafter be given; viz. *Solen vagina*, Linn.; *Panopæa Faujasi*, Menard; *Cardium multicostatum*, Broc.; *Venerupis eremita* (*Venus*, Broc.); *Venericardia Jouanetti*?, Desh.; *Pinna nobilis*, Broc.; *Pecten scabrellus*, Broc.; *P. latissimus*, Broc.; *Conus turricula* (Broc.), with other species of that genus; *Turritella terebra*, Broc.; *T. vermicularis*; *Pyrula reticulata*, Lamk.; *Natica canrena* (*Nerita*, Broc.); *Phorus agglutinans*, Lamk., as well as species of the genera Pholas, Venus, Cardium, Dentalium, Serpula, Balanus, &c.‡

The sections of St. Gallen (as pointed out to me by Professor

* These beds are described in Geol. Trans. 2nd Ser. vol. iii. pp. 326, 329, 370.

† For the general relations of these freshwater and marine strata of the molasse see the woodcut, fig. 14, p. 200.

‡ Whether these St. Gallen fossils be called older pliocene or younger miocene is immaterial to me, as I only seek to show that among them are numerous existing marine species. (See subsequent observations.)

Deicke) exhibit the strata with marine shells intercalated between freshwater deposits, which contain the *Melania Escheri* (Merian) and *Planorbis hispidus*, Pupa, Melanopsis, and small Potamides, with seams of lignite, &c.

The enumeration of the fossils of the marine molasse of St. Gallen, though far from being complete (not more than a third of the species I saw are mentioned), is I think sufficient to prove that these beds are of nearly the same age as the blue subapennine marls of Italy, and therefore of what has been called the older pliocene age. The marine shelly beds of the molasse in the canton of Berne, also low in the series, are equally referred by Professor Studer to this age; for although the shells there are neither so well preserved nor so numerous as at St. Gallen, the presence of the *Panopæa Faujasi, Pecten laticostatus* (Brod.), *Cyprina Islandica, Tellina tumida* (Brong.), all characteristic shells of the subapennine deposits amidst those which are recognizable, leaves little doubt on the subject. In Berne, as in St. Gallen and Zurich, the marine beds in question surmount (according to Professor Studer) a widely-spread lower freshwater deposit.

In the canton Vaud, where remains of tortoises, crocodiles and extinct quadrupeds occur, the order of superposition and relations of the different masses of the molasse are obscurely seen, particularly in the undulating region between the lakes of Neufchatel and Geneva. Still it is right to observe, that in the environs of Vevey, where molasse and conglomerate abound, no traces of any marine remains have been found; the only fossil indeed known there being a Palmacites of some size, detected by M. Collon*. There the tertiary conglomerate and molasse are truncated, and with an inverted dip (fig. 4, p. 182) seem to dip under the adjacent secondary rocks as in the diagrams (figs. 12 & 14, pp. 195, 200), though here they are in contact with rocks of the age of the Oxfordian Jura.

That marine strata overlie freshwater conglomerates, is indeed clearly perceived in the environs of Chambery and other parts of Savoy. The Canon Chamousset accompanied me to sections, where a conglomerate made up of the detritus of the adjacent neocomian limestones contains freshwater shells and lignite. In that tract, where all the intervening strata, representing the gault, upper greensand, chalk, nummulitic limestone and flysch, are absent, the freshwater conglomerate reposes at once on the secondary neocomian limestones from whence its materials have been derived, and passes upward into the marine molasse, as exposed in the woodcut (fig. 5, p. 184).

This lower freshwater accumulation in Savoy is not less than 1000 feet thick. Its lowest beds consist of limestone conglomerates followed by red marls and marlstone with green veins and spots, and occasional gypsum. Then follow other calcareous pebble bands, containing subordinate courses of marly limestone with freshwater shells.

* M. Blanchet of Lausanne has a rich collection of fossils from these fluvio-lacustrine deposits of the canton de Vaud. He believes that these mixed deposits are of different ages, each varying according to its proximity or remoteness from the chain of mountains from which it was washed into the bay by rivers (see his Supplement).

The latter are surmounted by marly sandy beds, approaching in character to molasse, which gradually pass up into the true marine molasse.

The marine molasse of the cantons St. Gallen and Zurich dips to the N.W., and is clearly surmounted by enormous accumulations which constitute the upper nagelflue, and throughout which nothing but terrestrial or freshwater remains have been detected, the species, of the genera Melania, Helix, Planorbis, Lymnea, being apparently undistinguishable from those of the nagelflue and molasse beneath the marine strata. It is probably this great upper member which is for the most part thrown into the remarkable inverted position exhibited in the diagrams figs. 12 & 14. In a portion of this upper member at Kapfnach, and in the Albis Hills near Zurich, are found freshwater beds, in which Helices and seeds of Chara occur together with the bones of *Mastodon angustidens, Palæomæryx, Orygotherium Escheri, Chalicomys Jägeri, Cervus lunatus, Hyotherium medium, Rhinoceros Schinzii,* all species recently described by M. Herman von Meyer. In the same deposit, leaves of Acer as well as parts of palmaceous plants are seen*.

Again, molasse and conglomerate occur in still higher positions; *i. e.* in the summits of the ranges near Zurich, where the pebbly beds are very cavernous, and have given rise to the name of "löchrige Nagelfluh;" but no characteristic organic remains have been found in it.

In following the surfaces of these vast accumulations as they recede from their dislocated and highly inclined positions on the flanks of the Alps into the great trough which extends up to the Jura, we find the beds becoming more and more horizontal, in which position they range up to the edges of the latter mountains. The same order of strata is however observable, and every here and there we see—notably near Baden in Switzerland—courses of marine shelly marls and sands charged with the same group of subapennine fossils† and covered by freshwater nagelflue.

The vegetable remains of the molasse seem all to be referable to a warm or Mediterranean climate, and they are all extinct species. To this consideration I shall presently revert.

* The *Mastodon angustidens* occurs at several other localities, viz. Buchberg, Elgg, Greit, &c. The *Rhinoceros incisivus* is found at Elgg, and the *Rhinoceros Schinzii* (Herm. v. Meyer) was extracted from nagelflue at Bolingen, near the foot of the Albis, where it is associated with *Unio Escheri* and extinct species of Paludina, Melania, &c. Molasse fossils, including tortoises, are also in force at Winterthur. This upper group of molasse with mammalia is clearly separated from the horizontal older alluvia of these regions, of which there is a fine example at Utznach, in which the *Elephas primigenius* or mammoth occurs, with land and freshwater shells, and pines, and other vegetables of existing forms.

† See the list of these fossils in the excellent monograph of the Baden country, by Professor Mousson of Zurich, "Geologische Skizze der Umgebungen von Bade im Canton Aargau von Alb. Mousson, Zurich, 1840." In this work the reader will find a very instructive tabular arrangement of all the jurassic and underlying rocks, which are very closely paralleled by fossil species with the oolitic deposits of England.

Freshwater Deposits of Œningen.

In following the surface of the uppermost beds of the nagelflue and molasse from the lofty hills which flank the chain of the Hoher Sentis, &c., the formation as it spreads over the lower grounds, extending from thence, and from the lake of Zurich to the lake of Constance and the Rhine, is chiefly characterized (where fossils and lignites have been detected) as a great terrestrial or estuary deposit. On the right bank of the Rhine, between Constance and Schaffhausen, the celebrated freshwater deposit, which I visited for the third time, has, it still appears to me, been formed in a depression of pre-existing molasse and nagelflue*. In revisiting this locality I was anxious to see what discoveries had been made, and what influence they might have, in conjunction with the recent description of the fossils, on the conclusions respecting the age of that formation which I formerly entertained. In regard to its overlying position I am happy to say that my former general view is supported by M. Studer, M. Escher, and all the Swiss geologists; viz. that these freshwater sands, marls and limestones are younger than the chief masses of molasse and nagelflue of Switzerland. As in my previous communication a very small woodcut only was given, I beg to annex another which better represents my present ideas.

Fig. 27.

4. Marls and detritus (with volcanic tuff of Escher).
3. Upper quarries of freshwater limestone.
2. Lower quarries of freshwater limestone.
1. Regenerated soft molasse (marine molasse of Escher).

The area over which the sandy marls, marlstone and limestone of this deposit extend, is of much greater dimensions than the spots where quarries have been opened and wherein the fossils have been found. This area, as far as it can be traced, is of an elongated elliptical form, extending with the Rhine from Berlingen, on the right bank of the river, to Wangen and Œningen near Stein on the left bank, a distance of not less than ten miles from east to west. This is inferred because freshwater shells have been found in the soft recomposed sandstone of Berlingen, which rock is of the very same character as that which

* On this occasion I was accompanied by Professor Brunner. For my previous description of Œningen see Trans. Geol. Soc. Lond. 2nd Ser. vol. iii. p. 277. In the little woodcut there given the surrounding molasse and nagelflue were indicated by inclined lines, though I then knew perfectly that in this tract such strata were not there inclined. These lines were only inserted to mark more strongly my belief that such rocks, *so highly inclined in the neighbouring country*, were of age anterior to the overlying marls and limestones of Œningen. See also the account of this deposit by M. Escher von der Linth, given by Herman von Meyer in his Palæologica, 1845, and my observations thereon, Journal of the Geol. Soc. Lond. vol. iii. p. 54.

forms the bottom of the so-called Œningen deposit (1). The ancient lacustrine expanse may indeed have occupied much of the broad valley now filled by the Rhine and the Unter See or lower lake; so that it is difficult to define its former limits on the E. and N.E.* To the south, however, and to the west and north-west it was manifestly bounded by hills of hard pre-existing nagelflue, whose summits are surmounted by erratic blocks only. No one can ascend the indestructible rock of nagelflue from which the castle of Hohenklingen overlooks the town of Stein, and then examine the edges of the contiguous freshwater accumulation, without coming to this conclusion. It is, indeed, evident that the lacustrine deposit was bounded by these hard rocks. The lowest beds of the Œningen basin, as seen in the ravines between Stein and Wangen, and in the lower terraces under the plateau of fossil limestones and marls exhibited in the preceding woodcut, are incoherent, micaceous, light-grey sands, with an occasional concretion (1) fig. 27. They are, in fact, regenerated molasse, and have been compounded out of the hard dark-coloured molasse building-stone, to which they have much the same resemblance, as the sands on the shore of a lake to the sandstone cliff on its sides from whence they have been derived. This is, I repeat, exactly the same soft stone as that which recurs at Berlingen, between Constance and Stockhorn, on the opposite bank of the Rhine, and where freshwater shells are found in it.

In ascending from Wangen to the quarries, a considerable thickness of these sands is exposed, and at their summit they inosculate with marly and calcareous courses, in which the lower quarries (now very little worked) are opened. Their strata (2) consist, on the whole, of alternations of *recomposed*, light-grey, micaceous, calcareous molasse, with thinly laminated, dark-grey marlstone and limestones of conchoidal fracture, which are highly fetid under the hammer. Though of irregular persistence and somewhat broken, these beds (the upper part of which is ferruginous) incline slightly to the west, or away from the valley of the Rhine to which they present their edges, and by which inclination they are carried under all the limestone and marl of the plateau. Among the fossils which they have afforded are the *Palæomœrix* of V. Meyer, together with portions of tortoises; but owing to the concretionary form of the beds and the irregularity of their composition (*i. e.* sand and marlstone inosculating), the fossils are neither so well preserved, nor so much sought after, as in the overlying quarries of flat bedded character.

Rising gently along the inclined surface of the plateau above the lower quarry, the substrata around the dome-shaped ground of Solenhofen are seen to consist of similar rocks passing upwards into marlstones or limestones, which at the distance of about three-quarters

* M. A. Escher de Linth makes the freshwater beds extend northwards by Schienen to the valley of the Aach. I did not revisit that portion of the ground, but I have perfect confidence in his section. The recent discovery, however, of freshwater shells in the underlying band at Berlingen (since M. Escher wrote) decides the nature of the band (1) of my section, which he termed with doubt "Meere's? molasse." (See Fauna der Vorwelt von H. v. Meyer, 1845, p. 49.)

of a mile from the lower quarry are fully displayed in the upper quarry*, the descending order in which is as follows:—

	Ft.	In.
Soft and decomposing bluish grey and white marls used as brick earth, the lower portion consisting of courses from two to eight inches thick, of finely laminated marlstones with very thin laminæ of chert, about .	20	0
Soft bed in which the tooth of a mastodon has been found	1	6
Fish-bed (marly limestone), fishes abundant	0	2
Insect-bed (very finely laminated)	0	2
"Kleine und grosse Moden," stone bands with a few fishes	4	0
"Salamander Platten," in which the *Andrias Scheuchzeri* was found; fishes rare	0	5
"Schildkrot schicht," or tortoise-bed, in which the *Chelydra Murchisoni* (Bell) occurred	0	6
Shale or marl, varying from two or three inches in one part to two feet in others	1	0
"Diehl Stein," or plank-bed, so called because it breaks into long thin board-like flags	1	0
Fox-bed, *i.e.* the marly limestone enclosing the *Galecynus Œningensis* ...	0	4
Fish-bed with numerous fishes, frogs, and several small quadrupeds.........	0	6
"Kessel Stein," or bottom beds of the quarry loaded with plants and the freshwater shells "Anodonta"	1	2

High as it may be in the geological series, and posterior as it certainly is to the marine strata of St. Gallen and Baden with certain existing species of sea shells, the Œningen deposit is not, however, as I formerly supposed, a link between extinct and existing nature. Indeed, whilst I expressed that opinion, I contended that stupendous changes had occurred since this lacustrine matter was accumulated. I showed to what a depth the valley of the Rhine had been subsequently excavated, and how the drift, erratic blocks, and löss had afterwards been deposited; but judging from the best opinions I could then obtain from naturalists respecting the characters of the animals, whether quadrupeds, fishes, shells or insects, or from the plants, I was led to think that they very nearly approached, and in some cases were undistinguishable from, living forms.

More precise researches, however, lead to a very different conclusion. Amidst the multitude of well-preserved fossils, not one, it is now said, is strictly identifiable with an existing species. The closest analogy, indeed, exists between the manner in which the animals and vegetables have been entombed in the mud of this former lake and that which would still prevail. The fossil insects Blatta and Nepa are there found, as I formerly said†, collocated with remains of the

* On this occasion we were so fortunate as to find the present proprietor of the quarries, M. Barth, busily directing his workmen, and as he has made researches for many years, I took down the description of each stratum from him. M. Barth having been unfortunate in trade now devotes himself exclusively to the extraction of the rarer fossils, and in preparing suites of them for sale. M. de Seyfried of Constance possesses the most perfect of the collections of the Œningen fossils with which I am acquainted, all found since I last visited that country. In it I observed five noble specimens of *Andrias Scheuchzeri* (Homo diluvii testis), *Lagomys Œningensis*, *Chelydra Murchisoni*, and another species of tortoise undescribed; and among many splendid fishes an eel three feet long, the *Coluber Oweni*, the tooth of the *Mastodon angustidens*, &c.

† Trans. Geol. Soc. London, 2nd Ser. vol. iii. p. 286.

leaves of the same genus of tree on which they still live; but the species are distinct from those now prevailing. On this point I quote the opinion of Professor Heer of Zurich. That zealous entomologist assured me, that out of 120 species of Coleoptera, 40 species of Neuroptera and 80 species of Hymenoptera (60 of the latter belonging to Formica), he has not, after the most rigid microscopic comparisons, been able to detect a single form, either aquatic or terrestrial, which can be identified with species now living in any part of the globe. Some of them, indeed, make close approaches to species now living in America and the Mediterranean, including Algeria, and some genera (at least six) are entirely new*.

Professor Agassiz classes the fishes of Œningen much in the same category, and the same may be said of the numerous quadrupeds, whether those so elaborately and well described by M. Herman von Meyer, or the extinct form of the Viverridæ named by Professor Owen *Galecynus Œningensis*, or the "Fossil Viverrine Fox of Œningen†." Even in regard to the plants, it does not appear that any can be identified with living forms; for although M. Göppert has said that he can discover no difference in one case between the cone of a pine of Œningen and the cone of the living *Pinus sylvestris*, he admits that without further evidence as to the glands and leaves, no proof can be obtained that it is not an extinct species.

Such being the facts, how are we henceforward to classify with certainty, tertiary deposits which have been formed *on land*, in relation to those which have been accumulated *in the sea*? In the latter, or the marine Swiss molasse, we find that strata formed anterior to the Œningen deposit contain shells of the subapennine æra, many, or some at all events, of which are now living in our seas‡; whilst the land and fluviatile animals of posterior date are *all* distinct from those now in existence. In reviewing the molasse and nagelflue as a whole, the evidence, as far as it goes, teaches us, that the formation was in many tracts almost entirely formed by rivers or in lakes; whilst in other parts, as near Berne and St. Gallen, there were powerful intercalations of deposits formed in bays of the sea. If then we consider the whole as a connected series, and admit that in the lowest as well as in the highest strata, and even up to the regenerated molasse and marls of Œningen, the land remains belong to extinct species, still we

* Professor Heer's monograph of the fossil insects of Œningen will, I doubt not, interest all entomologists as well as geologists, by the knowledge it exhibits of every analogy and comparison which can be set up between these fossils and the living forms of insects. Professor Heer intends to describe in a subsequent work the insects of Aix en Provence and other tracts.

† The animal collected by myself, and described as a fox by Mantell, is now named by Owen *Galecynus Œningensis*, or the "Fossil Viverrine Fox of Œningen." See Journal of the Geol. Soc. London, vol. iii. p. 55, with anatomical woodcuts.

‡ I here conform to the more generally received opinion concerning pliocene marine shells as advocated by Sir C. Lyell and M. Deshayes. M. Cantraine indeed believes that nearly all the true pliocene or subapennine species are still living (see Malacologie Mediterranienne et Littorale, Acad. de Bruxelles, tom. xii. des Mém. 1840). On the other hand, however, it is right to state, that M. Agassiz contends that no animal having the exact form of a fossil tertiary mollusk is now living in our seas.

have the remarkable fact, that in the subordinate marine masses many of the shells are living species.

This discrepancy in the evidences drawn from terrestrial and marine sources has already created divergent opinions respecting the age of strata among naturalists. Thus, judging from the vertebrata found in the older freshwater deposits of the Rhine and other parts of Germany, where marine evidences are wanting, M. Herman von Meyer would class as eocene that which other geologists call miocene, and he has naturally referred to the miocene age those very Œningen freshwater and terrestrial strata so charged with lost types, but which, as I now assert, were formed after the accumulations in which pliocene and living marine fossils occur.

This persistence of marine forms during a period in which a whole terrestrial fauna became extinct—a period it will be recollected when the proportion of the known remains of the land in reference to those of the sea was infinitely larger than in earlier times—may lead us to be cautious in deciding on the age of a secondary rock by the mere characters of its fossil vegetables (see p. 178). At all events, the contents of the upper tertiary deposits of Switzerland compel us to admit, that in any classification of a terrestrial formation by the more or less prevalence of existing types, not even the youngest of those Swiss strata at Œningen can be termed miocene or pliocene. So completely, indeed, do all its imbedded terrestrial animals seem to belong to lost types, that we have not yet even authority to call them eocene, although in reference to marine deposits they have been formed in part out of the detritus of the marine eocene Alpine rocks! In rendering our science exact, we must, therefore, I apprehend, classify strata deposited in fresh water or on land separately from those of submarine origin. In reference to the tertiary æra, we can only speak of the former, as *older* or *younger land* formations; since it is manifest, that (without a total disregard of the meaning of the words) we cannot apply to them the terminology employed to designate the tertiary *marine* stages*.

Dislocations in the Alps.

The previous pages having been chiefly devoted to the detection of the order in which the formations have been accumulated, I now invite attention to some examples of those grand phænomena of contortion and fracture of the strata which specially characterize these mountains. By whatever causes produced, these derangements are so great, that geologists accustomed to work in less troubled regions could scarcely have ventured to hope, that the Alps would have been found to explain any portion of the *succession* in the earth's deposits, still less that they should contain, as I have endeavoured to show, certain *links* to connect the secondary and tertiary rocks, which, if

* The commingling of lost types of large terrestrial animals with those of species scarcely distinguishable from our own in the rich tertiary deposits of the sub-Himalaya chain, is, also, a splendid example of the difficulty of synchronizing such terrestrial accumulations with the marine tertiary deposits named eocene, miocene, and pliocene.

not entirely wanting, are, at all events, feebly exhibited in Northern Europe. But passing from the survey of these valuable exceptional cases, which have been left for our instruction, I will now point out a few examples illustrative of the manner in which several consecutive Alpine formations have been first convoluted, then often inverted, and finally snapped asunder by enormous faults. To treat such a subject in the manner it deserves would require much more detailed knowledge than I possess, and the present notice must, therefore, only be viewed as affording data to assist in explaining the origin and progress of such great mutations.

Let the geological features of any one region of the Alps be appealed to, and it will be seen, that whatever be the major axis of the crystalline mass* in its centre, such also is the prevailing direction of all the sedimentary deposits which lie on either side. Thus in the Eastern Alps, we see two principal ellipsoidal ranges of granite, the one extending from the Iffiger Spitze above Meran to the environs of Brunnecken†, the other of nearly equal extent in the high region near the sources of the Mur, and extending along the left bank of that river to form the nucleus of the Noritian Alps. These ellipses, trending from W.S.W. to E.N.E., mark distinctly the major axis of the Eastern Alps; whilst to the south of Vienna the prolongation of this axis is indicated in the nucleus of the Leitha Gebirge‡. Now this direction from W.S.W. to E.N.E. is likewise that which has been impressed on all the sedimentary masses of these Eastern Alps, of transition, secondary or tertiary age, whether they be successively examined northwards to the valley of the Danube or southwards to the plains of Venice. Minor parallel ellipsoids of crystalline rock, indeed, appear in the Venetian Alps both at Recoaro and its neighbourhood and in the Cima d'Asti, which, whether they be mica schists or granitic rocks, have the same relations to the enveloping younger sedimentary deposits. Such also are the major axes of the great masses of crystalline rocks which occupy the central tracts of the Tyrol, the chief part of the Alps of Lombardy, and the nuclei of the Swiss Alps, and such also is the dominant strike of all the associated sedimentary deposits in these regions.

To the west of the longitude of Berne the chain assumes more of the north and south direction, and there again the sedimentary rocks, to a great degree metamorphosed, run parallel to the axes of the rude ellipses of Mont Cervin and Mont Blanc and their prolongations. And here it is to be remarked, that as we follow the chain from N.E. to S.W. we pass from the clearest types of the sedimentary rocks, and at length in the Savoy Alps are immersed in the highly altered mountains of secondary limestone before described. I am unable to define the manner in which the chief axes of these moun-

* The word 'crystalline mass' is meant to include granite, gneiss, mica schist, marble, &c., and in short all rocks, whether formed by eruption or by metamorphism of pre-existing deposits, which are now in a crystalline condition.

† M. von Buch specially called my attention to this ellipsoid of granite, around which all the rocks are powerfully metamorphosed (see *ante*, p. 167).

‡ Trans. Geol. Soc. vol. iii. p. 303; and Map, pl. 35.

tains trend in the Maritime Alps, where it would, however, almost seem that they bend round so as to be confluent with the Apennines and envelope the great depression of Piedmont and Lombardy; thus describing a grand sweep, or in other words an outward semicircular line, of which the Monferrato near Turin is the last external fold. It is enough for my present purpose, to show, that whatever be the direction of the chief crystalline axis of any one region in these mountains, such is the dominant strike of the flanking deposits. Now, whether such axes are marked by the protrusion of granite, syenite, or any other so-called eruptive rock, or are simply occupied by strata which have been metamorphosed, it is manifest that some powerful energy has been exerted throughout and along them, which action has so affected all the sedimentary deposits on their sides, as to produce a parallelism to the central axes, both in anticlinal and synclinal folds and in deep longitudinal fissures. If the valuable detailed maps preparing by M. Studer were published, this fact would be seen as respects Switzerland, and a glance at the admirable map of France of De Beaumont and Dufrénoy amply explains my meaning in regard to that highly dislocated portion of the chain which extends southwestwards from the region around Mont Blanc. For Piedmont and Savoy the reader is referred to the good illustrations of Sismonda, not yet, however, brought into one view.

In treating of the whole chain it must be admitted, that the Swiss and Savoy Alps have been most agitated; and it is in these most convulsed tracts that we may perhaps best learn what has been the nature of the movements of the strata and the order in which they have followed each other. In parts it is clear, that from the jurassic rocks to the "flysch" inclusive, there has been a continuous series of submarine deposits (see figs. 3, 4, 12, 14, and the group of sections of Hoher Sentis, Plate VII.). Many deep denudations, indeed, expose the whole of this series in lofty mountains on either side of deep valleys, each formation in conformable apposition. The most remarkable fact in this collocation is, that all these strata from the eocene downwards, have been thrown into undulations both rapid and gentle, and sometimes have been so contorted as to produce absolute inversions. I believe that such flexures were among the earliest of the great physical changes impressed upon these submarine strata, which, at the time when they were so bent, may I conceive have been of no greater solidity and compactness than many of the soft deposits which now constitute the crust of the earth in Russia* and other countries, where the processes of induration and crystallization have not been carried out. It seems to me, that however we may attempt to detect the power which produced these folds and contortions, we must admit that all the strata so folded together, had been accumulated the one over the other under the sea (often continuously), and could only have been slightly solidified before the operation commenced by which they all partook of common and conformable movements of undulation.

In no part of the Alps, which I have examined, are the curvatures

* See Russia and the Ural Mountains, vol. i. *passim*.

of the calcareous formations better exhibited than in the Altorf branch of the Lake of the four cantons,—that noble transverse fissure which penetrates so far into the heart of the chain (see fig. 12, p. 195). On the mountain slopes (often vertical precipices) on both sides of this deep cleft, various formations from the Oxfordian or Upper Jura (*o*), near the water's edge (Tell's Chapel), through the lower and upper neocomian, greensand, gault, and sewer-kalk, or equivalent of the chalk, up to the nummulitic and flysch rocks, are all seen to be twisted, and often conformably to each other, in numerous flexures, which increase in rapidity and intensity (in the Achsenberg for example) as you approach the centre of metamorphism (or towards St. Gothard), and decrease as you recede from it. In other words, the folds open out into broader and less complicated sweeps in proceeding from the north slope of St. Gothard as a centre to the flanks of the chain, where they expand into the canton of Lucerne. Some of these extraordinary appearances near Altorf and in the escarpments of the adjacent lake have been figured in two coloured diagrams by Dr. Lusser †. Faithfully delineating what he saw, and judging from the order of superposition, that author concluded, that rocks with green earth and nummulites were repeated several times over in the series, and that these fossils existed in strata (occasionally crystalline) of considerable antiquity, as well as in younger beds. The effort which Dr. Lusser made to classify the rocks of this disturbed tract by mineral characters and *apparent* order of superposition has, I need scarcely say, proved invalid; for as soon as you extricate the nummulitic zone from the labyrinth in which it is involved in the Achsenberg near Altorf (see fig. 12, p. 195 *ante*) and follow it out towards the N.N.W., it is seen to fold regularly over upon the surface of the cretaceous rocks, first in the sharp and partially broken synclinal of Syssikon, then in the dome or anticlinal of the mountain above Brunnen, and next in the broader synclinal of the valley of the Muotta.

The precipitous faces of rock on the sides of the lake of Altorf are indeed most instructive, in showing us the intimate connection between the chief axial line, the folds of the strata and the lines of fracture. In one portion of the lake, nearly midway between Brunnen and Fluelen, the centre of the folds of one of the masses appears in the opposite cliffs, and thus marks the general strike of such contortions to be parallel to the axis, or E.N.E. and W.S.W.; whilst a line of fracture equally visible on both sides of the transverse fissure is also parallel to the same (see *, fig. 12). In short, the order of operations seems undoubtedly to have been, *first contortion and then fracture*; the nuclei, or inner rolls of the folds, and the lines of dislo-

† Nachtragliche Bemerkungen zu der geognostischen Forschung und Darstellung der Alpen, vom St. Gothard bis am Zuger-See. Swiss Transactions, vol. i. p. 44. Although he does not appear to have noticed organic remains in these mountains, De Saussure has described some of their remarkable flexures and breaks. He speaks of the calcareous strata of the Achsenberg as exhibiting the form of the letter S several times repeated with fractures, and reminds us that Vallisnieri in his 'Origine delle Fontane' had remarked upon these grotesque outlines. He also mentions a great bend in the form of a C from which the strata extend horizontally below.—Voy. dans les Alpes, vol. iv. § ix. 1933 *et seq.* (see my fig. 13).

cation being parallel to each other and to the great axis of the chain. In tracing some of these folds, we see so clearly that an upper stratum has been twisted under one of greater antiquity (and which underlies it at a little distance), that we thus learn a lesson on the small scale which we may endeavour to apply to extensive masses; whilst some of the fractures are observed to have taken place along those portions of the flexure which have least resisted. As my chief attention was specially given to the cretaceous and supracretaceous rocks and their relations, I seldom endeavoured to grapple with the accumulation of obscurities, including metamorphism, which present themselves as the observer approaches the watershed of the chain; it having been sufficient for my purpose to note how the strata in question were uncoiled as they rolled over in great undulations from the centre to the flank. In continuation therefore of a description of the transverse section which passes from Altorf to the N.N.W. (fig. 12), I must in justice say, that, as far as mere outline goes, the undulations seem to conform to the wave-like progression so ably laid down by Professors Henry Rogers and W. Rogers in their map and sections of the Appalachian chain. In other words, the steeper sides of the anticlinal are the most remote from the axis, whilst the longer and less inclined face of each anticlinal faces the chain. This is observed first at Syssikon, and next it is remarkably well seen near the mouth of the Muotta-thal, the structure of which has been described. The nummulitic and cretaceous rocks on the south side of this valley are highly inclined and almost vertical, whilst on the north side they slope at the gentle angle of 20° to 25°. In the next grand curvature of these masses, or towards the Rigi, a tremendous dislocation has occurred*, by which, in fact, *the younger portion* of the nagelflue and molasse of pliocene age is brought with an inverted dip against the escarpment of the lower cretaceous rocks in the manner described in the above diagram. Doubtless this last is a fault of many thousand feet. The axis of the molasse external to the chain, runs parallel to it, as before mentioned, in the environs of Lucerne. Throughout an intermediate distance of several miles there is a development of all those massive and inclined strata of conglomerate and sandstone which form the Rigi. The youngest bed, therefore, of all that vast accumulation is thus brought into contact with, and apparently dips under, lower cretaceous rocks; and as the beds of pebble and sandstone must once have overlapped the cretaceous masses, nummulite rocks and flysch *out of whose materials they have been formed*, the fault must indeed be as enormous as the inversion is astounding.

This grand solution of continuity between the cretaceous rocks with their overlying companions, the nummulites and flysch on the one hand, and the molasse and nagelflue on the other, is the most striking dislocation in Switzerland. The line now mentioned trends from the flanks of Mont Pilatus and passes by the south side of the Rigi, to

* There are other minor folds, and probably dislocations, which I did not follow out, in the masses of cretaceous and neocomian limestone between the Muotta-thal and the Rigi. The dome-shaped arrangement of the sewer-kalk at Sewen indicates that this must be the case (see p. 193).

the east bank of the lake of Lowerz, where it marks the junction between the lofty cretaceous peaks of the Mythen above Schwyz, and the supracretaceous rocks of the Hacken pass and Lowerz. But here dislocated masses of flysch and fractured nummulite rocks are intercalated between the cretaceous escarpment under which they seem to dip, and those great sloping masses of conglomerate, which, constituting the Rossberg so celebrated for its landslip, appear in their turn to underlie the nummulite zone. This inverted position is again well displayed as you follow the same masses towards Einsiedeln, where the nagelflue overlying the middle and lower molasse is in distinct apposition to an escarpment of nummulite limestone, which dips rapidly away under mountains of flysch that are also thrown off to the S.S.E., or *towards the axis of the Alps* (fig. 13). This phænomenon is common along the northern flanks of the chain. It is, in fact, that prevalent feature throughout the external zone of the Eastern Alps on which Professor Sedgwick and myself insisted; but at that time we had not an adequate conception of the intensity of these movements, by which, on lines parallel to each other, the oldest portion of each group has often been thrown up on the external or younger side of the Alps, with its last-formed member let down as it were, so as to be in contact with the oldest rock in the tract, and with all the appearance of passing under it!

The distinctions between regular succession and discordance are admirably displayed around the Grünten mountain and between it and the higher Alps; for after an exhibition of perfect symmetry (figs. 17 and 18), we find the flysch truncated (fig. 19) against a wall of cretaceous rocks. We pass through that wall by the gorge of the Hirsch-sprung, and again we have undulations and slopes occupied by upper members of the series which are entirely lost on the steep side of the anticlinal. Again, at the outer or northernmost escarpment of the Grünten (fig. 18), we have the same tremendous fault as that before spoken of along the Rigi and Rossberg, showing the nagelflue and molasse in juxtaposition with the lower neocomian. In this last case, however, the molasse is rather thrown off to dip away from the secondary rocks; but along the same line of fault, and immediately to the west of the river Iller, all the mountains of nagelflue again appear to plunge directly under the zone of flysch. They there mark the grand outer line of disseverment between the molasse and all pre-existing strata, which trending from near Immenstadt in the Allgau, passes by Dörnbirn and Haslach* south of Bregenz. This same line of fracture is again magnificently displayed in the canton Appenzell, along the precipitous north-western face of the Hoher Sentis. There, the upper portions of the enormous masses of molasse and nagelflue, dipping away to the S.E. from the St. Gallen axis before-mentioned, occupy mountain pasture tracts†, whose

* At Haslach near Dörnbirn, on the right bank of the Rhine, the nummulite rock is so collocated, that any one ignorant of fossils would really believe that it passed under the limestones of the Stauffen, composed of lower and upper neocomian rocks.

† Handwyler Hohe, Kronberg, Petersalp, &c., these conglomerates range into the Speer mountain, and thence to Wesen.

sharp and peaked ridges have in some places the high inclination of 65° to 70°.

When viewed longitudinally in the little valley of Weissbad, nothing can be more striking than the aspect of these bold tertiary peaks on the one hand, and the massive cretaceous precipices on the other, under which they seem to dip*. Examination, however, shows an enormous void between these two classes of rocks. The upland valley is indeed encumbered with much detritus, as is frequently the case along such lines of fault, and for the most part fragments only of dismembered flysch, with a rare specimen of nummulite limestone, are to be seen as memorials of the vast destruction of intervening rocks which has occurred. In one spot, however, at a little cascade under the Thurm, one of the buttresses of the Sentis, I detected a portion of the flysch, which is fairly bent under the cretaceous masses of the mountain, which I believe to represent the sewer-kalk or chalk; for in the heights above this cascade, Prof. Brunner and myself reached, after some peril and labour, a zone of secondary green sandstone. M. Escher has, indeed, shown that the chief culminating masses are sewer-kalk or chalk based on greensand and neocomian. That author pointed out to me, that the Sentis group is not merely a double or triple chain, but is made up of six lines of ridges, in which the greensand and chalk are repeated with supracretaceous troughs. He has drawn for me the diagrams in the annexed plate (Pl. VII.), which are the result of his long and patient examination of this remarkable tract. These transverse sections, made at short intervals from each other, will explain better than pages of description, how the apparent alternation of formations, whose denuded edges crop out to the surface, is due to folds, the axes of which, though occasionally vertical, are usually oblique or inverted towards the high chain of the Alps, and thus often present their chief escarpment to the hills of younger tertiary conglomerate. By this arrangement, nummulitic eocene rocks (*f, g*) dip for the most part under strata of anterior age; and whilst, on the S.E. face of the mountain, they plunge towards the Alps (there regularly overlying the chalk and greensand), on the north-western side they are truncated between the molasse (*m*) on the one hand and the cretaceous rocks (*a, b, c, d*) on the other, but usually dipping under the latter.

Another most instructive section, and parallel to the above, is that which proceeds from the molasse and nagelflue, the mountain called the Speer (fig. 14, p. 200) on the N.N.W. across an inverted, inclined axis, which clearly exposes nummulite rocks and sewer-kalk on either side of a nucleus of neocomian limestone; whilst by another fold the whole series up to the flysch is displayed in a lofty basin, where the inoceramus limestone rises rapidly into the lofty mountain Lyskamm, from which, after some undulations, we see a regular descending order through the whole cretaceous rocks and the jurassic system of this region, as displayed in the cliffs on the north side of the lake of Wallenstadt.

If each Alpine region be examined in detail, and its geological fea-

* See fig. 14, p. 200, and plate of M. Escher's Sections, pl. vii. In the latter the six ridges alluded to are numbered i. to vi. I have pointed out the transition bed (*e*) and have distinguished the eocene from the cretaceous.—R. I. M.

tures laid down on maps in the manner in which L. von Buch, Prof. Studer and M. Escher de Linth are working them out, it will be seen, that although their major axes have a strike from E.N.E. to W.S.W., there are numberless local deviations, and sometimes to a very considerable extent. In fact, it is in the very nature of the formations which clasp round such ellipsoids as those before spoken of, that they should present local aberrations from any one chief line. Such divarications occur in the masses which surround the great ellipsoid of the Grisons and the canton Glarus; for although the major axis of that tract proceeds from E.N.E. to W.S.W., the strata where they conform in outline to the *ends* of the ellipse, depart considerably from the normal direction. I examined this phænomenon on the north-eastern portion of the external zone of this great ellipsoid in the company of M. Escher, viz. in the environs of the lake of Wallenstadt; and as a map of this tract was coloured for me on the spot by my companion, I have exhibited it to the Geological Society, to illustrate the phænomenon under consideration. To attempt to describe this tract in words would be in vain, and I therefore content myself with saying, that this map shows, that whilst the chief anticlinal and synclinal lines conform to the general axis of the chain, the rock masses of various ages, from the jurassic to the nummulitic rocks and flysch inclusive (which in the chief ridge of Sentis and along its outer face strike E.N.E.), are bent round to the S.E. and S. at the east end of the lake of Wallenstadt and in the valley of the Rhine near Sargans. In this short space the rocks, therefore, become strikingly divergent from the major axis, or in other words, *they fold round the extremity of the ellipsoid.* I must leave others to expatiate on the phænomenon, which will be the better understood when M. Studer shall have developed all his views, and when it may be ascertained, that the massive ellipsoids of Mont Blanc, the Finsteraarhorn, the St. Gothard, La Selvretta, &c. have been acted upon by subterranean forces peculiar to each, and yet all partaking of one common line of direction.

It is worthy of remark, that just as the metamorphism of the rocks is greater as we approach the centre of the chain, so do the sedimentary masses the more arrange themselves on the surface, as if their external configuration were intimately connected with some *grand crystalline change.* On the other hand, as we extend our researches to the outer zones of the chain, we pass over *numerous folds and breaks,* all of which are evidently referable to pure mechanical agency. Thus, on the N.W. face of the synclinal valley of Wildhaus, we meet with the system of flexures in the Hoher Sentis already alluded to (Pl. VII.), whereby the neocomian, greensand and chalk are repeated on lines trending due N.E. and S.W., and forming the ridges and troughs of that remarkable group, slightly divergent from parallelism to the true axis. In alluding to the synclinal troughs which run parallel to the major axes of the Alps, it is to be observed, that in one tract the same trough will be found unbroken, which when followed in its direction, shows different degrees of rupture. One of the troughs before alluded to in the promontory of Bürgen (figs. 9 & 10, p. 192), on the west side of the Lake of the four cantons, or in other words, the prolongation of the great synclinal occupied by the Alpnach branch of the Lake of the four cantons, is seen to constitute a good massive synclinal-formed hill, the promontory of Bürgen, in which the nummulite and flysch rocks are troughed on neocomian and cretaceous limestones; but if followed to the opposite side of the lake to Viznau, viz. in the same direction (in the space of two or three miles), that which was in a synclinal form has become the scene of that grand fault or rupture by which the upper nagelflue plunges against and apparently under the neocomian, almost to the exclusion of the nummulite and flysch rocks, fragments of which only appear (fig. 12, p. 195). Following on this line to the N.E., across the lake of Lowerz, the representatives of the nummulite rocks and flysch are intercalated, though in a highly broken condition, between the molasse and nagelflue of the Rossberg and the cretaceous rocks of the Mythen; whilst, still further to the N.E., these nummulitic rocks, so squeezed up on the flanks of the Mythen, expand into the tracts south of Einsiedeln, where I have mentioned them as having an inverted dip, or towards the axis of the chain (fig. 13, p. 197). Thus, that which is an overlap in one portion of the sides of a synclinal, and whereby an enormous transposition or slide of the masses has occurred, often occasioning the absolute destruction of copious formations along the line of fracture, on another part of the same line is, as far as external appearances go, a complete overthrow, in which the older rocks are superposed to the younger.

As the same physical relations of the rocks, whether in anticlinal or synclinal forms, are seldom persistent for more than a few leagues, and rarely in absolutely right lines, so but few of the longitudinal faults are continued for great distances without interruption or change in their conditions; and although some of them pass across transverse valleys without much deviation from their strike, it is not unfrequent to see a considerable lateral displacement, or as it were a movement "en échellon," in masses occupying the opposite sides of any broad transverse valley. In crossing the valley of the Rhine, for example, near its "débouché" into the lake of Constance at Bregenz, in the direction or continuation of the synclinal flysch valley of Wildhaus, we find a large outlier of cretaceous rock at Eschen on the right bank, which is in fact an anticlinal of neocomian, flanked by sewer-kalk or chalk, and trending N.E., whilst the chief trough or synclinal of flysch setting on to the south of Feldkirch, trends decidedly E.N.E. across the Ill*.

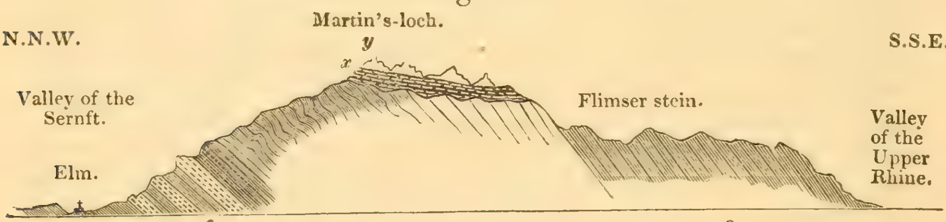
The great cretaceous masses of the Hoher Sentis are repeated or continued, it is true, in a general way in the mountains of the Hohe Kugel and the Stauffen (the insulated hill of Kamor in the valley of the Rhine serving as a link between the opposite promontories); but there the nummulite limestone, instead of being thrown off the cretaceous rocks, as in the Fähnern mountain on the left bank, as before explained (fig. 15), is abruptly collocated with an inverted dip (fig. 16) against a grand neocomian escarpment; whilst between that junction

* See Würl's Map of Switzerland, which is recommended strongly to all geographers and geologists.

and the molasse, the beds of flysch are exposed vertically in the synclinal of the valley of Oberdorf. This Dörnbirn zone of nummulite and flysch rocks is therefore the third parallel trough on the right bank of the Rhine, reckoning from the higher and central Alps, just as the zone of the same rocks in the Fähnern, which is almost lost in the fault of the Weissbad valley, is the third repetition of such formations on the left bank of that river, reckoning from the copious mass of it in the high mountains of Glarus, which extends from the heights of Harstock across the valley of the Sernft by Elm and Engi to the baths of Pfeffers and the environs of Sargans on the N.E. In one portion of the outermost of these folds, or that of the "Fähnern mountain," we have seen how symmetrically the nummulite rock and flysch overlie the cretaceous rocks; whilst on the same line on the north, a flank of the Hoher Sentis, a few miles distant only, the whole formation is obliterated by the great fault. In the second or intervening zone of Wildhaus, between the Sentis and the Kurfursten mountains, the nummulite rocks and flysch are regularly troughed upon cretaceous rocks. In the inner parallel, however, or that nearest the axis of the chain, the phænomena of inversion "en masse" so exceed in grandeur anything of which I could have formed an idea, that I must direct attention to it, particularly as I had the advantage of travelling over a lofty portion of the inverted tract in company with M. Escher, who has the exclusive merit of having worked out the data.

Grand inversion of masses in the Canton Glarus.—Ascending the valley of the Sernft by Engi to Elm, M. Escher and myself thence traversed the Martin's-loch pass, about 8000 feet above the sea; and in this ridge, which separates the canton Glarus from the Grisons, I saw the rocks which I now describe (fig. 28). The lowest

Fig. 28.



{ g. Flysch.
{ f. Nummulite rocks and Glarus slates.
x. Apocryphal limestone.
y. Crystalline schist.
o. Jura limestone.

visible strata are schists and Glarus slates, the continuation of those containing fishes, and with them sandy calcareous grits and limestones with green earth and nummulites (*f*). These bands plunge directly into and under the mountain, or to the S.S.E., and are overlaid by a very quartzose variety of the flysch (*g*) which seemed to me to be a partially altered rock. On the sloping surface of these grits we detected a few loose fragments of limestone with Inoceramus and Belemnites which seemed to have fallen from some adjacent summit. The flysch, however, continues to be the chief rock of the mountain until you reach the depression in the high ridge where the track passes into the Grisons, and the crest is there so narrow and elevated, that we positively sat upon the peaks of flysch with one leg in the Grisons and the other in Glarus. Widening to about 100 feet or more to the south-west of the mountain-path, this flysch is then directly surmounted by a mass of hard grey subcrystalline limestone (*x*) (about 150 feet thick), which is perforated by a natural tunnel or hole*, and hence the name of Martin's-loch. This limestone is, as far as my eye could discern (and it commanded several miles both to the east and west), continuously superposed to the flysch in varying and irregular thicknesses, and more or less in a tabular position, over a great area, including the peaks of Hanstock, Linterberg, and Kärpfstock. M. Escher had, indeed, sedulously followed the range, and had found in it jurassic ammonites near the Kärpfstock. Now, this limestone is in its turn distinctly overlaid by a zone of talc and mica schist (*y*), in parts having quite the aspect of a primary rock. This uppermost rock, according to M. Escher, is an integral part or continuation of the Sernft conglomerates and schists which are seen in the adjacent vale of Wallenstadt to lie beneath the whole secondary series. Before I made this section, I had supposed that the younger and nummulitic deposits might be simply plastered up on the sides of the older rocks, and not really pass under them. But the examination of the lofty and narrow ledge I had traversed checked such hypotheses, for on both sides of it I witnessed the same relations. Again, I tried to imagine, that without any inversion of the strata, metamorphism had here seized upon all the upper strata to the exclusion of the lower; but this speculation was equally fruitless; for, independently of the proof obtained by M. Escher, that the overlying limestone contained ammonites, that rock is quite unconformable to the flysch on the edges of which it reposes irregularly. I was also well assured from pretty extensive observation, that no such rock existed in any part of the supracretaceous series. In descending from the summit-ridge into the valley of the Vorder Rhein in the Grisons, I had, indeed, another and an independent proof, that the rocks *underlying* the solid limestone, with its cover of talc schist, were really of supracretaceous age, for we found in them both nummulites and the same teeth of fishes which characterize the flysch in many other tracts. At this point the fossiliferous "flysch" beneath seemed to be quite uncon-

* M. Escher informs me that the superposition of the jurassic rocks to the nummulitic extends to the Rosenlair mountain, in the canton of Bern, and to the Grisons. In the canton Glarus he has found the same relations to range from Martin's-loch to the Panix pass, where crystalline schists, equally resting on the limestone in question and on nummulite rocks, are further surmounted by a limestone with Pentacrinites, and resembling the modified inferior oolite and lias of these regions. If ever, therefore, it should be attempted to explain away the anomaly of Martin's-loch (as M. Escher well observes in a letter to me), by supposing that its enigmatical limestone and overlying chlorite schists are mere modifications of true overlying "flysch" on Jura limestone, still the superposition of the pentacrinite limestone to the whole of the series is inexplicable except on the supposition of a complete overthrow "en masse."

formable to the overlying limestones and talc schists. In proceeding, however, to the opening from the glacier of Segnes, where the waters issuing from a small lake or tarn, rush through crevices in the secondary (Oxfordian) limestone, the very same masses of flysch seem to dip under that limestone, which in its extension occupies the striking ridges called the Flimser Stein, on the left bank of the Vorder Rhein. Yet, these very same masses of jurassic limestone, so inverted in the tract described, when followed to the heights south of Pfeffers Baden, are found to plunge under the whole of the massive limestones of neocomian and cretaceous age, and finally to be surmounted by nummulite rocks and those grand masses of flysch from which the mineral waters issue ; and thus, in proceeding towards the lake of Wallenstadt, or towards the flank of the chain, all is symmetrical and each rock resumes its normal position. Whether therefore I examined the pass of Martin's-loch and its respective sides, and looked at its absolute sections, or cast my eye to a distance over the terraces of limestone surmounting flysch and nummulite rocks as seen from its lofty summit, I was convinced that M. Escher was correct in his delineation and mapping of the ground, although he ingenuously urged me to try in every way to detect some error in his views, so fully was he aware of the monstrosity of the apparent inversion*.

I dare not pretend to offer an explanation of the "modus operandi" by which such a marvellous mutation of order has been produced over so vast an area. I had indeed previously witnessed every possible contortion on a minor scale, and I might think it only necessary to amplify the *measure* of such movements. But it became necessary to admit, that the strata had been inverted, not by frequent folds, as on the sides of the lake of Altorf or in the Hoher Sentis, but in one enormous overthrow; so that over the wide horizontal area above-mentioned, the uppermost strata which might have been lying in troughs or depressions due to some grand early plication, were covered by the lateral extrusion over them of older and more crystalline masses; the latter having been forced from their central position by a movement operating from centre to flanks, or in other words, from the axial line of disturbance towards the sides of the chain. One inference, indeed, seemed certain, that if the masses have been thus inverted, there must have since occurred enormous denudations to leave the older limestone and talc schist merely as the narrow cappings which they form on the summits of the ridges in the manner represented in fig. 28. The grandeur of this phænomenon may to some extent be imagined by consulting that section; but a true conception of it can be alone formed by climbing over the ridges in which the facts are laid bare, in one of the most pictorial regions of the Alps. Not the least extraordinary feature of the phænomenon is its apparent uniformity, simplicity and grandeur, and the absence throughout the tract of those mechanical plications, which, as we remove our ob-

* The map and sections in which this startling phænomenon is recorded, are published in the work on the statistics of the Canton Glarus, by Professor Heer, previously referred to.

servations from the supposed centre of disturbance, become so manifest in the outer group of the Hoher Sentis in the same longitude. I am aware that there is a great difficulty in accounting for the lateral folds and plications of the Alpine strata, from the supposed absence of adequate central masses of erupted matter to dislodge, roll over or compress into smaller horizontal areas, strata which must once have been regularly extended in sheets. But might not the formation of great central crystalline ellipsoids, whether eruptive or metamorphic, serve in some measure to account for this? May not these ellipsoids, in being transformed and amplified, have operated as great centres of mechanical force? And with our knowledge of the position here and there of very considerable masses of true granite, may not much of that rock have acted without being visible, and may not large masses of it be hidden under unfathomable glaciers?

But leaving this enigma, let us return to the consideration of the lateral folds to which the strata of these mountains have been mechanically subjected. In them we learn not to be sceptical concerning the truth of many sections in the Alps, such in particular as those of M. Hugi, which represent rapid repetitions of lias and different jurassic formations in parallel sheets; for we need only suppose the superficial portion of narrow undulations removed by a powerful denudation, and many of the phænomena he represents would be at once realized.

I am happy to bring forward these few data at the present moment, when Professor H. Rogers, one of the authors of the undulatory or earthquake theory as applied to mountains, is in England, and when he has taken the trouble to point out to me how *some* of my facts may, as he thinks, be explained on his principles of illustration. Putting aside his theory, we have only, indeed, to look at the elaborate map of the Appalachian chain, by his brother and himself, and witness the numerous ellipses into which the palæozoic masses have there been turned, and scan the sections of these authors, based on positive data and outcrops of mineral masses worked for use, in order to comprehend how the enormous faults and slides have there occurred just where the strata have been most bent and inverted in reference to the centre of disturbance. Thus, the comparatively low chain of North America may throw light on some of the most complicated problems of our science, which could scarcely ever have been satisfactorily worked out amid the confusion of the Central Alps, such large portions of them being inaccessible to man and covered with eternal snow.

The inversion or the dipping of the strata towards the centre of a chain, so as to place the older over the younger deposits, has been a subject of wonder, and has hitherto been considered scarcely explicable upon any satisfactory hypothesis. In viewing the Ural mountains, where the same phænomenon is copiously displayed, I was disposed to account for such apparent inversion, by supposing that the broken ends of the strata had fallen into abysses or cavities produced by the extravasation of the enormous masses of igneously formed rock, which are there seen at hand as if ready to explain the facts.

But this explanation is totally inapplicable to the Appalachians. It is almost impossible also to apply this reasoning to the Alps, from the absence of masses of erupted matter adequate to account for the phænomenon by displacement. But, however we may theorize, it must be admitted, that in nearly all the alpine folds to which my attention was directed, the longer leg of each anticlinal slopes towards the centre of the chain, whilst the steeper talus or shorter leg of the flexure is away from it (see figs. 12 & 14, and Plate VII.). Besides the occurrence of this phænomenon, which is the basis of the theory of Professor Rogers, the Alps seem further to exhibit, as far as I know them, the same longitudinal faults as the Appalachians, whereby fractures having occurred either on the most bent portion, or the steep side of the anticlinal or synclinal folds, the result has been (explain it how we may) the lateral overlapping of the older rocks upon the younger. In saying that I am not prepared to subscribe to the earthquake theory, I have to thank Professor H. Rogers for having drawn diagrams to explain two of the most frequent cases of such overlap and inversion, as they occur indeed in my own sections, showing how the axes of each trough or ridge were first forced into oblique positions, followed by the fractures in question, and then by the transgressive sliding of older over newer deposits by lateral pressure. The following is his explanation.

"I have endeavoured (says Professor Rogers) in the annexed diagrams to illustrate two very common kinds of faults or dislocations occurring in regions of closely-compressed or inverted flexures. In one case (fig. 29. Nos. 1, 2 & 3) the fracture coincides, or very nearly so, with the anticlinal axis plane and the plane which cuts the two branches of the anticlinal flexure at the same angle; the other instance (fig. 30. Nos. 1, 2, 3) is where the dislocation is in the synclinal axis plane. The displacements here shown are both of them upcasts along the inclined plane of the fault. In all oblique compressed flexures, this plane of the fault *dips of necessity towards a more disturbed side of the district.* The effect of both of these classes of fracture is to bring an older set of strata superimposed in approximate parallelism of dip upon a newer series, but with opposite conditions, the anticlinal fracture inverting the beds on the side below or beyond the fault, while the synclinal fracture inverts those on the upper or nearer side: I think it will be found that the first phasis is by far the most common in the Alps. The greater part of the dislocations of the Appalachian chain are certainly of this character, the fracture being either in the anticlinal plane or a little beyond the axis, in the short inverted leg of the flexure. Most of the cases of inversion in the Alps which your interesting sections display, and to which you have kindly drawn my attention, are, I think, *simply instances of dislocation along the anticlinal planes of inverted or closely-compressed oblique flexures.* A few, however, appear to have resulted from faults along the synclinal planes. I have not here exhibited the other less usual forms of dislocation, or treated of the cases where the displacements are downthrows and not upthrows along the inclined plane of the fault."

This ingenious explanation of Professor H. Rogers may, it appears to me, be very well applied to those examples in the Alps where, as assumed by him in his diagrams, the strata of different ages have originally been continuously and conformably superposed. Such,

Fig. 29.

Fracture through the anticlinal axis-plane of an inverted flexure (the elevated mountains are to the right hand).

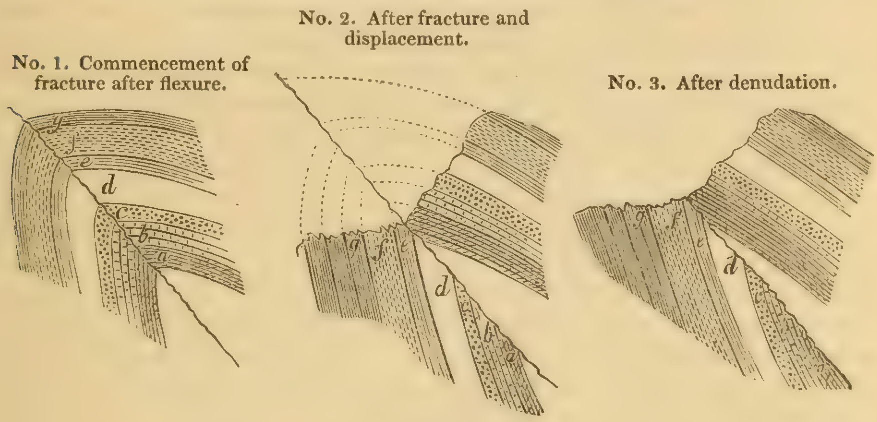
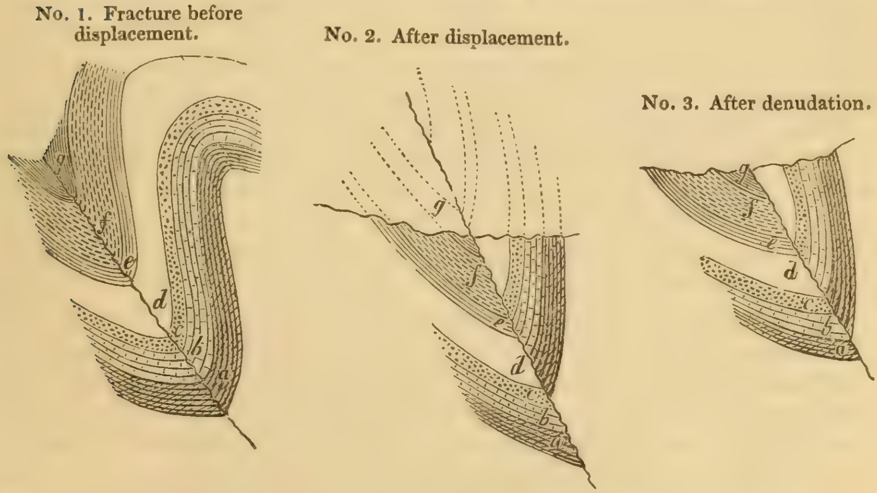


Fig. 30.

Fracture through the synclinal axis-plane of an inverted flexure.



for example, may have been the case in all those tracts where the cretaceous rocks were formerly surmounted by nummulite limestone and flysch, and where, after having been thrown into inverted anticlinals and synclinals, they were afterwards fractured and denuded in the manner described. Of this class of faults the figures 16 and 19 may be cited as very *probably* answering to the law of displacement observed in the United States*. In the first of these, near Dörnbirn,

* I say *probably*, because in the Alps the subterranean course of faults has not been ascertained by mining operations as in the United States, and examination is usually much impeded by vast quantities of detritus.

the nummulitic strata (*f*) which are inclined at an angle of about 45°, may really pass under the truncated edges of the lower neocomian limestone (*a*) in the manner represented. In fig. 19 the beds of flysch of the Bolghen may be similarly overlapped by the neocomian limestones of the Schwartzenberg in a similar manner, though probably the angle of the line of fault is different from that at Dörnbirn. In both these cases, as in many others throughout the Alps, where the pressure has been so exerted from the centre towards the flanks of the chain as to invert the axes of a series of formations *originally conformable*, the law or rule of Professor Rogers may be found to apply. On the other hand, a different method of reasoning may be necessary, in reference to the great Swiss fault between the molasse and all pre-existing rocks (see figs. 12, 13, 14, 17, &c.); for in no case was the molasse and nagelflue originally superposed conformably on the pre-existing strata out of which it has been formed. These older strata must, in fact, have undergone many of their contortions before the molasse was accumulated on their flanks, and in no instance can the latter be observed in conformable undulation with the former. In no case (as far as I know) do the molasse and nagelflue partake of any fold which has affected the older rocks. On the contrary, they are always abruptly truncated against such older strata, and more frequently with an inverted dip than otherwise. It is indeed manifest from the composition of the nagelflue, that when it was formed, the secondary rocks of the Alps, and even the nummulite rock and flysch, were hard solid masses; in fact, just in the lithological state we now find them. Again, we cannot look at the sections on the flanks of the Rigi, Hoher Sentis, &c. (figs. 12, 13, 14, pp. 195, 197, 200, &c.), where the upper conglomerate of the molasse is forced into inverted and unconformable contact with the older rocks, without perceiving that the great anticlinal of the regenerated and younger strata (*m*) is vertical, and not inverted as in the older and folded rocks. And this fact teaches us, that the forces which upheaved the molasse and nagelflue were independent of those which contorted and produced the earlier fractures in the chain.

But whatever view we may take, the phænomena of the group of the Hoher Sentis present us with very remarkable problems not easily reconcilable (see Pl. VII. p. 243). Whether viewed from the plains around the lake of Constance, or examined in its precipitous and rugged sides, few geologists would doubt that this cluster of mountains had taken up its position relative to the lower country by a great upcast*. Yet nowhere within it has M. Escher been able to detect anything like a centre of upheaval, still less any motive cause of elevation; for the highest summit is not composed of the oldest rock of the chain, viz. the lower neocomian (*a*), but, on the contrary, of the equivalent of the chalk (*d*). Its remarkable features are rapid folds (doubtless accompanied by some considerable faults), by which, in fact, the

* In my section I have hypothetically drawn the line of the great fault between the molasse and the older rocks nearly vertical, but whether it inclines away from the chain, according to the usual form of upcasts, or continues to pass under the older rocks, is not known.

group where most extended is divided, as before said, into no less than six or seven parallel ridges, with intervening troughs; and all this in a very short horizontal distance, wherein nearly all the strata from the lowest neocomian to the flysch above the nummulites are repeated over and over. Now, if these plications with vertical and inclined axes be due to any force which has proceeded from the centre of the Alps, is it not extraordinary that this group of the Hoher Sentis, so far from that centre, should exhibit this extraordinary amount of contortion, and should also in this respect differ so essentially from other parts of the zone of which it is a prolongation? for in following the same band of the calcareous mountains to the south-west, through Switzerland, it is found to be of much simpler contour; presenting seldom, if ever, more than one or two folds and a fault*.

General View of Changes in the Alps.

Whilst the inaccessible forms of large portions of the Alps, their fractures and curvatures, and the enormous piles of rubbish on their slopes, render it difficult to trace accurate sections of them, the general survey of this chain warns us not to infer the *independence of formations* from the unconformable or broken relations of any one tract. Having full confidence in the accuracy of the observations of M. Favre in the region so much examined by De Saussure,—observations the more to be admired as they have been carried out in the very spirit of his illustrious precursor,—let us admit with him that the *terrain à nummulite* near Geneva† and in parts of Savoy reposes on jurassic rocks, or neocomian limestone or greensand, just as it has been observed in the Maritime Alps by Sismonda, and near Chambery by Chamousset. Still, this is only a proof, that in such localities the intermediate cretaceous beds have either not been elaborated, or have been denuded by local causes before the deposition of the nummulite rocks commenced. Such examples of a want of regular sequence cannot be maintained, as M. Favre contends, to be proofs of independence, when set against the examples of superposition and passage into the chalk at Thones in Savoy, in the Appenzell Alps, and in the various parts of Switzerland and Bavaria above cited. The latter must be viewed as the rules of order and succession. Again, judging from the local sections near Samoens and Taninge in

* Professors Studer and Brunner have written to me on the application of the theory of Professor Rogers to the Alps. Though both of them seem to have had in a certain sense a perception of his views, still his explanations of faults appear to me to be distinct from those of any of his precursors or contemporaries. The sections of M. Dumont of the palæozoic strata of the Ardennes and the palæozoic strata around Liege make perhaps the nearest approach to them. Professor Studer had shown, that the undulations of the Jura, as described by Thurman, resulted from the elevation of the Alps (Bull. Soc. Géol. Fr. vol. ix. and Géographie Physique, t. xi. p. 235). But Professor H. Rogers is quite of a different opinion respecting the undulations of the Jura. Judging from their form, *i.e.* with the long slopes towards the French side, and their steep slopes towards the Alps, he infers, on the contrary, that the propelling force came from the Black Forest.

† Bulletin de la Soc. Géol. Fr. 2nd ser. vol. iv. pp. 999–1001.

Savoy, M. Favre believes that the flysch is as independent of the nummulite rock as the latter is of the pre-existing limestone; whilst, if the above-mentioned instance at Thones in the same region was not sufficient to prove the contrary, I have shown by many other examples, that nummulite rocks and flysch constitute one and the same natural group in which no general severance has taken place. I recur to this point, because several continental geologists have insisted on the establishment of the "independence" of formations by an amount of unconformity which in my opinion is simply due to *partial* dislocations and overlappings of the strata. Now, it is quite manifest from the examination of any large region, that movements of the subsoil have occurred in one tract both during and after the accumulation of a deposit, which extending their influence to a certain distance only, have not interfered with the continuous succession of the same deposits in a neighbouring country. Changes of level at various periods, accompanied by contortions and breaks, have often produced those transgressions from which "independence" is assumed; whilst in following out these very masses into other tracts a clear and conformable succession is developed. English geologists need, in truth, no caution on this head, for the phænomenon is well known to them, and it has been recognised on the grandest scale in North America, through the labours of our associates of that continent.

Is there then no formation in the Alps so completely and universally broken off from all other deposits that it is really independent of them all? As to the oldest sedimentary rocks of the chain, it is unquestionably true that some of them (all those at least which are affected by a rude slaty cleavage) are so essentially distinct from the deposits which followed, that we may fairly suppose that they acquired their mutations in an earlier epoch. The most distinct, however, as well as the grandest of the examples of true independence, is that of the molasse and nagelflue of Switzerland, to whose position so many references have been made. As relates to Switzerland and all the northern face of the Alps, these deposits appear to have been so completely dissevered from all pre-existing strata, as to leave a considerable geological *vacuum* between them and the eocene group. It has accordingly been seen, that there is a vast difference in the fossils of the nummulitic group of that chain and those of the succeeding molasse, a difference which induces me to class the latter rather with the older pliocene than with the miocene. But when we turn to the southern flank of the chain, we there find, as I have shown, an apparent conformity from the cretaceous rocks through both eocene and miocene into the pliocene, although the axial line, it is to be recollected, is perfectly parallel to that of Switzerland and Bavaria, where the great hiatus exists. In the Italian case, I believe that another *parallel* elevation, posterior to the great upheaval of the eocene, raised the external fringe of younger tertiary rocks into the hills of Bassano and Asolo. In treating of Italy and the Apennines, I shall, indeed, endeavour to show that those portions of the sections of the tertiary series which are either denuded or imperfectly seen in the tract between the Brenta and the Piave, are taken up and clearly displayed in the Monferrato ridge, and that the Superga exhibits, on the one hand, a downward transition from what has been considered true and pure miocene into nummulitic strata, and upwards, on the other, into the richest subapennine or pliocene marls and sands. The great hiatus on the northern flank of the Alps may represent, perhaps, the upper portion of eocene, and the lower part of what has been termed the miocene age, whilst on the south, evidences have been left, of apparent transitions from one to the other.

The conclusion therefore is, that without quitting the Alps and their immediate flanks, we may argue for or against the independence of several formations, according to the tract we survey. In England the coal is generally conformable to the mountain or carboniferous limestone. But now we know, that what is true in England and the west of Europe, is not so in certain parts of Bohemia and Poland. In these two countries a great dislocation has taken place after the deposition of the mountain or carboniferous limestone with its large Producti, and before the accumulation of the overlying coal-fields; the former being highly inclined together with Devonian and other palæozoic rocks, whilst the latter are horizontal.

Nothing, however, that I have stated must be taken as militating against the indisputable phænomena of dislocations having occurred in one region whilst adjacent countries remained quiescent,—phænomena which often enable us to mark the æras of such disturbances. It is not against such general views of M. É. de Beaumont that I contend, but simply against the abuse of them, in the hands of those who would magnify into too great importance local and partial lines of rupture. At the same time, I cannot doubt that great mutations of outline have taken place at different periods, not only in and along the same chain of mountains on lines parallel to each other, but even at *different periods upon the very same line*. Judging from the analogies in existing nature, such events might well indeed be supposed to happen upon any one line of fissure, where the earth's crust had been once much weakened by rupture. On this point I may revert to proofs, cited by myself in the north-eastern portion of the Silurian region of the British Isles, to show that similarly constituted igneous matter had been successively extruded along the same line of fissure or vent of habitual eruption, at one period mingling and alternating with the Silurian sediments, afterwards throwing them on edge, next affecting carboniferous strata which had been deposited on the edges of the Silurian rocks, and at a subsequent epoch cutting in dykes through the horizontal new red sandstone, thereby isolating a basin of lias*. *Now, all this occurred upon one and the same line at those successive epochs.*

In concluding this portion of the memoir, I must further be excused when I refer to another chapter of the 'Silurian System†' for what I consider to be a true delineation of Alpine phænomena, although on a smaller scale. In the Alps, as in Siluria, we see local divergent strikes, sometimes of considerable extent, amidst rocks of the same

* Silurian System, pp. 294 *et seq.*

† See Chapter XLII. p. 572.

age, and parallelism of masses which were formed at different epochs, and in both regions we trace the disturbance and transgression of certain strata in one tract, and their inosculation and quiet transition in another.

In the preceding pages I have endeavoured to present one general view of the successive formations of the Alps, from the earliest periods in which there are traces of life, until that grand rupture occurred, by which the youngest tertiary deposits of the north flank of the chain underwent those tremendous movements, which left them in their highly-inclined and apparently inverted positions. With the exception of the evidences of a very limited terrestrial vegetation afforded by some of the older strata, and again by the lower portion of the eocene or nummulitic group (which can be accounted for by vegetable matter having been drifted into bays or estuaries), nearly all the sedimentary rocks bespeak, through their imbedded organic remains, a continuous accumulation under the sea. Passing by for the present the palæozoic rocks and the trias, as yet only known in the Eastern Alps, and limiting our attention to the Western Alps, we cannot view the grand succession of jurassic, cretaceous and nummulitic formations without perceiving, that although some of them were unquestionably formed in shallow water, even these must have been depressed to very great depths in order to account for the copious and continuous superposition of other and younger marine deposits of vast thickness. In appealing to the series of natural-history records as written on the walls of the Alps, we find that extensive and sometimes entire changes in the animals of these seas took place, even when the beds in which their relics are now entombed appear to have succeeded each other without any general physical fractures or derangements of the then existing surface. In no case is this so remarkable, however, as when the nummulitic or eocene group surmounts by conformable transition the uppermost member of the cretaceous system.

At length, however, a period arrived, when all these great masses, which for the most part had hitherto been in a submarine condition, were elevated and desiccated, so as to constitute *terra firma*, probably in the form of a rocky and abrupt island. It was this land, of whose altitude we can now form no accurate idea, which furnished the pebbles, sand, marl and other materials which compose the molasse and nagelflue. The absence of all links to connect this molasse of the Northern Alps with the pre-existing eocene strata coincides, therefore, with the facts, that, owing to disturbance and elevation, the older tertiary strata constituted terrestrial masses, before the earliest-formed pebbles or sand of the nagelflue were deposited. In this way the vast hiatus between the one set of rocks and the other is well explained. In examining the molasse, we are assured by its fossil remains, whether animal or vegetable, that during the very long period which must have elapsed during its increment, the climate must have been much warmer than that of the same region in the present day. The arborescent palms and intertropical plants which then grew upon the adjacent lands of the Alps and the Jura, the rhinoceros and other large herbivorous quadrupeds which browsed upon them, the large tortoises and the great aquatic salamanders of the lakes, as well as the marine shells of the then bays of the sea, are all unanswerable evidences of a very different climate from that which now prevails. So far we can without difficulty picture to ourselves the former state of things during the accumulation of the molasse. But when we attempt satisfactorily to analyse the physical changes even of this æra, we encounter considerable difficulties. The boldest speculator may be well startled when he is called upon to explain the *modus operandi* by which regularly stratified masses, thousands of feet thick and for the most part formed under fresh water, have been piled up one on the other. He may at first suppose that the well-rounded Alpine pebbles in these strata resulted from the action of various rivers; but a survey of the region soon convinces him that such local causes would be wholly inadequate to explain such a general phænomenon. The grandeur, width, depth, and, above all, the longitudinal persistence of this enormous mound of detrital, yet finely laminated materials, ranging as it does *along the whole external northern face of the chain*, can never be explained by the action of separate rivers which issued from openings into insular lands, unquestionably of much less height than the present Alps. Such lands could only give rise to small partial deltas, each streaming out from the centre of their origin like spokes in a wheel, and could never have produced the one gigantic accumulation of the molasse and nagelflue, which does not run far up into the recesses of the Alps, but constitutes, on the contrary, their broad, external barrier. It may, indeed, be suggested that the detritus resulting from innumerable small torrents descending from a precipitous rocky isle, were accumulated on a steep shelving shore, like that of the present Maritime Alps; but however this may have been, it is manifest that the bottom of the waters which bathed that shore, whether freshwater, brackish or marine, must have been successively depressed to enormous depths. This long-continued depression can indeed alone enable us to account for the heaping-up of these subaqueous materials throughout such a thickness, and consequently during so long a period. It is also self-evident, that whilst they were depositing, the materials of the molasse must have been arranged in strata which sloped away from their parent rocks of the Alps.

At this point, then, in the history of these mountains, we can arrive by an interpretation of the materials in our hands. But with the close of the molasse period, a change came over the surface, compared with which all antecedent phænomena fade away in importance. The very deposits of molasse and pebbles, which till then formed sloping deposits on the shore, or more or less grand horizontal masses at certain distances from it, suddenly underwent those powerful upheavals parallel to the lines of dislocation of the adjacent chain;—movements which not only threw up horizontal strata into vertical axes, but cast down the youngest accumulations of that long period into positions which make them appear to pass under the very rocks out of which they had been formed. Although in estimating such gigantic movements the powers of imagination are at fault, surely it is not unphilosophical, with such unanswerable data before us, to believe that in those days the crust of the earth was affected by forces of infinitely greater intensity than those which now prevail. That the elevation, dislocation and apparent inversion of the molasse was a sudden operation or catastrophe, is clearly demonstrated, both by the physical relations of the strata of that age to those which succeeded them, and by proofs of an immediate change of climate, probably due to a great rise of new lands, and the elevation to much higher altitudes of all the country which preexisted. In attestation of both these inferences, we see the ends of the inclined, and often vertical beds of molasse, whose contents bespeak a warm or Mediterranean climate, covered abruptly by horizontal accumulations of ancient alluvia, the animals and vegetables in which announce a climate little, if at all, different from that of the present day. The extent to which these old water-worn alluvia once filled up the valleys of the Alps, thereby indicating that the chain was then of less altitude than at present—the formation of ancient glaciers—the transport of huge erratic blocks to vast distances, and the great and irregular elevations and deep denudations which the whole area has undergone, are all phænomena pertaining to this most interesting chain, on which, though much has already been said, I hope at a future day to express my opinions.

Part II.

On the Cretaceous and Nummulitic Rocks of the Carpathian Mountains.

In 1843 I examined the northern flank of the Tatra group of the Carpathian mountains with Professor Zeuschner, and although I never published a detailed account of that survey, I gave the general results of it in the work upon Russia and the Ural Mountains. I then believed that all the Carpathian sandstones, as well as the flysch of the Alps, were of cretaceous age; but I now present a section (fig. 31) accompanied by explanations, to show, that whilst many of these sandstones are of secondary age, there are others which, surmounting true nummulitic eocene deposits, are clearly tertiary. This section is therefore now brought forward, both to confirm what has been stated in the preceding pages, and to extend and modify the view which I previously entertained concerning the classification of the formations on the flanks of the Carpathian mountains†.

The lofty axis of the Tatra is occupied by granitic rocks, which on their northern side are flanked, first by talc schists, and next by hard quartzose and altered sandstones, concerning whose age I will not speculate (see 1 & 2 of fig. 31). These rocks are surmounted by great masses of hard subcrystalline limestone (3), often in a state of marble, and with few traces of regular bedding. Near the iron forges of Zagopane, these limestones are visibly stratified, plunging to the north, and they there alternate with a schistose shale (3*) in which the *Terebratula biplicata* occurs in abundance. Again, in the turreted ridges called Muran (or the Wall) the limestones also dip to

† See Russia and the Ural Mountains, vol. i. p. 264.

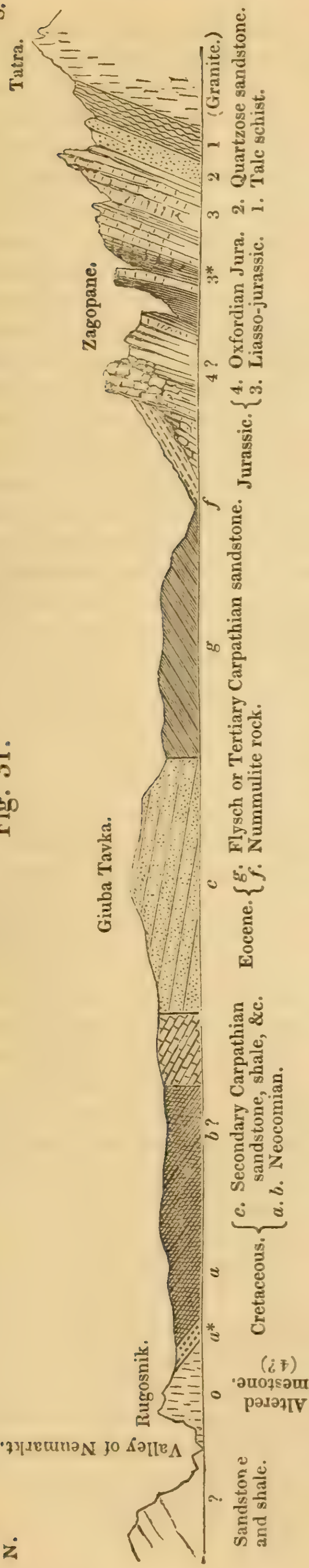


Fig. 31.

the north, but with many undulations and fractures, and in them the following fossils are found, as identified by M. Zeuschner:—*Ammonites Walcotti, A. Bucklandi, A. annularis, Nautilus acutus* (V. Buch), *Belemnites digitalis, Terebratula biplicata, Spirifer Walcotti, S. rostratus,* with Aptychi, Cidarites, Pentacrinites, and some remains of ichthyolites. This group of fossils leaves no doubt, that the limestones containing them belong to the liasso-jurassic limestones. In the interval between the spots where these fossils are collected and the outer edge of the Tatra, there are other limestones in a more or less crystalline state, which, compressed by high inclination into a small horizontal distance, are difficult of access on account of dense woods and their rugged outline. To these I cannot pretend to assign a precise age. On their flank, and particularly on the left bank of the Biala Dujanec, where that stream issues from the gorge of Zagopane, they are unconformably and irregularly covered by a band of nummulitic limestone (*f*), which dips off at an angle of 35° to 40° and passes under a portion of certain schists, sandstones and impure limestones (*g*), which occupy a portion of the hilly tract extending northwards to the valley of Neumarkt. This nummulite limestone is thick-bedded, of grey colour, in part a coarse calcareous grit, and even a small conglomerate made up of fragments of the underlying limestones, and is much charged with magnesia. It contains nummulites throughout a thickness of upwards of 100 feet, but most abundantly in the upper beds. Among these, besides the *Nummulina globulus*, Leym.?, there is the large species *N. planospira*?, so common in the Alps and elsewhere; and these typical fossils are also, as in many other regions cited, associated with certain pectens, ostreæ, &c., and large echinoderms, &c. In short, the fossil assemblage of genera and forms is so precisely the same as that seen in the supracretaceous nummulitic rocks of the Alps, that no doubt can exist as to the age of the deposit. Though denuded at this point, the nummulitic rock is conformably followed to the north, on the other side of a small brook, by dark shale and grey and green sandstone (*g*), which as certainly represent a portion of the upper alpine flysch. Thus far all is clear. But in traversing the undulating ridges between this spot and Wieliczka or Cracow on the north, a very complicated and broken series of sandstones, shale and limestones is passed over, the greater part of which have hitherto been gregariously merged under the name of Carpathian sandstone. Now, as secondary fossils have been found in some of them near Cracow, it becomes absolutely necessary to endeavour to explain the apparent anomaly and to separate the above-mentioned tertiary flysch, which distinctly overlies the nummulitic eocene, from other rocks, often closely resembling it in mineral characters, which are as certainly of cretaceous and secondary age.

Scarcely has the traveller advanced a few miles from the outer edge of the Tatra to the north, than he meets with a low ridge of limestone, which runs parallel to the main chain by Zafflary and Rugosnik. On inspecting this limestone (*o* of fig. 31) I had no doubt, that its mural form and altered condition were due to an upcast along a line of eruption. This supposition was, indeed, confirmed by the existence of an outburst of porphyry a few miles to the east, precisely on the strike of the beds. From the names of the fossils first collected by Professor Zeuschner, such as *Ammonites Murchisonæ*, *A. Conybeari*, *A. biplex*, *A. Tatricus*, *Terebratula dyphia*, and others, it appeared probable that this rock was simply an upcast on a small scale of some upper portion of the great adjacent jurassic chain, which had been upheaved through overlying schists and sandstones. More careful examination of other fossils collected from this locality by Zeuschner has, as Count Keyserling informs me, detected at least eight species of the lower neocomian, viz. *Ammonites Calypso*, *A. Morellianus*, *A. diphyllus*, *A. picturatus*, *A. subfimbriatus*, *A. fascicularis*, with *Scaphites Ivanii*, &c. In this collocation (even if the names in the first list be correct) there need, it appears to me, be no contradiction; for it is the usual case in the Alps, that strata with Oxfordian fossils are at once overlaid by the lower neocomian limestone. The physical features, indeed, favour this view; for the mass of the lowest limestone visible is a highly altered, veined and reddish rock, in many parts amorphous and crystalline, with many slickenside surfaces, and in parts a breccia, which presenting bluff escarpments to the valley of Neumarkt, is overlaid to the south, as represented in the diagram, by dark shale and nodules of ironstone, and then by thinner-bedded, scaly, greyish-white limestones (*a**), which may well represent the lower neocomian, and in which I doubt not the last-mentioned species were found. I persist, therefore, in my belief that these limestones were really upheaved, along a fissure parallel to the main Carpathian chain†. It is indeed manifest (see fig. 31) that the north and south edges of this trough of sandstones are entirely dissimilar; for the strata constituting its north end rest upon limestones

† See Russia in Europe and the Ural Mountains, vol. i. p. 264.

containing cretaceous and jurassic fossils; whilst its southern limb is composed of nummulitic rocks of eocene age resting on lias.

Although I had not sufficient time at my disposal to determine the detailed relations of all the strata between the external face of the Tatra and the valley of Neumarkt, a section with which M. Zeuschner favoured me sufficiently explains, that the flysch (*g*) which overlies the nummulites, and dips to the north, is met by a great mass of Carpathian sandstone, &c., which occupying the Giuba Tavka, is inclined to the south in the manner represented in fig. 31. Subjected to other fractures, this sandstone (probably its lower member) is found a little further northwards to overlie conformably the calcareous ridge (*o*) before spoken of, in the upper part of which neocomian or lower greensand fossils occur, and whose lower division is characterized by Oxfordian jurassic forms. In this way I can readily understand how the nummulitic rock (*f*) and its overlying member (*g*) should really be eocene, whilst the great mass of Carpathian sandstone (*c*) which is separated from the former by a fault, may, as I have always thought, represent parts of the cretaceous system (upper greensand, &c.?). I can also now well understand how the equivalents of the lower greensand (*a*, *b*) should have afforded the above-mentioned characteristic fossils; the whole reposing on an upcast outer ridge of jurassic limestone. Having convinced myself that the nummulitic rocks on the north flank of the Tatra are eocene, I cannot doubt that the masses thereof which lie on the south side of that chain are of similar age. Thus, the sections of M. Zeuschner would lead me to believe, that the nummulitic rocks and overlying sandstones of the valley of Kradak, which he considers to be jurassic, are really the true eocene, which there reposing on lower Jura are truncated against the granite of the higher Tatra. Other nummulitic rocks are repeated to the south of the lesser Tatra.

For all these reasons I feel assured, that Professor Zeuschner has erred in placing this nummulitic limestone in the jurassic series, or at the base of the whole external zone of the Carpathian sandstones and limestones. For, whatever may be the age of the formation on which this nummulitic rock reposes, its zoological characters are unmistakeable; whilst both on the north and south sides of the Tatra, it is immediately covered by strata which represent the flysch.

In the Carpathians, as in the Alps and Italy, great confusion has arisen from deciding on the age of sandstones by their mere mineral characters; for, although it is manifest that rocks of this aspect and containing fucoids clearly overlie the nummulitic limestone, there are other cases, like those of Gosau and other parts of the Eastern Alps, where the lithological characters of the eocene greensand descend far into the cretaceous system. The highly contorted, broken and dislocated region between Neumarkt and Rugosnik on the south and Cracow on the north, over which I passed, affords a good illustration of this point, and also of the extreme difficulty, in the absence of fossils, of being able to draw any neat line of demarcation between some of these sandstones and schists. I have repeatedly noted, that the presence of fucoids can never be accepted as any test of the age of rocks; inasmuch as these fossils have a vertical range from the secondary greensand upwards to beds thousands of feet above the equivalent of the white chalk. In the Carpathians, the same or nearly the same lithological character prevails from the strata representing the lower neocomian up into beds above the nummulitic limestone; and if the normal relations of this region were not excessively distorted, we should, I have no doubt, see that the younger secondary and older tertiary there often pass into each other, preserving the same mineral types.

Thus, if the section (fig. 31) from the flanks of the Tatra be continued from the environs of Zafflary and the valley of Neumarkt to the valley of the Vistula, we may interpret the sandstones, conglomerates and schists of that tract to be both of secondary and tertiary age; for, notwithstanding many dislocations and contortions, it appeared to me, that on the whole the grey sandstones of the hills north of the Biala Dunajec dip away from the axis of Zafflary and Rugosnik, in which jurassic and lower neocomian fossils occur. In this way the hills near Svienty Cruz, about 2000 feet above the sea, which contain fragments of coaly matter and thin seams of lignite, may possibly be paralleled with the strata, which at the outer zone of all the series of similar aspect, extending from Liebertoft to the hills south of Wieliczka, contain what are called upper neocomian, or lower greensand fossils. However this may be, one of the underlying masses dips to the north, and the other or outer zone to the south. The result is, that the greater portion of the intervening strata lie in a rudely undulating and broken trough; and thus I am disposed to think, until contradictory fossil proofs be obtained, that a portion of the series north of Svienty Sebastian, consisting of thick-bedded macigno sandstone of grey and grass-green colours with white veins, (which at Struya and in the hill of Kotan near Luboin are surmounted by dark shale and schist,) and also the strata extending to the valley of the Rabba, may stand in the place of the supracretaceous macigno alpin or upper flysch of the Alps.

But wherever the white chalk or its representative and the nummulitic limestone are absent on the flanks of the Carpathians, and fossils cannot be detected, the geologist must be at fault. Fortunately, however, the palæontological researches of Prof. Zeuschner have proved, that many of these green sandstones, schists and conglomerates are of true cretaceous age. Thus, in the ravines near Liebertoft, two Polish miles south of Cracow, M. Zeuschner led me into gorges where grey, flaglike calcareous grits, occasionally passing almost into conglomerates with black fragments (lithologically, indeed, undistinguishable from supracretaceous rocks), contain ammonites, belemnites, and a species of Aptychus. In these strata, as they range thence towards Wieliczka, M. Zeuschner has since detected *Belemnites bipartitus* (Blainv.), *B. pistilliformis* (Bl.), *B. dilatatus* (Bl.), which present on the whole adequate proof that these sandy beds represent the neocomian. In short, they resemble to some extent the English type of lower greensand. In the county of Trentschin, between Orlova and Podkrad, the so-called Carpathian sandstone, on the other hand, is probably the upper greensand; for, along the space of half a German mile, it there contains *Gryphæa columba*, *Cardium Hillanum*, and in other places (Zips, Zglo, Wercizer) *Pholadomya Esmarckii*; whilst plants referred by Göppert to the upper greensand, including *Salicites crassifolius*, occur at Kluknawa and Petzoldtii.

It is thus manifest, that in the generic word Carpathian sandstone, as in the words "Wiener sandstein," "flysch" and "macigno," deposits of lower greensand, upper greensand, and of supracretaceous or eocene greensand have been confounded. The value, therefore, of the section between Zagopane and Zafflary (fig. 31) is apparent, because the order of superposition there clearly establishes a parallel between the schists and sandstone overlying the nummulite rocks and the great mass of strata of that age in the Alps. On the other hand, the fossil researches of M. Zeuschner afford clear evidence, that other and large portions of this sandy argillaceous series are equivalents of members of the cretaceous system*. This is precisely what I have indicated, where the mineral representatives of the white chalk of Switzerland and Bavaria approach the Eastern Alps, and where the whole series between the neocomian limestone and the molasse or nagelflue assumes its arenaceous or northern type.

Part III.

On the chief Formations of the Apennines and Italy.

Although less complicated than the Alps, and not containing a vestige of the older formations which have been detected in parts of that chain, the Apennines and their flanks offer many difficult problems, which even at this day remain in some degree obscure. The labours of native geologists in the last few years have, it is true, done much to clear away these doubts, the proofs of which will be found in the proceedings of the last three meetings of the men of science of Italy†. After personal inspection of some of the tracts in which the leading questions have been agitated, I will now endeavour to point out the extent to which the structure of the peninsula agrees with that of the Alps. In the first place, then, the whole of the palæozoic series is wanting in the continent of Italy, nor are there sufficient grounds for supposing that the trias has any existence in it. For although the Marquess Pareto, one of the leaders of our science in Italy, has suggested, that the conglomerate called Verrucano (the

* Count Keyserling, to whom I am indebted for a clear and concise view of the last researches of Prof. Zeuschner, reminds me, that the curious body called a Sphærosiderites, and described by Professor Glocker of Breslau (Acta Acad. Cæs. Leop. Carol. Nat. Curios. tom. xix. part 2. p. 673 and tab. 79), which M. von Buch first proclaimed to be a Nautilus, has under the examination of M. von Hauer, jun., proved to be the *Nautilus plicatus* (Fitton) of the lower greensand, or *N. requienianus* (D'Orb.). This fossil occurs in Moravia near Frankstatt and Tickau, in what is called by M. von Hauer "*Wiener sandstein* !" For a full account of the secondary fossils of the Carpathians, see Zeuschner's memoir on the structure of the Tatra Verh. R.K. Miner. Gesr. St. Petersburgh, 1847, which I only received when this sheet was in print. So far as I have had time to study it, this memoir would rather confirm my opinions.—June 25.

† See the volumes of the "Riunione degli Scienziati Italiani" of the Milan, Genoa and Venice meetings.

lowest known sedimentary stratum) may be the equivalent of the trias, that opinion cannot be adopted without some fossil evidences. Whilst the mainland is void of palæozoic rocks, they exist however in Sardinia, where they were discovered by General della Marmora. These rocks prove by their fossils to be true Silurian limestones and schists*. In Sardinia, deposits with species of palæozoic coal plants also occur, but unluckily the political troubles of Italy prevented my examination of these rocks. General della Marmora has, however, left no spot of the island unsurveyed, and having made a beautiful topographical map of it, he will soon complete his important work, and inform us whether the coal deposits of that island, like those of Oporto described by Mr. Sharpe, are associated with the Silurian rocks, or are of subsequent age. The existence of Lower Silurian rocks in Portugal, as recently made known to us by Mr. Sharpe†—the prevalence of Devonian fossils in the north of Spain, and the presence of both Silurian and Devonian strata in Morocco‡, where they were first recognised by M. Coquand—their persistence along the African Atlas and their reappearance near Constantinople, are data sufficient to enable us to picture to ourselves a vast girdle of palæozoic rocks of which the Alps and the Pyrenees formed the northern and the north-western limits, and which, having been elevated from beneath the sea at a very ancient period, have constituted the shores of a large Mediterranean in which the secondary and tertiary rocks of Italy have since been accumulated. In this sense, Sardinia may perhaps be only viewed as a detached island in this ancient basin.

Excluding from our present consideration the eruptive rocks, whether plutonic or volcanic, which have perforated the subsoil of Italy in so many places, and not now alluding to certain ancient crystalline rocks of Calabria and Sicily, it may be said that the chief mineral masses of the peninsula in ascending order are—1st, limestones and schists; 2ndly, hard sandstones and impure limestones often compact; and 3rdly, marls, sands and conglomerates. The lowest of these great lithological groups embraces in some regions both the jurassic and cretaceous systems; the second or arenaceous group represents in given countries both the upper cretaceous and that which I have shown to be the eocene of the Alps; whilst the third contains the miocene, pliocene, and other overlying strata. To this general litho-

* General della Marmora kindly sent to me a collection of those fossils, including orthoceratites and graptolites. These were examined and partially named by M. de Verneuil, to whom I transmitted them; but having lost that memorandum, which was forwarded to me in Italy, I subsequently referred these fossils to Mr. Sharpe, who is satisfied that they belong to the Lower Silurian group. In addition to orthoceratites, graptolites, crinoids, &c., Mr. Sharpe recognises eight or nine species of Orthis, among the best-preserved of which are the *Orthis patera* (Salter, MSS.), common near Bala, and *O. Lusitanica* (Sharpe), of the Lower Silurian rocks of Vallongo near Oporto, closely related to the *O. flabellulum*, Sow. Sil. Syst. The *Spirifer terebratuliformis* (M'Coy) also occurs,—a species of the Lower Silurian rocks of Cumberland and Ireland.

† See Journ. Geol. Soc. Lond. vol. v. p. 142, and pl. 6. fig. 5 (Russia in Europe and Ural Mountains, Map of).

‡ For the Devonian rocks of the Asturias see Paillette's memoir, Bull. Soc. Géol. de France, vol. ii. p. 439, and for the palæozoic rocks of Morocco see id. vol. iv. p. 1188.

logical arrangement there are, however, local exceptions of considerable extent. In many tracts, also, the absence or extreme rarity of fossils, and the rapid undulations and frequent breaks in the strata, render it very difficult closely to identify each rock-formation with its equivalent in other parts of Europe. This last remark applies chiefly to the rocks of jurassic and cretaceous age; for the great masses of the hard sandstone or macigno, particularly where it is associated with nummulites, are unquestionably supracretaceous or eocene; whilst each of the younger deposits which overlie them is easily referable, both by order of superposition and abundant organic remains, to its respective place in the tertiary series.

In his recently published general geological map of Italy and its adjacent isles, M. Collegno having inserted the Silurian rocks of Sardinia as the lowest known sedimentary deposit, attempts two divisions only of all the rock masses of the peninsula beneath the miocene. The lowest of these, from the verrucano conglomerate upwards to the Oxfordian Jura, is coloured as jurassic; whilst all the overlying strata, whether they represent the neocomian, upper greensand and chalk, together with the nummulitic limestones and macigno, are classed together as cretaceous. It will be readily understood, from what has been said of the Alps, that I must object to the arbitrary union of the two last-mentioned masses with the cretaceous rocks; and hence one of my chief objects will be to show, that in Italy, as in the Alps, the nummulitic and upper macigno group is also of eocene age. I shall further indicate the existence of a natural succession from the top of the eocene or bottom of the miocene up into the pliocene, wherein the fossils exhibit a zoological transition into the latter period. But before I enter on these prominent points of this part of the memoir, I will first say a few words on the jurassic rocks, which are the oldest in which organic remains have been discovered in the peninsula, and then give a brief sketch of the true cretaceous rocks which succeed to them.

The best key to an acquaintance with the lowest strata containing organic remains, with which I am acquainted, is that which is exhibited in the promontories of the gulf of La Spezia and the adjacent parallel ridges of the Apuan Alps. This tract has long been known to English and French geologists by the able description of Sir Henry De la Beche, published many years ago, and to Italians by a memoir of M. Guidoni *. Even at the time when he wrote, Sir H. De la Beche suggested, that the fossils found on the west side of the bay were probably of oolitic or jurassic age, though from their peculiar characters and the supposed presence among them of orthoceratites and goniatites (the latter being then called ammonites of the coal-fields), he very properly left the question somewhat open. But since then, additional collections and a rigid examination of the organic remains have settled the question. The supposed small orthoceratites are found to be simply the alveoli of belemnites, and the ammonites, though not occurring in England, belong to forms known in the jurassic series of Southern Europe. Grouping the observations of his contemporaries, and adding fresh data of his own, the

* See Trans. Géol. Soc. Fr. 1ere sér. vol. i. p. 23, and Giornale Ligustico, 1828.

late Professor Pilla* has recently given a section across the gulf of La Spezia, with the main points of which I entirely agree, particularly in proving, that the ammonitiferous band is not the oldest limestone of the tract, as was formerly supposed, but, on the contrary, is the youngest of its Jura deposits. In any attempt to classify the jurassic rocks of Italy, it must be admitted, that they differ so much from the types of Northern Europe, whether in the composition of the rocks or in the paucity and peculiarity of their fossils, that English geologists will agree with me in thinking, that it is even more unwise than in the Alps to endeavour to force their divisions into too close an accordance with our well-known and clearly-characterized British formations. The true doctrine on this point has, indeed, been clearly laid down by Von Buch in a masterly generalization, in which, dwelling on certain marked fossils only, which pervade the Alps, Carpathians and Italy, he has signalized the existence of two great bands, the lower of which may be termed Jura-liassic; the other and overlying mass, the equivalent of the Oxford oolite and clay. I have already indicated in a general manner how this classification is applicable to the Alps, and I have now only to add, that though it has been as yet much less clearly developed in Italy, there are sufficient evidences of its value among the undulations of the Apennines and their flanking parallel ridges.

Jurassic formations in the gulf of La Spezia, in the adjoining mountains of the Apuan Alps, and in the Monti Pisani, &c.—The promontories which flank the long and deep bay of La Spezia on the E. and W. are composed of limestones, which, trending from N.N.W. to S.S.E., are parallel to the loftier ridges of the same age, which further in the interior and to the south constitute the serrated chain of Carrara, Massa and Serravezza, and are, after a short interval, reproduced in the Pisan hills. After looking at the latter I walked over the Apuan Alps, passing from Gallicano in the valley of the Serchio on the east, by the peaks of Le Pannie and the pass of Petrosciano to Stazzemma and Serravezza; and then flanking the western zone of these Alps by Massa and Carrara to Sarzana, I traversed to La Spezia. If I had seen the calcareous masses in the Apuan Alps only as they there appear in the form of dolomites, rauch-kalk, and many varieties of ornamental and statuary marble, I should have been wholly unprepared to admit that they could be the equivalents of the liassic and jurassic series. But I satisfied myself that all these crystalline rocks, even where they rise into the lofty peaks of Altissimo, are simply altered masses, which in their prolongation to the Pisan hills contain fossils. Among the lowest strata are crystalline schists and pebbly conglomerate or verrucano. The geological equivalent of this conglomerate has been much discussed; some geologists, like M. Pilla, desiring to prove it to be palæozoic; others, like Pareto as before said, believing it to represent the trias; and others, including Collegno, viewing it simply as the base of the lias. In the mean-

* Unhappily cut off in the flower of his age at Mantua, in the late war in the north of Italy. I had not the advantage of being acquainted with the memoir of Professor Pilla when I examined La Spezia, but I was aware of his views in general, as also of those of M. Collegno, who communicated a description of the tract to the meeting of the Italian men of science at Venice, in which he specially adverted to a great longitudinal fault.

time, no trace of organisms having been detected in the verrucano, it is enough to repeat, that it underlies the *fossiliferous* liasso-jurassic limestones. The lowest masses in the deep gorges near Stazzemma are the well-known mottled "Bardiglio" and other marbles. These are overlaid by schists with quartz veins, which have been converted into dark slates having a true cleavage, and are largely worked for use. The latter are covered by massive buttresses of cavernous "rauch-kalk," in parts graduating into a black and dark dolomite forming picturesque peaks. On the eastern side of the range this massive buttress is irregularly overlapped by lighter-coloured limestones with flints, possibly the representative of the neocomian limestones, which in their turn throw off macigno and other overlying rocks. In ascertaining that the crystalline marbles of Carrara are really altered jurassic rocks, Professor Pilla has shown, that the dark-coloured fossiliferous limestone of the valley of the Tecchia, which contains the same fossils as the marble of Porto Venere, can be followed until it graduates by a change of colour and crystallization into the pure white marble of Carrara*. Professor Savi admits that the mineral masses exhibit the same general succession in the Pietre Santine and Apuan Alps as in the Pisan hills†. Now the latter, which I examined, are unquestionably for the most part of jurassic, or of what some geologists may call Jura-liassic age, as proved by fossils.

In the parallel of Carrara and to the north of that place, the white marble rocks, forming regular strata, rise up with associated schists into the lofty peaks of Altissimo, &c., and dipping to the W. and N.N.W. form the eastern boundary of a great trough watered by the Magra, the centre of which, occupied by tertiary and alluvial accumulations (Caniparolo and Sarzana), is flanked on either side by low hills of macigno, the strata of which repose, on the east, upon the limestones of the Apuan Alps, and on the west, upon the calcareous promontory that forms the eastern side of the gulf of La Spezia.

When this promontory is surveyed in the coast cliffs between the headland of Ponte Corvo near the mouth of the Magra and the town of La Spezia, it is seen to be made up, on a miniature scale, of nearly all the varieties of limestone, schist, breccia, rauch-kalk and marble, which constitute the lofty parallel chain of the Apuan Alps. I made a detailed examination of all the strata from the south of Capo Corvo, by Porto Telaro to the old fort of St. Bartolommeo, and found that there was there the same ascending order as in the Apuan Alps, and I was therefore convinced that it was simply a less elevated parallel fold of similar rock-masses (fig. 32). The lower strata are grey, calcareous schists, courses of scaly limestone, in parts highly altered, overlapped by a strong band of white, thick-bedded, impure, statuary marble, with a schistose lamination. This passes up into a concretionary, mottled, purple and white limestone, large calcareous geodes being arranged in the laminæ of deposit in a base of glossy purple and green schist. This calcareous group (1) is

* Bull. Soc. Géol. de France, 1847, vol. iv. p. 1069.

† Considerazioni sulla struttura geologica delle Montagne Pietre Santine, dal Prof. Cav. Paolo Savi: Pisa, 1847.

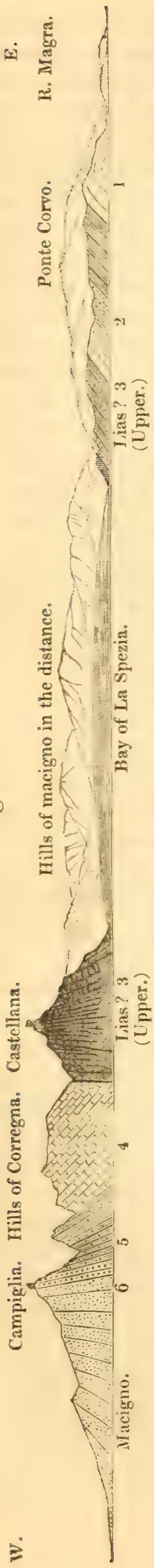


Fig. 32.

surmounted by a quartzo-schistose mass (2), which presents the aspect of having undergone a metamorphosis which has affected the hard purple schists, the conglomerate or pebbly beds, and the green schists above them, the latter being traversed in many directions by white veins of carbonate of lime. This mass (2), not less than 300 feet thick, is amorphous, and in colour partially resembles serpentine*. After passing a portion of the cliff which is obscured by detritus, a dark or almost black limestone with white veins appears, undulating irregularly, and plunging on the whole to the west and by north. This rock is covered by dark schists, the whole probably representing the dark limestone and schists of Porto Venere on the opposite side of the bay. These thin-bedded dark masses are followed by the remarkable rocks which constitute the sea-worn, amorphous and cavernous rauch-kalk on which the picturesque old town of Porto Telaro is built. From this point, passing to the fort of St. Bartolommeo, there are undulations and breaks in lower and obscurer cliffs, in which the thin-bedded siliceous schists (slates of Stazzemma) appear here and there beneath the rauch-kalk. All the calcareous rocks of this series are flanked by a vertically twisted and confused, coarse conglomerate, made up of lumps of all the above-mentioned rocks.

I have spoken of this highly modified range on the east side of the gulf to show its lithological accordance with the chief masses in the Apuan Alps, and because it exhibits the same order of succession of mineral masses. It is however only on the western shores of the bay, in another parallel undulation of these limestones, further removed from the chief axes of disturbance, that their age can be read off by help of some imbedded fossils. The black limestones, with white and yellow veins and associated dark schists (No. 3), but not so metamorphosed as on the east side of the bay, form the chief nucleus of this western promontory. Ranging in highly inclined and vertical forms, by the lofty, unfinished fort of Castellana, they strike from N.N.W. to S.S.E., into the isle of Palmaria, where they are largely quarried as the black and brown marble of Porto Venere. Among the fossils in this rock I procured a *Lima*, which resembles a lower secondary fossil, and certain imperfect

* I could not help suspecting the contiguity of some eruptive rock to this peculiar limestone, and my boatman assured me that when the sea was lower one of my predecessors had discovered a point of porphyry.

coralline bodies, which occasionally weather out on the surface. M. Pilla compares this rock with the lower ammonitic or liasso-jurassic limestones of Como, and he cites the fossils as pertaining to the genera *Cardita, Modiola, Pecten, Terebratula,* but does not name the species.

A transverse section of the western promontory, from the gulf south of La Spezia by the hills of Corregna to Campiglia, exhibits a great line of fracture*, irregularly parallel to the ridge, along which the highly twisted beds of dark-coloured limestones and schists (4) have been snapped asunder, and by which a portion of the Porto Venere series is thrown into an inverted position, and seems irregularly to overlap a series of strata which are unquestionably of younger age. These are, first, grey limestones and dolomites, dipping to the N. and S. of E. at 45°, followed by schists, shale, and very thin-bedded, finely laminated *red* and grey limestone, the angle of inclination in which increases gradually to 70° E.N.E. and E. It is in this group, particularly in certain red and grey limestones, that most of the ammonites and other peculiar fossils of La Spezia occur, which have been enumerated by Sir H. De la Beche.

The above fossil zone is underlaid by rotten schists with sandy rotten limestone, and then by numerous alternations of green and grey limestone, whitish calcareous grits, purple and white and red schists, in parts almost jaspideous, with courses of whitish limestone, the whole (5) in very thin-bedded strata, in which unluckily no fossils have been discovered. This calcareous series is flanked by a wall of sandy and pebbly conglomerate, on which stands the lofty village of Campiglia; and the beds, after first positively underlying all the older series at an angle of 80°, first become vertical, and then dipping away to the west form the base of all the hills of fine macigno sandstone. This conglomerate and the associated macigno are thus seen to partake intimately of the same great elevations and flexures which have affected the older limestones in the Apuan Alps and in the gulf of La Spezia.

It is now well known that the macigno of this tract, which, both from mineral character and order of superposition, was formerly taken by geologists for the most ancient, is in fact the youngest of this series; but whether it represents a portion of the cretaceous system, or is younger, is, in the absence of all fossils, still doubtful. That this macigno is in an inverted position is also noticed by Pilla†. In enumerating the list of fossils of the upper jurassic at Corregna, that author mentions *Ammonites Tatricus* and *Nerinæa* (the former I found myself), and I have therefore no doubt that this band represents the "ammonitico rosso" or Oxfordian of the Alps, and that the masses intercalated between it and the macigno are probably imperfect and non-fossiliferous equivalents of some member of the cretaceous rocks.

* M. Collegno sent a memoir on La Spezia to be read at the meeting of the Scienziati Italiani of Venice, 1847, in which he indicated a great line of fault parallel to the strike. He afterwards explained his view of the phænomenon to me.

† Bull. de la Soc. Géol. de France, vol. iv. p. 1069, section pl. 6. fig. 2.

I will only add, that I believe the deep bay of La Spezia has been excavated in a synclinal trough of macigno, whilst the hard inferior limestones and marbles have resisted, and form broken anticlinals on either side of the bay. On the east we see, in fact, another and broader parallel synclinal trough, the valley of the Magra, which has been excavated in similar macigno, covered by some remnants of overlying tertiary. Again, when we traverse the great anticlinal of the Apuan Alps, and descend into the valley of the Serchio, we meet with a third and similar trough, on the eastern side of which the lower portion of the macigno rises up into mountainous elevations, of which hereafter.

I have commenced with this superficial sketch of the general arrangement of the rocks in this northern tract of Italy, not merely because the oldest known limestones in the chain of the Apennines are brought out in parallel anticlinals, but because the outline of *ridge and furrow*, here so clearly developed, is a key to the general structure of the Apennines. In truth, the Italian peninsula is not characterized by one central backbone or central axis, but is made up of a frequent repetition of axes, the rocks composing which are sometimes much altered, often dismembered, and frequently covered over by younger sediments; the older portions of the series being only seen at intervals as we follow the chain from N.N.W. to S.S.E. Thus, jurassic rocks have not been detected in the broad and mountainous undulations which extend over the principalities of Lucca and Parma, or the country of Genoa, a region almost entirely occupied by limestones and macigno sandstone, whose age I shall presently endeavour to explain.

In the northern portion of the Tuscan Maremma, I examined, in company with M. Pilla and M. Coquand, the axis of jurassic rocks which, at Campiglia, are converted into domes of crystalline white marble in the contiguity of points of granite. This marble throws off on its flanks a compact thin-bedded limestone with encrinites overlaid by schists, with *Posidonia Jossiæ*, the latter being abruptly truncated against masses of macigno and alberese. This jurassic group is evidently the prolongation of one of the zones of the above-described Apuan Alps and Pisan hills*. The existence of true jurassic rocks has further been clearly indicated by M. E. de Vecchi in Monte Cetona, on another parallel between the Maremma and the Apennines. The nucleus of this hill is evidently the same Oxfordian limestone with *Ammonites Tatricus* which constitutes the upper group at La Spezia. Again, in another parallel, the group of mountains between the Maremma and Sienna, composed of white, yellow and red marbles (the Montagnuolo Senese), the whole reposing on a conglomerate, probably represent the jurassic series, since they are overlaid by scaglia; but no fossils have yet been detected in them.

In following the chief ridges of the Apennines to the south, buttresses of true jurassic rocks are indeed here and there visible, rising out from beneath overlying formations. Ammonites, of the group

* Some of the phænomena on the flanks of the granite of Campiglia and the promontory of Piombino are analogous to those of the adjacent isle of Elba, and the rocks are loaded with various crystals of iron ore.

of *A. elegans*, occur in the mountains east of Perugia, and also in the red marble limestone of Monte Malbe, west of that city. The *Ammonites Tatricus* and others of the Oxfordian group are found in the limestones of Monte Subasio, east of Assisi, and at La Rossa, between Fossato and Fimbriano. In this region also, as in the Apuan Alps and at La Spezia, such ammonitic rocks rise out as axes, throwing off troughs of younger strata, the sides of the hills being for the most part occupied by vast accumulations of macigno.

At Cesi, near Terni, on the very outer western edge of the Apennine chain, I found red limestone and shale, in parts undistinguishable from the "ammonitico rosso" of the Venetian Alps or that of La Spezia, presenting a bluff escarpment to the tertiary subapennine accumulations of the valley of the Tiber, and loaded with characteristic ammonites, such as *Ammonites Tatricus*, *A. biplex*, &c. The red ammonitic rocks of Cesi, which are clearly of Oxfordian age, repose upon a grey limestone of perhaps a thousand feet in thickness, with siliceous or flint nodules, and are covered by flaglike limestones and bosses and peaks of dolomite. Now, if characteristic fossils were not found in the red zone (a rare phænomenon in the Apennines), who could have divined the age of these rocks? and how should we have seen speculations on the underlying flinty cream-coloured limestone being perchance neocomian or scaglia? It is indeed a nauseous task for the geologist to wander for days in these mountains without the trace of fossils, and hence the ammonites of Cesi are invaluable landmarks.

The palæontological researches of Professor Ponzi in the eastern half of the Papal States, when combined with the mineralogical descriptions of his distinguished coadjutor Count Lavinia Medici Spada, in reference to the volcanic and crystalline rocks, will, I trust, at no distant day be embodied in a work which, coupled with the labours of Count A. C. Spada and Prof. Orsini on the Adriatic side of the great axis of the Apennines, will throw much light on this subject. Professor Ponzi has assured me, that however difficult to separate these limestones lithologically, there are numerous places along the western edge of the chief ridge of the Apennines (extending from Scheggia and Monte Cucco on the N.N.W. by Fossato Gualdo to Col Fiorito on the S.S.E.), where limestones with jurassic ammonites occur, and that near La Scheggia and elsewhere these are seen to pass under cretaceous rocks. Now, this ridge is parallel to others of similar age: 1st, that of Monte Subasio and its prolongations on the east side of the valley of Spoleto; 2ndly, of Cesi, west of Terni; and 3rdly, that of Monte Cetona; and another might even be enumerated in the Tuscan Maremma. These facts sufficiently indicate the prevalent outline of ridges and troughs directed from N.N.W. to S.S.E., into which so large a portion of the peninsula is divided. Patient examination, however, can alone detect the extent to which true jurassic rocks, as defined by the fossils, are separable from those of neocomian and cretaceous age.

Amidst the varieties of marble which abound in the Roman States, there is little doubt that the common red "cottannello," of which the great columns in the façade of St. Peter are made, as well as the "breccia di Simone," are the Roman representatives of the "ammonitico rosso," or Oxfordian.

Of the extent to which jurassic rocks may crop out on various parallels of the grand mountainous undulating region of the central Apennines, which runs down from the lofty Sibilla and Leonessa into the kingdom of Naples, no one is yet perfectly informed; but the researches of Orsini and Alessandro Spada teach us that jurassic rocks reoccur on the eastern side of the axis, the chief elevated points of which are either cretaceous or nummulitic. I satisfied myself, indeed, that the mass of mountains coloured as jurassic by Collegno, which extends from Civita Castellana to Gaeta, is cretaceous, and forms part of the rocks of that age around Naples*. The lowest visible strata, however, in the great promontory on the south side of the bay of Naples, and notably the bituminous limestones of Torre Orlando, are classed by Agassiz as jurassic because they contain the *Pycnodus rhombus*, Ag., *Notagogus Pentlandi*, Ag., &c. Again, certain lower strata of the Val Giffoni, east of Nocera, may be referred to the age of the lias, in consequence of the description of their ichthyolites by Sir P. Egerton, viz. the *Semionotus Pentlandi* (Egert.), *S. pustulifer* (Egert.), and *S. minutus* (Egert.)†.

Cretaceous Rocks of Italy.

Clear distinctions between the cretaceous and jurassic rocks of Italy can, for reasons already assigned, be seldom safely effected, except where the one or the other contains fossils, and can thus be compared with the types in the Alps. At Nice on the west, near Milan in the centre, and in the Vicentine on the east, the flanks of the Alps afford us, indeed, good keys, which explain the order of succession. But we no sooner quit the edges of those mountains and advance into Italy, than we lose for a long space nearly all evidences of true cretaceous rocks as proved by their fossils. We then find ourselves in broad, mountainous undulations of sandstone, schist, and impure limestone, some of which have a striking resemblance to the flysch of the Alps. The geological map of Liguria Marittima, by the Marquis Pareto, extending from Nice on the one hand to La Spezia on the other, and the work that accompanies it‡, expose the difficulties, which even an able geologist intimately acquainted with his country

* The author of this map is aware of the error, and informed me of it before I visited the tract. In the first effort to map a country such errata are inevitable, and our best thanks are due to M. Collegno for his endeavour to produce the first general geological map of his country.

† See Proc. Geol. Soc. Lond. vol. iv. p. 183.

‡ In the 'Cenni geologici sulla Liguria Marittima,' p. 30–47, Pareto considers all the macigno and alberese of Liguria to be cretaceous or secondary, because it contains fucoids. It is nowhere associated with nummulites. But in respect even to the latter, he classes the lowest great band of them at Nice as also cretaceous, because it succeeds in overlying order to a representative of the chalk in which green grains abound. In truth, however, there can be no doubt that all the nummulite rock of Nice is truly eocene and tertiary, and that it reposes on the equivalent of the chalk with inocerami. As to the non-fossiliferous macigno and alberese of the Genovesato, it is hopeless at present to define their age with pre-

experiences, in handling this part of the subject in such a region. At Nice indeed the succession is clearly shown from neocomian limestone, through greensand and chalk, up to overlying nummulitic strata; but in the whole of the tract east and west of Genoa, the slaty, hard, calcareous flagstones (alberese) and the macigno sandstones are grouped together as a higher member of the secondary series. In following the northern edges of the great plain of Piedmont, a wall of crystalline and eruptive rock subtends the alluvial plains of the Po; and though some representatives of cretaceous rocks flank the Alps and rest upon jurassic limestones to the north of Milan and near Como, I shall not now speak of these, because I have not visited them.

Good types of the cretaceous rocks of the north of Italy occur, however, in that outlier of the Alps with which I am acquainted, the Euganean hills. Separated from the chain by the trough of the lower tertiary deposits of the Vicentine, these hills, long known to consist chiefly of eruptive trachytes and scaglia, or the equivalent of the chalk, have, thanks to their vicinity to the abode of scientific men at Padua, been at length well developed. In his elaborate work, full of lithological and mineral description and views concerning the pseudo-volcanic operations of the region, M. Da Rio has also the merit of having enumerated, with the assistance of Professor Catullo and others, a certain number of fossils*. But these were not so described or grouped as to furnish to any extent geological divisions in the secondary rocks, though on the whole the strata containing Ammonites, Belemnites, and certain Echini (*Ananchytes ovatus*) were separated from the strata loaded with nummulites, which, in following Brongniart, M. da Rio considered to be tertiary. The more recent researches of Pasini and Catullo, and particularly those of De Zigno, show that the calcareous masses, formerly known under the terms of grey, white and red scaglia, are divisible into formations by their fossils; the lowest of these representing the Oxfordian or "ammonitico rosso" of the Alps, with *Ammonites Hommairi* (D'Orb.), *A. biplex* (Sow), and *A. Zignoanus* (D'Orb.). The next or neocomian, forming the base of the cretaceous system, is characterized by the *Crioceras Duvalii*, *Belemnites dilatatus* (Blainv.), *Ammonites cryptoceras* (D'Orb.), *A. Astierianus* (D'Orb.), and *A. infundibulum* (D'Orb.). The next overlying stage is considered to be the "Aptien," D'Orb., and contains the *Hippurites neocomiensis*, with Spherulites and *Ammonites Guettardi*. The uppermost band is the scaglia, or true equivalent of the white chalk, with *Inoceramus Lamarckii*, *Ananchytes tuberculatus*, *Holaster*, &c.

In his description of the "Terreno-Cretaceo" of the Venetian Alps, as exhibited in the Monfenera between Fener on the north and Pede-

cision, void as they are of fossils and perforated in all directions by serpentine and eruptive rocks. It may however be supposed, as suggested in the text, that a part of them may be cretaceous, and a part, on the parallel of strata which elsewhere contain nummulites. The same species of fucoids ranging throughout the eocene of the Alps down into the lower chalk of Northern Italy, are no criteria of age.

* Orittologia Euganea del Nobile Niccolo da Rio, Padova, 1836, with a coloured map and a lithographic profile.

robba on the south, M. de Zigno has fully developed the order and component parts of the "cretaceous system" of Northern Italy. Identifying the "biancone" with the "majolica" of Milan, he shows, by its several species of Crioceras and many species of Ammonites, published by D'Orbigny as neocomian from Provence, that these Italian limestones form truly the base of the cretaceous rocks, and are perfectly to be distinguished from the grey and red scaglia above them, and from the Oxfordian Jura or "ammonitico rosso" beneath them. I can only venture to differ from the Italian geologists when they state that a limestone between the neocomian and the upper scaglia contains nummulites. All the small bodies *supposed to be nummulites**, when seen on the surface of such cretaceous limestones, have proved to be other genera of foraminifera (chiefly Orbitolites) when closely examined. The course of sandstone intercalated between the so-called neocomian and the scaglia or chalk is perfectly in accordance with the section of the Grünten and Bavarian Alps (see p. 204).

In the Euganean hills, then, as in the Venetian Alps, the upper member of the chalk is surmounted by the well-known lower tertiary nummulitic rocks of the Vicentine, in which species of nummulites occur, together with Turbinolia and other fossils. This tertiary group runs into the hills south of Vicenza, which constitutes a part of the eocene accumulations before alluded to. When, however, we quit this Euganean outlier or island, and travel over the intervening plains to the centre of the Apennines, we are, as in Liguria, immersed in that very different mineral type to which allusion has already been made. The limestones, some of which may stand in the place of upper members of the cretaceous system, are traversed by serpentines, and scarcely ever contain the trace of animal organic remains. In vain, for example, does the geologist explore the limestones constituting the chief ridge between Bologna and Florence, or the axis between Liguria and Piedmont; for with a few examples of fucoids only, he can find no fossil base-line whatever in descending order, and

* See "Sul Terreno Cretaceo dell' Italia Settentrionale," Padova 1846. When the Men of Science were assembled at Venice in 1847, I in vain endeavoured to detect a true nummulite found in this cretaceous rock. Among the unequivocal neocomian fossil species of D'Orbigny, cited by De Zigno, are, *Ammonites astierianus*, *A. Guettardi*, *A. macilentus*, *A. Juilleti*, *A. inæqualicostatus*, *A. Grasianus*, *A. Morelianus*, *A. subfimbriatus*, *A. recticostatus*, *A. Matheronii*, *A. Terverii*, *A. bidichotomus* (Leym.), *Belemnites dilatatus* (Blainv.), *B. latus* (Bl.), *Crioceras Emerici* (D'Orb.), *C. Duvalii* (Léveillé), and *C. Da Rio* (Zigno). With these and the *Spatangus retusus* are associated two species of Aptychus. One of the latter has been supposed by Von Buch to occur also in the upper Jura. In his memoir before referred to, M. Zeuschner cites two species of jurassic Aptychi and the *Terebratula diphya* as being associated with many forms of neocomian age in the same band of Carpathian rocks, an anomaly which I have endeavoured to explain, pp. 260, 261.

In his description, M. de Zigno further shows, that the conjoint elevation of the cretaceous and overlying tertiaries has extended from the tract where I first described it to the longitude of Feltre. Whilst these pages are passing through the press, I learn from M. de Zigno that he has in great part carried out the work to which I alluded p. 223.

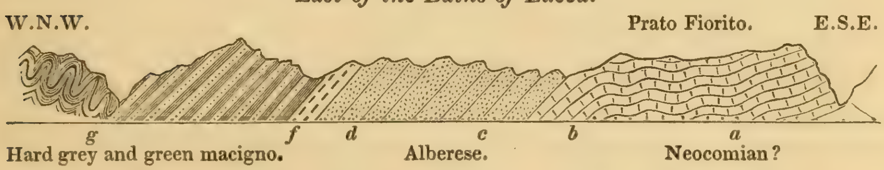
the vast masses of associated macigno sandstone are scarcely more productive. As to the fucoids found in the Florentine Apennines, they have much too great a vertical range to afford any criterion whatever of the true age of the rocks. Forms said to be similar occur in the grey or lower scaglia of the Venetian Alps, and are, as I have shown, still more abundantly developed in the supracretaceous macigno or flysch of the Northern Alps.

Rare as they are, certain fossils have, however, been found; and the existence of the solitary *Hamites Micheli* of Fiesole, of one ammonite discovered by Mr. Pentland, and of another by the Marchese Pareto, are, in the absence of other countervailing fossil proofs, enough to satisfy me, that there is here a zone, which, in a peculiar lithological form, represents the cretaceous system, as on the north flank of the Carpathians. I consider this group to be the equivalent of the upper greensand and chalk, which has assumed very much the same "flysch" or macigno characters as the cretaceous deposits of Gosau. I am very far, however, from agreeing with Professor Savi, that all the macigno is cretaceous. On the contrary, I am convinced that probably *the largest masses* of that rock, and particularly whenever they surmount or are associated with nummulitic strata, are of eocene age. The beds at Perolla, near Massa Marittima, which contain the Gryphæa figured by Pilla, represent in my estimate the uppermost cretaceous, or band of transition into the lower tertiary rocks.

True equivalents of the neocomian are, as before said, rare in the north of Italy. In the environs of the baths of Lucca, the position and lithological aspect of the mountain called "Prato Fiorito" led me to believe that it was of neocomian age. It is composed of compact cream-coloured limestone (*a* and *b*, fig. 33), with numerous nodules of

Fig. 33.

East of the Baths of Lucca.



flint, precisely resembling the "biancone" which in the Venetian Alps is proved to be of that age. Moreover, I found it to be surmounted by bands of impure sandy limestone, schist, red scaglia, &c. (*c* and *d*), which might very well pass for the greensand and chalk; whilst the great mass of macigno overlying the whole series constituted the chief peaks of the surrounding mountains. These again are followed by a peculiar calcareous breccia and agglomerate (*f*), which seemed to occupy the usual place of the chief nummulitic zone of Italy; the whole being surmounted by the great mass of macigno of which the surrounding adjacent mountains are for the most part composed. But, after a long search, I could find no organic remains except a rude cast, which might be a Crioceras, and which I detected near the summit of the supposed neocomian. Fucoids indeed are seen on the faces of the scaglia-like and impure limestone which here underlies the great mass of macigno.

Passing from these difficulties, in defining the equivalents of the cretaceous rocks in Liguria, Modena, Lucca and Tuscany, and their relations to inferior and superior strata, the true cretaceous system is not only observable at intervals in the southward range of the Apennines, but on various parallels resumes its calcareous and fossil characters, and constitutes ridges of considerable length in Southern Italy. In the Papal States these limestones, undergoing many undulations and breaks, constitute the chief chains which flank the valleys of Umbria, the Sabine mountains (Tivoli, Subiaco and Palestrina), and the Volscian hills extending to Gaeta and Naples. Although these rocks are in their upper portion chiefly characterized by hippurites, I am unprepared to define to what extent they may be divided into formations representing the neocomian or lower greensand, as separated from the upper greensand and chalk. I will, however, presently describe how these hippuritic limestones of the Sabine hills are surmounted by nummulitic rocks and macigno. In the limestones of Gaeta, whether crystalline, saccharoid or compact, I found many hippurites. The same rocks rising up into the ridge of Monte Marzo, near St. Agata, are underlaid by a thin-bedded, earthy and sometimes bituminous, dark-coloured limestone, which may be considered neocomian. The jurassic limestones of Sorrento are of great thickness and contain hippurites ; whilst the whole of the above series dips under macigno.

On the Eocene Rocks of Italy and their relations.

The group of this age, as clearly indicated by its overlying relations to true cretaceous rocks, has been sufficiently described in respect to the Venetian Alps, the Vicentine and Euganean hills. It is also so well known in the environs of Nice, that it is sufficient to cite the memoirs in which it has been noticed*. The great change in mineral aspect which these deposits undergo, as they pass from

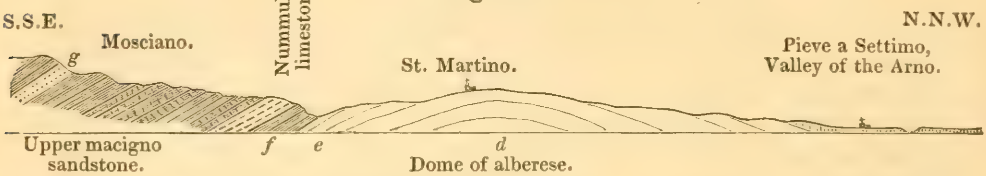
* I visited Nice in 1828 in company with Sir C. Lyell, since which period much progress has been made in our acquaintance with the succession of the strata in its environs. I have, however, a sufficient recollection of the physical relations of the rock-masses to understand the value of the descriptions of the Marquis Pareto (Liguria Marittima), and of M. Perez. The latter gave a very elaborate account of the nummulitic deposits of that tract at the Genoa meeting of the Scienziati Italiani ; but whilst he allowed that the greater part of the nummulitic fossils were eocene, still, in compliance with the prevailing fashion, he classed them as cretaceous, as well as the adjacent macigno of the Maritime Alps which overlies the nummulitic group. The sections are, in a general sense, so in accordance with my own in the Alps and Apennines, that it is unnecessary I should do more than say, that they exhibit a succession of various bands containing nummulites, ostreæ, &c., the lowest of which repose on beds (often a greensand) with *inocerami of the chalk*, and which in other places are charged with other types of the upper cretaceous groups. A limestone with neocomian fossils, and another with Oxfordian jurassic fossils, in descending order, completes therefore the analogy with the succession in the Venetian Alps. The conclusion of M. Perez is, that the macigno of the Maritime Alps is everywhere more recent than the nummulitic limestone.

one region to another, and above all the accompanying phænomenon of an almost entire disappearance of organic remains, have necessarily involved them in much obscurity in Liguria, Modena and Tuscany. As a whole, there is indeed a strong lithological resemblance, as before said, between the rocks called macigno by the Italians, and the flysch and Wiener sandstein of the Swiss and Austrian geologists. In the Apennines, as in the Alps (I have already alluded to it in the Apuan ridge), there is a fine-grained small micaceous sandstone which much resembles the ordinary macigno, whose exact age, whether cretaceous or eocene, may be doubtful; but I now simply treat of that macigno which, wherever there have been no inversions, is either intercalated with, or superposed *en masse* to, the nummulitic rocks. If we appeal to the environs of Florence, we see that, however wanting in a clear cretaceous base-line in the vicinity of that city, the whole of the Tuscan series of alberese and macigno sandstones repose upon secondary limestone (chiefly jurassic) in the Pisan hills on the west, at Monte Cetona and Campiglia on the south, and in the central Apennines of Monte Verame and Citta di Castello on the east. In defining the relations of the component parts of this group, I have already expressed my belief, that in parts of Tuscany the lower portion is probably the non-fossiliferous representative of the upper portion of the cretaceous system. In fact, the term "alberese" is so loosely applied to every light-coloured limestone, pure or impure, which dips under or alternates with macigno, and which may happen to contain fucoids, that it would be very hazardous, in tracts so void of organic remains, to define the neat limits between secondary and tertiary. We have not here, as in the Alps, either a neocomian limestone with its fossils to represent the lower greensand of the English, nor anything like the Alpine equivalents of upper greensand and chalk. But, if so obscure in the descending order (and he who crosses the chain from Bologna to Florence will admit this to be the case), these tracts have, however, one strong point of comparison with the Alps in the lithological resemblance of their upper macigno to the flysch of the Swiss. They further resemble certain Alpine tracts in having no rigid boundary or break between the lowest strata in which nummulites occur, and the beds above and below them. The best proof of this is, that Professor Pilla described as one natural physical group, which he termed "Etrurian," that which, on further inquiry, he conceived to be composed in its lower part of strata referable to the chalk, and in its higher part of a peculiar intermediary formation. As this Etrurian system (*so named from the country in all Europe most deprived of organic remains*) is thus composed of both secondary and tertiary strata, it is manifest that the term is geologically inadmissible.

Whilst then the lowest alberese, and some macigno, may remain as very ill-characterized cretaceous rocks, the upper Etrurian of Pilla is in fact nothing more than the eocene group of the Alps, like which it contains, in some localities, zones of nummulitic limestone, and is further surmounted by vast accumulations of macigno sandstone.

The nummulitic limestone of Mosciano, near Florence, having been much spoken of by Pilla and others, and having attracted the notice of the geologists of the meeting at Florence, I visited* and made a section of the strata which I now produce (fig. 34), as it differs

Fig. 34.



essentially from those hitherto published†. It shows an underlying light grey limestone or alberese, with fucoids followed by schists; next by the nummulitic limestone (*f*); and lastly by a vast overlying mass of macigno sandstone (*g*), as seen in the hills above St. Martino. The lowest beds at the Calcinajo, to the south of Pieve-a-Settimo, are thin-bedded, cream-coloured limestones (*d*?) of conchoidal fracture, with marlstones which contain the *Fucoides intricatus* and *F. Targioni*‡. These limestones, alternating with whitish schists or marl, form a low dome, the south side of which dips under other schists or shales of black and red colours, the "galestro" of the natives (*e*), which are covered by a thin band of micaceous sandstone or macigno. Then come impure gritty light grey limestones in strong beds of four to five feet thick (*f*), which contain small nummulites (*N. globulus*?) and minute foraminifera, and towards their upper portion pebbles of older compact limestone. These graduate upwards into flaglike, sandy, impure limestone of a bluish tint, which forms the passage into a great and distinctly overlying mass of "macigno" (*g*). Beds of coarse grit or small conglomerate occur near the base of the sandstones, in which are pebbles of quartz and diallage, and above them are small micaceous sandstones, which, although weathering yellowish, are of the usual grey macigno colours when freshly quarried. Some of these masses assume spheroidal shapes, and there are other alternations of similar sandstones and shale, and coarse grits (conglomerates, &c.), which occupy the summits of the adjacent hills. Now, all these beds are perfectly conformable, and from below the village of St. Martino to the tops of the hills they dip to the S.S.E. at angles gradually decreasing from 20° to 10°. It is thus seen, that the nummulites occurring in the lower part of all the macigno which is here exposed, are clearly covered by another and much greater mass of macigno. These strata are therefore, according to my view, on the very same parallel as the nummulitic and flysch group of the Alps.

The hills near Pistoja, and, in short, everywhere around the vale

* I was kindly accompanied by the Marchese Carlo Torrigiani and Professor Targioni-Tozzetti.

† Compare my section with that of Pilla in his work, entitled "Distinzione del Terreno Etruri tra' piani secondari del mezzo-giorno di Europa." Pisa, 1846. Tav. iii. fig. 3; and Mém. Soc. Géol. Fr. vol. ii. 2nd ser. p. 163.

‡ Where these limestones are of a bluish-grey colour they are called "Colombino," as distinguished from the whiter beds or "alberese."

of the Arno, afford sections of macigno, and, whether of grey or greenish-grey colours, it is usually the same slightly micaceous and feebly calcareous sandstone with grains of black schist, the fine building-stone of this region. At Ripa-fratta and other places to the north of the Pisan hills, this macigno is seen to dip away from all the chief underlying calcareous masses. But unfortunately the absence of fossils between the ammonitic group of the latter and the lowest beds of true macigno (the interval being occupied by compact limestone with flints), defeats any attempt at close comparisons *.

In ascending the valley of the Arno above Florence, and particularly between Ponte Sieve and Incisa, strong bands of alberese limestone undulate in rapid flexures or anticlinals, and dip under vast thicknesses of macigno, which roll over rapidly to the W.N.W. and E.S.E. At Monte Consuma these macigno rocks contain two or three courses of nummulitic limestone, as Professor Pilla has already indicated.

The grand masses of macigno which occupy the sides of the upper valley of the Tiber near Arezzo and thence range down to the environs of Perugia may be followed to the flanks of the highest Apennines, where they are seen to repose on the secondary limestones. Between Arezzo and Perugia the macigno is copiously developed, forming the hills on the eastern shores of the Thrasymene lake; it there clearly alternates with subordinate calcareous bands, and is itself often slightly calciferous. It is here near the centre of a vast trough, the limits of which are the secondary limestones of Monte Cetona on the west and the Apennines on the east. I was not able to satisfy myself, by any absolute superposition to strata with cretaceous fossils, whether these rocks are really of lower tertiary age; but my impression is that they are simply prolongations of the eocene macigno of Arezzo and Monte Consuma, in which nummulitic bands occur. In examining them I was reminded of an observation made by my lamented friend M. Alex. Brongniart, who, when I first showed him characteristic specimens of the upper silurian rock of Ludlow, exclaimed that they were true "macigno." I assert that the small micaceous, slightly calcareous, earthy sandstones, breaking to a bluish heart within, and weathering to a dirty

* "Sulla costituzione geologica dei monti Pisani, memoria del Prof. Cav. Paolo Savi, Pisa, 1846." Placing the nummulitic limestone as the uppermost bed of the cretaceous rocks, Professor Savi shows that it reposes on alberese with fucoids with and without flints, macigno sandstone, argillaceous schists, and mottled limestone with fucoids. Beneath this upper group are other and darker-coloured limestones, with flints and fucoids, which form the base of the cretaceous rocks. He then classes in the upper member of the jurassic series a light grey limestone (also with flints), which, he says, passes into and contains some of the fossils of the red ammonitic rock, about which no doubt exists. His lower jurassic or lias is made up of whitish limestone with fossil bivalves and turriculated shells, of a dark grey limestone, also with some obscure fossils, and lastly, at its base, of the "Verrucano." The only horizon clearly marked by its secondary fossils in all this series is the "ammonitico rosso;" but judging from the overlying position of the nummulites in the south of Italy, as well as in the north, it is probable that the great mass or lower portion of alberese limestones is, I repeat, really cretaceous. See a translation of Prof. Savi's Memoir in Quart. Journ. Geol. Soc. vol. iii. part ii. p. 1–10.

ash-colour, on which Flaminius was defeated by Hannibal, are scarcely to be distinguished from those on which Caractacus made his last stand against the Romans, although the one is either eocene or younger cretaceous and the other Silurian palæozoic! I make this remark both as a fair excuse for the older geologists, who in a region so void of fossils had considered this macigno to be an ancient "greywacke"; and still more as a reason why the latter word should never more be used, except in a mineralogical sense. This solid macigno of the Thrasymene and Perugia, graduating upwards into thinner courses with flaglike calcareous bands, is surmounted by the pebbly, sandy, and marly accumulations on which Perugia is built*.

The whole of the western edge of the Apennines from Foligno to Rome is void of macigno, and the grand trough or basin, between that Apennine escarpment on the east and the ridges of secondary limestone of the Siennese and Roman Maremma on the west, is exclusively occupied by volcanic and tertiary deposits, through which a few islets or outliers of Apennine limestone, such as Mount Soracte, rear their heads as you approach to Rome. But to the south of Narni and in the Sabine mountains east of Rome, where the limestones are manifestly cretaceous, we again meet with overlying nummulitic rocks and macigno,—not indeed on the external or western face of the chain at Tivoli and Palestrina, but between those places and Subiaco. The chief limestone of this tract, even when in that state of marble called "Occhio di Pavone," has been found to contain hippurites. In traversing the chain from Palestrina to Subiaco, I perceived, that whilst it presented a broken and often abrupt escarpment to the plain of the Campagna, the hippurite limestone, when followed across its strike or to the east, soon folds over in rapid undulations accompanied by great fractures, and at Olévano is surmounted by an impure sandy limestone charged with nummulites and pectens. The whole calcareous series then plunges under troughs filled with macigno sandstone, precisely similar to that of Tuscany, and which, though weathering externally to rusty yellow and dirty ash-colour, is, when quarried into, the same dull bluish grey psammite with minute grains of black schist, so well known as the building-stone of Florence. These macigno beds are occasionally vertical, and often so broken and squeezed up between the older limestones (with a strike from S.S.E. to N.N.W.), that persons unaccustomed to their relations elsewhere might well be induced to suppose that they underlie the older rocks. At Rojati, however, which stands on a fine thick-bedded macigno with alternating layers of shale, that dips away at a slight angle (this place being near the centre of a trough), the rock passes downwards into the same sandy and siliceous limestones which form the summit of the picturesque cretaceous hill of Olévano. Again, at Subiaco (see fig. 35), the church of Maria della Valle is built on an inclined, nodular, grey macigno with soft partings, which, covered by a mass of unconformable and horizontal tertiary conglomerate, passes down-

* An accident which injured one of my legs prevented my exploring the hilly tracts east of Perugia and Assisi. But I could hear of no nummulites in the environs, and the Museum of the University does not contain them.

wards into the upper beds of the great cretaceous limestones, of which all the surrounding mountains are composed, and in the grottoes of which St. Benedict established his famous monastery. Here, as at Olévano, the beds between the solid hippuritic limestones and the macigno are sandy or siliceous, dirty or yellowish white limestones,

Fig. 35.

Sabine Hills.

Pliocene or Post-pliocene. *z*. Conglomerate.
Eocene. { *g*. Macigno. *f*. Nummulite limestone.
Cretaceous. *d*. Hippurite limestone.

with nummulites and pectens. Near Agosta, lower down the valley of the Teverone, there are extensive quarries of this macigno where the rock, being deeply cut into, is blue-hearted, of concretionary forms on the great scale, and quite undistinguishable from the "Pietra forte" of Florence. The strata dip slightly across the valley and appear to plunge under the massive limestone cliffs of Agosta, but this appearance is fallacious, and is simply the result of one of the numerous faults of the chain; for the macigno is inclined at 10° or 12° only, and the secondary limestone plunges 45°. It is, I apprehend, from such examples that the supposed intercalation of the overlying macigno with the secondary limestones has been supposed to exist.

Judging from the section and brief description by MM. Alessandro Spada and Orsini* of the rocks between the watershed of the Apennines and the Adriatic in the parallel of Ascoli and the Tronto river, it would appear that there is there a much greater simplicity of structure than on the western side of the axis. This symmetrical disposition may be accounted for by the absence of those eruptive and volcanic rocks which are so abundant along the western slopes of the chain. Although I was prevented from visiting the Adriatic shores by the political state of the country, I cannot refer to the sections of Spada and Orsini without suggesting that one essential phænomenon of that region is in accordance with my own views. Their diagram shows a concordant passage from the limestone called "majolica" into overlying limestone with nummulites, and thence upwards through grey impure limestones with fucoids into macigno. Now whether this majolica be, as I suspect, neocomian and not jurassic (as they believe), and whether there be or be not any representative of the white chalk, we have clearly an ascending succession, in which the *macigno is the highest mass, and is overlaid only by tertiary miocene strata with gypsum.* The question after all is, what are the fossils which are there associated with true nummulites? and from

* Bull. Soc. Géol. Fr. 2 Ser. t. ii. p. 408, 1845.

all I could learn, they are there similar to those which have been described from other places. In other words, *they are not cretaceous*, but form the peculiar group in question. In this case, therefore, we have simply the well-known Alpine order of nummulite limestones, sometimes overlying neocomian and sometimes resting upon upper cretaceous rocks, and surmounted by vast masses of "flysch," *i. e.* of impure limestone with fucoids, sandstones, &c. There is, however, in this section a feature which wholly disagrees with the physical relations of Northern Italy. The gypseous molasse or miocene of the authors is placed as an unconformable mass between the macigno and the lower subapennine, and equally unconformable to both. I confess that this feature is unknown to me in any part of Italy, and I believe it to be merely local, because the authors themselves state that at Ascoli the same formations are *conformable*. In regard to the miocene and pliocene, the examples of a gradual transition from one to the other are indeed without number, as will presently be noted.

It is unnecessary to multiply examples of the superposition of the chief mass of the macigno to the youngest secondary rocks or hippuritic limestone of Central Italy. In following the upper road from Rome to Naples, any one may rapidly satisfy himself on this point at Ferentino, on the north side of which masses of inclined macigno with finely laminated sandy marls, dip away from a boss of the scaglia limestone and pass under all the younger and unconformable tertiary series of the Campagna. The masses of macigno on the south-western face of the great promontory of Sorrento, which forms the south side of the bay of Naples, also overlie cretaceous or hippuritic limestones, and the same order is seen in many tracts.

It is probable that the best fossiliferous exposition in the kingdom of Naples of both the upper cretaceous and the true nummulitic eocene, is exhibited in the grand Adriatic promontory of Monte Gargano, which it was my full intention to have visited, had the recent political troubles not prevented me. The late Professor Pilla is perhaps the only geologist who has examined and described it. But unluckily at the period of his visit he was not so well versed in stratigraphical geology and organic remains as he subsequently became, and I know from himself that he intended to revise his sections of that great headland. In default of a personal visit I was gratified to find, in the Royal Mineralogical Museum of Naples, so ably directed by Professor Scacchi*, a very illustrative series of the rocks and fossils of this Monte Gargano, the inspection of which left no doubt whatever in my mind, that the order of succession is there the same as that which I have witnessed in the Venetian Alps, the Papal States and other districts. The oldest rock is evidently the compact and hard white limestone with flints, and containing five species of Hippurites, besides Ammonites and Nerinææ. Then follow other beds, in which it would be presumptuous in me to attempt to decide the exact order. One of these is a red breccia; another is a peculiar

* Professor Scacchi himself intends soon to visit Monte Gargano and publish a detailed description of the order of the strata and their fossils. A full account of this promontory will form a beautiful monograph.

coralline, cavernous limestone with Pectens, Volutes, Olivæ, Dentalia, a large Fusus, Terebellum, &c.; a third contains Balani and Turbinoliæ. Now, the white limestone associated with this group is lithologically a true "calcaire grossier" loaded with nummulites. Among these nummulites, whatever may be their names, M. d'Archiac, who has examined them at my request, has declared that the four species to which he assigns them, all exist in the Lower Pyrenees. One of these, the *N. lævigata*, Lamk., occurs also in the London clay at Bracklesham, in the lower tertiary of Belgium, and in the Vicentine; and another is the form so very common in the Alps, whether it be termed *N. planospira* (Boub.) or *N. assilinoides* (Rüt.); whilst a fourth is the *N. granulosa* (D'Arch.) of Dax and the Pyrenees. These coincidences leave no doubt in my mind as to the age of the beds. I may also add, that in no one of the numerous rock-specimens I examined, is there an example of a nummulite occurring in the same fragment as the hippurites; and in fact there is also a clear lithological distinction between the hard, compact and flinty, white hippurite limestone, and the equally white but coarse granular limestone with nummulites.

The collections of Monte Gargano present, indeed, other fossils of a much younger series in a calcareous tuff, and as among these are the *Pecten latissimus*, *Panopæa Faujasi*, and other well-known subapennine shells, the existence there of pliocene deposits, as along other parts of the shores of the Mediterranean and Adriatic, is clearly marked.

On the Miocene, Pliocene, and Younger Tertiary Deposits of Italy.

The existence of deposits of miocene and pliocene age in the north of Italy has been long established; but geologists have not sufficiently directed attention to those sections in the peninsula, which best indicate transitions from the one group to the other. In the first place, therefore, I will endeavour to show, how in the north of Italy the oldest miocene, if not partly eocene, gradually inosculates and passes up into the overlying subapennine strata*. I have indeed already to some extent illustrated this point in the sections of Bassano and Asolo (p. 223), and have said that M. de Zigno will soon have collected, identified, and published the fossils which there lie in strata intercalated between the nummulitic eocene beneath and the subapennine marls and conglomerates above them.

The region to which I first invite attention, as exhibiting an uninterrupted succession from the top of the eocene or bottom of the miocene, through a full development of the latter up into the most copious accumulations of subapennine or pliocene, is that group of hills called the Monferrato, which ranges itself in a horse-shoe form, as defined by the course of the Po, between Turin on the west and Alexandria on the east. In the great plain occupied by coarse drift

* The reader who may desire to see the extent to which my observations and conclusions agree with those of other authors, may consult Pareto's Liguria Marittima, Pilla's Geologia, Philippi, &c.

which lies between the northern flexure of the Po, and the wall of crystalline and eruptive rocks which form the edge of the Alps, a great group of true cretaceous and older eocene formations may have formerly existed ; but of these no traces now remain. The oldest rocks visible are those which, on the right bank of the Po, range from Gassino by Casal Borgone and the hills south of Verrua ; in other words, they form the northern limit or escarpment of the Monferrato. Amid the sandy marls which there abound, certain peculiar and mottled limestones protrude, either in vertical or highly inclined positions, which, because they seem at one spot to have a certain direction and contain nummulites, have been described as *cretaceous* by M. Collegno* and by M. Sismonda. Since those authors wrote, the Marquis Pareto has in my opinion taken the true view of the subject, and has considered these beds to be tertiary and intimately associated with the miocene of the Superga.

Accompanied by the two excellent palæontologists of Turin, Dr. E. Sismonda and M. Bellardi, I made a transverse section of the ridge to the east of the ground which I had examined twenty years ago in company with Sir C. Lyell ; and a simple description of this section will I hope set at rest the question as to the age of the lowest visible rocks in these ridges, and also indicate a gradual transition upwards into younger tertiary strata. In ascending the hill-side from the banks of the Po near Gassino, I found that micaceous marls dip south, and afterwards become vertical and graduate into calcareous sandstone locally called molasse. After passing over a slope obscured by vegetation, other sandy marls are seen to reappear at a higher level in vertical positions, and enclosing an equally vertical band of mottled, small concretionary limestone with nummulites (*g* of fig. 36), which strikes N.N.E. and S.S.W. A short interval is occupied by strata of green-grained marlstone with some imperfect minute plants, when there follows another and much stronger band of about 12 feet thick of similarly mottled, subconcretionary, blue-hearted limestone, which, striking from W.S.W. to E.N.E., plunges to the S.S.E. at an angle of from 50° to 60°, and is covered by impure limestone or calcareous sandstone. Ascending over a few undulating mounds of marl and sandstone (the site of old quarries where the limestone has been extracted), the same band of mottled limestone is met with, dipping at a high angle to the north.

To decide upon the age of this limestone (*g* of fig. 36), as M. Collegno has attempted to do, by noting the direction of any one of its broken masses, seems to me futile. Suffice it to say, that the chief

* Mémoires de la Soc. Géol. de Fr. vol. ii. p. 203. M. Collegno has also coloured in as cretaceous the whole of the eastern end of the Monferrato from Verrua to Casale, for which he has no better authority than the occasional reappearance of the Gassino limestones, sometimes with, sometimes without nummulites. I regret much that I had not time to explore the eastern part of the Monferrato, in which M. Collegno lays down a much broader mass of what he calls cretaceous ; for judging from all other analogies, and even from what he writes himself, I have little doubt that downward passages there exist into the true eocene or equivalent of the flysch of the Alps ; such rocks being, in fact, a part of the cretaceous group of that author.

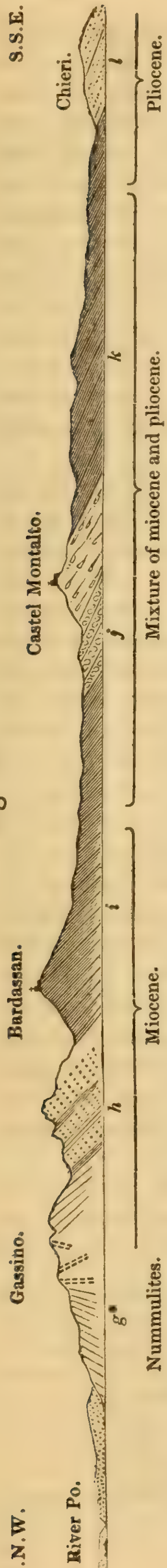


Fig. 36.

mass of marls and sands strikes W.S.W. and E.N.E., and that such is also the strike of the principal mass of the mottled nummulitic limestone, and of the grand masses of conglomerate, sand and marl which constitute the higher and highly inclined miocene strata in the ridges of the Superga and Monferrato.

The nummulitic limestone (g^*) may be considered as an irregular axis, which throws off partially a few younger and broken beds to the north, that form the gypseous and other hillocks on the banks of the Po, and pass under the pliocene strata of Verrua and Crescentino; whilst it is manifestly succeeded on the south by the whole ascending series of the Superga and Monferrato.

It is also equally clear that this nummulitic rock is truly tertiary, if we judge from the other fossils associated with the *Nummulina placentula* (Desh.). Thus, the terebratula on which Collegno reckoned as a proof of cretaceous age, is now known to be a common species of the older tertiary of this tract. In this very limestone we found the great oyster, *O. gigantea*, fragments of pectens and corals, and above all the tooth of a fish (*Oxyrhina Desori*, Ag.), all well-known tertiary forms. Again, in the sandy beds, absolutely resting on those dislocated limestones, the *Pecten Burdigalensis* with Pectunculi and Turbinoliæ occur, and there is therefore no sort of doubt of the age of the rock.

I was much struck with the resemblance of the mottled, concretionary and coralline limestone of Gassino to the rock of Castel-Cucco between Asolo and Possagno, which is also the uppermost limit of nummulites (p. 222). I therefore consider, that in connecting the nummulitic base of the section of the Superga with a well-known band in the clear succession on the flanks of the Venetian Alps, I establish a connecting link between the eocene deposits of the Alps and the miocene of northern Italy.

In traversing southwards to Bardassan, across the ridges of conglomerate, both coarse and fine (h), which occupy the chief summits, and separate the valleys excavated in the softer marl or sandy shale, I had little to observe that is not already known; for these elevations and depressions are the direct eastern prolongations of the miocene of the Superga; but in descending from the hills to the south by Castel Montalto to the plain of Chieri, the development of the strata and the gradual change from the miocene into the pliocene type is too remarkable not to be specially noticed. On the south slope of the hill of Bardassan the coarse conglomerates have entirely disappeared, and are succeeded by sand, marlstone and marl (*i*), in which are forms of Cerithium, Cardium, Vermetus, &c. These are followed by sandstone (*j*) and impure calcareous concretions, which as you approach Castel Montalto alternate with finely laminated shale. In all this space (not less than two English miles), the strata dip at 20° to 25° to the south, and certain subapennine shells occur, such as the *Lucina Astensis* (a well-known species of the hills of Asti, which we found near Bardassan), associated with the *Cleodora obtusa* and *Ringicula Bonelli* of the Superga; thus already proving an intermixture of species which authors may cite, some as miocene, others as pliocene.

Pursuing the ascending section, and leaving behind all the true miocene sandstones, we come into marls, shale and marlstone, often white, which are overlaid by other marls descending under the yellow sands of Chieri. These last-mentioned marls (*k*), which are usually considered subapennine and are covered by sands (*l*), charged with the youngest known shells of the group, contain the following species, as named for me by Dr. E. Sismonda:—

Turbinolia duodecimcostata, *Goldf.*, P.
Terebratula DeBuchi, *Mich.*, M.
Ostrea cochlear, *Poli*, P.M.
Pecten cristatus, *Bronn*, P.
Nucula concava, *Bronn.*
  interrupta, *Nyst.*
  Nicobarica, *Lk.*, P.
  placentina, *Lk.*, P.M.
  rostrata, *Lk.*
Limopsis aurita, *Sassi*, M.
Arca diluvii, *Lk.*, M.
Lucina Astensis, *Bon.*, M.
  spuria, *Desh.*, P.M.
  transversa, *Bronn*, P.
Venus alternans, *E. Sismd.*, P.
Erycina complanata, *Récl.*
Bornia seminulum, *Phil.*
Dentalium circinnatum, *Sow.*
  coarctatum, *Lk.*, M.
  fossile, *Linn.*, M.
  inæquale, *Bronn*, M.
  pseudo-entalis, *Lk.*, M.
  rectum, *Linn.*, M.
  sexangulare, *Lk.*, M.
Cerithium vulgatum, *Brug.*, P.M.
  inflatum, *Bell.*, M.
Nassa costulata, *Ren.*, M.
  semistriata, *Br.*, P.
  serrata, *Br.*, P.
Buccinum polygonum, *Br.*, P.M.
Cassidaria echinophora, *Lk.*, P.M.
Cassis texta, *Bronn*, P.M.
  variabilis, *Bell. et Mich.*, M.
Cancellaria Bonelli, *Bell.*, M.
  calcarata, *Br.*
  lyrata, *Br.*, M.
  mitræformis, *Br.*
Cancellaria varicosa, *Br.*, P.M.
Pleurotoma brevirostris, M.
  cataphracta, *Br.*, M.
  Coquandi, *Bell.*
  denticula, *Bast.*, M.
  dimidiata, *Br.*, M.
  intermedia, *Bronn*, M.
  intorta, *Br.*, M.
  monilis, *Br.*, M.
  obtusangula, *Br.*, M.
  rotata, *Br.*, P.M.
  turricula, *Br.*, P.M.
  turritelloides, *Bell.*
  Rochettæ, *Bell.*
Raphitoma harpula, *Bell.*, M.
  plicatella, *Bell.*, M.
  vulpecula, *Bell.*, P.M.
  columnæ, *Bell.*
  textilis, *Bell.*, M.
Ficula ficoides, *E. Sismd.*
Fusus aduncus, *Bronn*, M.
  angulosus, *E. Sismd.*, P.M.
  crispus, *Bors.*, M.
  lamellosus, *Bors.*, M.
  longiroster, *Br.*, M.
  mitræformis, *Br.*, M.
Triton Apenninicum, *Bronn*, M.
Ranella marginata, *Sow.*, P.M.
  reticularis, *E. Sismd.*, P.M.
Murex craticulatus, *Br.*, P.
  funiculosus, *Bors.*
  fusulus, *Br.*, M.
  Lassaignei, *Grat.*, M.
  polymorphus, *Br.*, P.M.
  spinicosta, *Bronn*, M.
Typhis fistulosus, *Mich.*, M.
Columbella nassoides, *Bell.*, M.

Columbella thiara, *Bon.*, M.
turgidula, *Bell.*, M.
Mitra scrobiculata, *Br.*, M.
pyramidella, *Br.*
Conus antediluvianus, *Brug.*, M.
bisulcatus, *Bell. et Mich.*, P.
Brocchii, *Bronn*, P.
Chenopus pes-graculi, *Phil.*, M.
Turbo fimbriatus, *Bronn*, M.
Solarium moniliferum, *Bronn.*
Phorus testigerus, *Bronn*, M.
Nerita proteus, *Bon.*, M.
Natica helicina, *Br.*, P.M.
pseudo-epiglottina, *E. Sismd.*, M.
millepunctata, *L.*, P.M.
Ringicula Bonelli, *Desh.*, M.
buccinea, *Desh.*, M.
striata, *E. Sismd.*, M.
Turritella subangulata, *Br.*, M.
varicosa, *Br.*
Bulla uniplicata, *Bell.*, M.

As the ascending series, in which intermixture takes place, is of considerable dimensions, and as even close to Chieri we still meet with a great number of Superga species, it is evident that a considerable thickness of beds may be classed either as miocene or pliocene, according to the forms which the observer may happen to meet with. Amidst the species collected from these blue marls, which are geologically subapennine (Castelnuovo and Pino), those marked M. exist in the miocene of the Superga; those marked P. are exclusively pliocene; and the individuals with the affix P.M. are common to the Superga and the true pliocene. Out of the 95 species, then, found in this one zone of blue marl, 16 are peculiar to it, 52 are known in the miocene, 10 in the pliocene, and 17 are common to the two formations.

The citation of this important fact teaches us, that the more closely the artificial limits of what geologists call formations are worked out, the more impossible will it be to draw fixed lines between natural groups of strata which, like these, have succeeded to each other without physical disturbances. At all events, wherever the different members of the same system so graduate into each other stratigraphically, mineralogically, and zoologically, the tints of colour by which they are characterized in a map should also be blended along such mixed frontiers.

In passing from the sandy beds in question by Castel Montalto to Pino and Chieri (the angle of inclination diminishing as we recede from the higher ground), the masses of which we have been speaking are conformably overlaid by a great thickness of yellow sands with some inosculating marls, which constitute the true subapennine beds of the Astesan, so well known to geologists through the works of Brocchi and others. In these uppermost beds nearly all traces of anything purely miocene have disappeared, and we are immersed in that same type of shells with *Panopæa Faujasi*, &c. which at St. Gallen and other places characterizes the marine molasse of Switzerland (see *antè*, p. 230)*. I specially, then, caution geologists against employing that term in a sense which is to convey an idea of age, for as used at Turin the word *molasse* is exclusively applied to the strata of true miocene age, whilst in Switzerland the greater part of it is pliocene. Again, the pliocene deposits in Switzerland are hard sand-

* This miocene is laid down in Collegno's map, but in my opinion, as above explained, a great error prevails in that part of it which represents the eastern portion of the Monferrato as cretaceous.

stones and conglomerates, whilst in Italy they are soft marls and sands.

The true pliocene deposits of Asti occupy a broad trough, watered by the rivers Tanaro and Bormida, on the southern side of which rise up those micaceous and often greenish sandstones of miocene age, so largely displayed in Piedmont. On a former occasion (1828) I traversed a large breadth of these between Savona and Acqui in the company of Sir C. Lyell, and in my last visit I examined them in travelling to Genoa from Alexandria. Between Gavi and Arquata, they have all the characters of a regenerated macigno, and at Serravalle and Ligurosa rise up from beneath the subapennine marls and sands in highly inclined sandstones and marls, underlaid by powerful bands of conglomerate that dip 40° to the N. or N.N.W. In this manner we reach the opposite or southern side of the great tertiary trough of the Astesan, and are again in the equivalents of the Superga conglomerate. I could discover, however, no course of underlying nummulitic limestone similar to that of Gassino. At the same time it must be stated, that the system of macigno and alberese, which is considered by Pareto to be the equivalent of the nummulitic group (?), succeeds near Ronco, dipping at a high angle under the whole of the conglomerate and miocene series of Piedmont. I cannot positively say whether these underlying beds of flagstone and macigno on the south side of the basin are conformable to the overlying miocene series, but in a rapid survey they seemed to me to be so, and also to be in a much less crystallized and altered state than in the environs of Genoa.

The miocene of Piedmont contains the coal deposits of Caddibuona*, so long known and so often described, on account of the remains of the Anthracotheria associated with lacustrine and fluviatile fossils; and as we travel down into the peninsula similar examples are met with. The interstratification of freshwater or estuary beds (containing Melanopsis, Melania and Neritina) with marine tertiary strata, has been pointed out as occurring in several parts of the north of Italy by the Marquis Pareto†. Near Siena, as will presently appear, such beds manifestly inosculate with the upper strata of subapennine age; whilst in the environs of Tortona they seem (judging from that author's section and description) to lie low in what must be defined as the true pliocene formation. The fact, however, is, that as some of the acknowledged miocene strata of the peninsula are of terrestrial and freshwater character (Caddibuona, Monte Massi and Monte Bamboli in the Maremma, &c.), there can be little doubt, that the more observation is extended, the more evidences shall we find of such local freshwater intercalations throughout the tertiary series in many parts of Italy.

* I visited this place with Sir C. Lyell, in passing from Savona to Acqui. Its powerful conglomerates are possibly of the same age as those of the Superga (see Lyell's Principles of Geology, 1st edition, vol. iii. p. 221, woodcut No. 55, and 4th ed. id. vol. iv. p. 152).

† See the Marquis Pareto's memoir, read at the Scientific Congress of Turin, 1844, entitled "Sopra alcune alternative di strati marini e fluviatili nei terreni di sedimento superiore dei Colli Subapennini."

At Canniparola, on the west side of the valley of the Magra near Sarzana, coal supposed to be of miocene age has been worked in several seams, and is associated with many plants of dicotyledonous structure. These works are now abandoned. On exploring the natural outcrop of the mineral, on the sides of the torrent called La Girona, I perceived that the coal seams subordinate to shale with plants, reposed, in highly inclined strata dipping to the west, on shale with calcareous nodules. The latter passes downwards into a soft macigno or finely micaceous sandstone, and from that into dark-coloured and party-coloured schists and marlstone with conchoidal fracture. Below these there appeared to me to be a transition into true hard and older macigno with white veins, the inclination increasing to verticality with the slope of the mountain sides. These beds being partially dislocated, strike both a little to the west and a little to the east of north; but the main direction is north and by west, and south and by east, or parallel to the chief ridge of the Apuan Alps, from which they are separated by a vast mass of underlying macigno. On the other hand, the coal strata are surmounted by ochreous sandy conglomerates, which being further removed from the axis of elevation, dip down to the vale of the Massa at a less inclination, and are lost in alluvial accumulations.

A traverse of the Apennines from Bologna to Florence exhibits, on the flanks of the chain near the former city, blue marl and sand of subapennine age, reposing on micaceous sandstone.

These masses, thus exposed in a low anticlinal on this outer parallel, are better seen on the high road as you pass by Pianura to Lojano, arranged in an elevated trough, near the north-western side of which courses of lignite (1) are surmounted by nodular strata and shelly blue marls, and these by the sands and white marls on which Pianura stands. Above these come other sandy marls with large nodules of dark grey, micaceous, ferruginous marlstone, in which I found many Cardia, Pectunculi, Nuculæ and Venericardiæ. These shelly beds, overlaid by a vast thickness of blue marl (2), and covered by yellow and white conglomerates and sands (3), are clearly the subapennine group of Brocchi, which, after dipping for a certain distance to the west, are bent up in a trough. From the summits of the conglomerate hills near Lojano, the dip being reversed, or to the N.E., the subapennine group is supported on the other side of the basin by nodular strata, together with a system of soft micaceous sandstones and pebbly conglomerates of considerable thickness, which alternate with certain shaly marls and greenish sandstones. These lower, undulating sandstones and conglomerates with marls, &c. most clearly represent the Superga series (*h* of fig. 36), and are of miocene age. In the construction, therefore, of a detailed geological map, this portion of the east flank of the Apennines might be shown to exhibit two axes or undulations of miocenic sandstones and conglomerates, troughing between them a mass of true subapennine beds, and again throwing off the upper beds towards the low country. At Lojano, the second post from Bologna (as it appeared to me in a rapid survey), the miocene conglomerates are cut off by a longitudinal fault from the macigno,

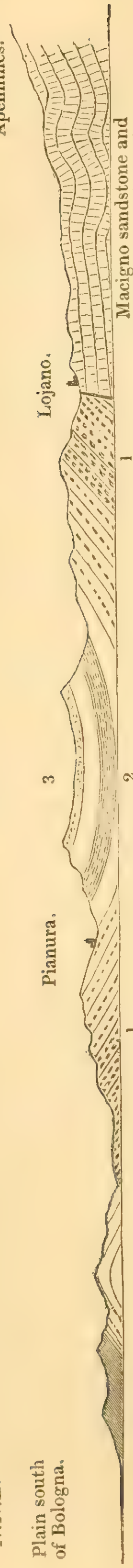


Fig. 37.

3. Yellow sands and conglomerates. } Subapennine or Pliocene.
2. Blue marl.
1. Miocene conglomerates and sands, &c.

which succeeds to the west: for the latter is only slightly inclined to the east, and is a hard, micaceous, true macigno sandstone, which, flaglike near the surface, passes down into thick beds. This rock, receiving its peculiar tint from numerous minute fragments of black schist, is undistinguishable from the macigno alpin or flysch of the Alps. It occurs, in fact, on the western edge of those great undulations of alberese, and other limestones, which, perforated by serpentine at Monte Berici and Sasso di Castro near Covigliajo, form the chief mass of that group already spoken of, whose geological equivalents in the absence of fossils it is so difficult to define.

Thus, whilst the Bolognese Apennines expose an intimate connection between the miocene and pliocene groups, they afford, as far as I saw, no indications of an unbroken succession from the macigno to the overlying miocene. It appeared, indeed, to me, that in descending towards Florence by Campo Santo and Crespiano, a conglomerate (probably miocene) was there also adherent to the sides of the mountains of older date; but in that portion of Tuscany the union between the miocene and pliocene, as above described, is wanting.

The picturesque hills around Lari, on the south side of the Arno near Pisa, which I visited with Professor Pilla, are for the most part composed of subapennine blue marl, loaded with shells and covered by yellow sands; the *Ostrea hippopus*, *Pecten laticostatus*, and large *Panopæa Faujasi* lying about in abundance. The villages stand on insulated points of the overlying sands or sandy marls, the remnants of former great denudations, all the strata being horizontal. These elevated sandy and loamy points are rich and fertile, whilst the denuded argillaceous marls of the valleys are sterile;—physical features which so prevail in vast tertiary tracts throughout Italy, that the agricultural characters alone are there sufficient to indicate the age of the strata. Near Casciano, however, to the south of Lari, as well seen in the quarries of Sta Frediana, other and lower sandstones of harder character, rise out abruptly from beneath the subapennine cover, and form broken and undulating domes. These beds contain highly ornamented small Echini, small Ostreæ, and other shells, together with fishes' teeth and palates, unknown in the overlying formation. The strata are specially characterized by as oft, calcareous yellow sandstone, arranged in large concretionary shapes, which here and there passes into limestone and calc grit, but in many parts disintegrates into fine yellow sand, in which caverns have been excavated. It is this rock which has afforded the numerous Lenticulites and other foraminifera described in the works of Soldani and Targioni-Tozzetti. They are accompanied by a very minute Terebratula, to which M. Pilla particularly directed my attention, and which at first sight had much the aspect of forms known only in palæozoic rocks*.

There can be no doubt that the foraminiferous rock of S^ta^ Frediana is of miocene age, but as it has here been brought up through the subapennine strata, along one of those lines of fracture so common in the adjacent region of the Maremma, we naturally miss the links, stratigraphical and zoological, which connect the miocene and pliocene in the Monferrato of Turin and in the Lower Apennines of Bologna.

Further southward, and in entering the Tuscan Maremma, rocks of this miocene age re-occur, overlying the ridges of alberese and macigno which there rise up, and in one place, Botro di Laspa near Pomaja, *i. e.* in the direct road from Pisa to the Maremma, contain the same small Terebratula as at Frediana. I examined the flanks of the lateral valley through which that route passes, and where the miocene contains large masses of gypsum. Traversing the hills from Castellini to the copper-mines of Monte Catini†, I thence made an excursion into the heart of the Tuscan Maremma to explore the relations of the coal beds of that tract which have been so largely opened out, and would, doubtless, have been rendered useful, had not revolutionary agitation checked all public and private expenditure.

* See "Osservazioni sopra l' età della pietra lenticolare di Casciano nelle colline Pisane, di Leopoldo Pilla." In this notice, published after a joint examination which I made with him, Professor Pilla corrects a first sketch, in which he had considered this lenticular limestone as of subapennine age, and shows that at S^ta^ Frediana and Parlascio it constituted islets or reefs of rock of miocene age in a sea of subapennine age. The corals, Lenticulites, Echini, Terebratulæ, &c., are supposed to be miocenic, whilst certain Ostreæ and Pectens are presumed to be pliocenic. It does not, however, appear that the latter are identical with known subapennine species. My lamented friend Professor Pilla had formed an opinion respecting the usual horizontality of subapennine strata, as contrasted with the inclination of all beds of miocenic age, in which I cannot participate. In this case I believe that the oldest tertiary of this part of the basin has been heaved up through the overlying strata on lines from north to south; and I cannot agree with him, that these older masses ever formed ancient islets, around which the younger were accumulated. On the contrary, I am convinced that here, as in the Monferrato, the whole submarine tertiary series was *originally* deposited successively and without a break.

† At Monte Catini, where I was hospitably received by Mr. Sloane, the intelligent proprietor of the mines, and in other places, I examined the serpentine, gabbro, and other eruptive or unstratified rocks, into the consideration of which I shall not enter in this memoir, the object of which points exclusively to sedimentary succession. The chief phænomena have been already described by Mr. W. Hamilton, Journ. Geol. Soc. London, vol. i. p. 291, and have been copiously dwelt upon by Savi, Pilla, and others.

Micaceous sandstone, which I believe to be of miocene age, with traces of stems of plants, appears in the conical hillock near Monte Catini; but the strata are there so dislocated in their relations to serpentine and gabbro, that no distinct order is visible. It was the belief of Professor Pilla, that much of the argillaceous and sterile marl of the deep denudations around Volterra, particularly the lower portion which contains large masses of gypsum and salt-springs, is also of miocene age. Of this there are no fossil proofs of which I could hear. It is, however, certain that the thick unfossiliferous marls are surmounted by others, and finally by yellow sands and sandstone, the "panchina," on which stands the noble ancient city of Volterra. These are true subapennine beds with many fossils; the tombs of the Necropolis being excavated in the sandy "panchina."

Pomerancia, to the south of Volterra, is placed on a high plateau of shelly tuff, which probably pertains to the upper portion of the pliocene, but the mountains to the east and south are macigno and alberese (possibly of cretaceous age?), with nuclei of still older rocks. Not now adverting to these rocks, or to the hot springs issuing through them which afford the boracic acid*, I will briefly notice the coal deposits of Monte Bamboli and Monte Massi, which lie still further to the southward. These deposits are described by Savi and Pilla, and the coal has been analysed by Matteucci. For my own part, I consider them to be of about the same age (miocene) as the coal of Caddibuona in Piedmont and of Fuveau near Toulon in the south of France†.

At Monte Bamboli the coal-seams, varying from eighteen inches to five feet and inclined about 30°, rest on earthy and broken schists, which are so nearly in contact with the surface of the so-called alberese of this tract, that I could scarcely divest myself of the idea that the one had succeeded conformably to the other; but although the upper schists or galestri of the alberese appeared to graduate into the gritty schist and the latter into the coal-seams, the whole dipping to the W.S.W., I was subsequently led to believe, from the sections at Monte Massi, that the apparent conformity is accidental. The coal, of which there are here two courses, is interlaced with a band of an earthy, shelly, freshwater limestone with mytili; and the surface of the coal-seams, in which plants and shells occur in a schist or "bat," graduates up into a considerable thickness of a thin, flat-bedded, sandy, impure limestone, which is followed by an indurated clay rock, and the latter by a coarse conglomerate. Whilst the coal-beds dip 30° S.W. in the shaft west of the works, they may be observed in the side of the torrent north of the engine to roll over to the N.N.E., and in one spot they dip 70°. In these dislocations

* In reference to the various, intensely hot springs which afford the boracic salt, I will only here say, that they seemed to me to issue from fissures having a direction from north and by west to south and by east, and that these parallel linear outbursts thus seem fairly to represent the last remnants of that grand subterranean evolution of heat which in former ages has so affected all this range of the Maremma.

† See description of this coal-field by Sir C. Lyell and myself, Proc. Geol. Soc. vol. i. p. 150.

the coal seems to follow all the accidents and undulations of the subjacent, so-called alberese, limestone on which it rests. Besides mytili and plants, the tooth of a pachyderm has been found in this tertiary coal, which M. Pomel has named *Iotherium*.

The other accumulations of this age occupy broken troughs throughout the Tuscan and Roman Maremma, and those which I visited, lie to the south of the rocky village of Monte Massi, where three shafts have been opened and where the coal is much developed (see fig. 38). Eruptive rocks, chiefly of serpentinous character, occupy the summits, and on one of these the grotesque village of Monte

Fig. 38.

s. Serpentine breccia.
d. ? Alberese.

Miocene. { 3. Shale and coal. 2. Mytilus limestone and coal. 1. Miocene conglomerates and coal.

Massi is perched. The rock is here a serpentinous breccia, classed as "euphotide," which throws off vertical patches of alberese (*d*) on all sides. But instead of the short interval which occurs at Monte Bamboli between the surface of the alberese and the coal, we have, first, a conglomerate of alberese, secondly, a thick mass of grey stratified shale or clay, and thirdly, grits and small pebbly conglomerates, with fragments of serpentine (ophiolite grit of Savi), on the last-mentioned of which the lowest bed of coal reposes. This succession is obvious in descending from Monte Massi to the banks of the brook on the S.S.W., in which the natural outcrop of the lower coal is seen. Even this lower coal (1) is not considered the same as that of Monte Bamboli; for after ascending through shale and grit, &c., another seam occurs which is interlaced with and surmounted by the very same *mytilus limestone* as that of Monte Bamboli (2), the whole dipping away at about 25° to S.S.W. Then follows a considerable breadth of argillaceous shale, the angle of inclination decreasing as the beds advance into that broad valley which terminates in the mouth of the Ombrone at Grossetto. Subordinate to this shale and claystone is the third or great seam of coal (3), which is of considerable thickness, and into which I descended by the new pits. Many portions of the coal, whether judging from the eye or from its chemical analysis, differ little from the inferior but useful qualities of British combustible of the palæozoic age. Unluckily, however, both Monte Massi and Monte Bamboli are at some distance from the seaboard, and no rail- or tram-roads having been yet constructed, all the expenditure of the miners will be thrown away if public assistance be not given to them*. The statistical data of these coal tracts, the great heat experienced in the deep shafts at Monte Massi, the gases (not inflam-

* I was accompanied to these tracts by M. Caillaud, the principal director of the Leghorn Coal Company, and by M. Petiot, the intelligent French engineer who has directed the works.

mable) therein, and other points of great interest, must now be passed over.

If a geologist examined the district of Monte Bamboli only, he might form a conclusion that the beds with coal at once succeeded to the alberese limestone; but at Monte Massi he sees that one underlying conglomerate is formed out of that rock, and that another, derived from the serpentines associated with it, forms the absolute base and support of this capacious and very remarkable coal tract, which although referred to the miocene age and clearly subjacent to all the lower subapennine, has more the aspect of an old coal-field than any other of similar date with which I am acquainted*.

I do not pretend to be able satisfactorily to define the exact limits and relations of all the members of the tertiary accumulations of different parts of Central Italy. In the southern part of Tuscany it was, however, clear to me, in a traverse which I made from Volterra to Siena, and also by examining the deep railroad cuttings to the north of the latter city, that the whole of the pliocene or subapennine series properly so called, *i. e.* the blue shelly marls (1) and their overlying yellow sandstone (panchina) and conglomerate (2), are there surmounted by the freshwater limestone (3), which occupies plateaux between Monte Reggioni and Colle, and in a deep denudation at the latter place is seen to rest on shelly subapennine strata, as expressed in the opposite diagram (fig. 39). Near Castello St. Geminiano on the west, the yellow subapennine sands with shells rise out rapidly from beneath this tufaceous limestone with its Lymnææ, Planorbes and other shells, and at Monte Reggioni on the east a similar infraposition is equally clear. Towards Siena this freshwater formation becomes a massive travertine, and constitutes undulating hills of hard and tough cavernous rock; among the lower masses is a very coarse conglomerate with huge angular fragments of Apennine limestone, often two and three feet in diameter. The strata of reddish colours, which are cut through by the railroad towards the source of the Staggia, are evidently a portion of this same irregularly deposited and block travertine, the whole of which overlies the subapennine group. In this tract there are considerable fractures, and wedge-shaped masses of the shelly blue marl are here and there forced up against the overlying conglomerate and travertine.

The more detailed order of this district, which cannot, however, be expressed in a general woodcut, seemed to me to exhibit in a descending series beneath the vegetable soil, 1st, coarse alluvia; 2nd, finely laminated sandy loam; 3rd, lacustrine limestone with Lymnææ

* For details respecting these coal tracts of the Tuscan Maremma, see Professor Savi's work, "Sopra i carboni fossili dei terreni mioceni delle Maremme Toscane, Pisa, 1843." Among the fossils he cites bones, possibly belonging to carnivora, and teeth of rodentia, *Mytilus Brardi* (Brongn.), opercula of univalves, and imperfect casts which may belong to Buccinum, Fusus and Cardiaceæ. The characteristic plants are Palmacites, a Musacea termed Uraniophyllites by Prof. Pietro Savi, with leaves of various dicotyledons (oak, plane, elder, cornel), cones of pine, &c. Prof. Pilla has also described these tracts in a memoir entitled "Sopra il carbon fossile trovato in Maremma," Florence, 1843; and in a work called "Breve Cenno della richezza minerale delle Toscana," Pisa, 1845.

Fig. 39.

and Planorbes, based upon and passing into a coarse travertine, with calcareous agglomerate and breccia; 4th, conglomerates of Apennine limestone, the surfaces of the rounded pebbles being often covered with Balani and Serpulæ, and associated with yellow sands containing large Ostreæ and Pectens, &c.; these graduate down into calciferous yellow sandstone, the "*panchina**" building-stone of the country, with concretions of calcareous grit, &c.; 5th, blue marls, which are much richer in shells in their upper parts only, where they graduate into the yellow sands.

The larger and lower portion of these marls is, indeed, throughout large tracts as sterile in organic remains as it is in its agricultural character. The desolate region between Siena and Radicofani is entirely composed of these naked, dull grey marls. On the other hand, the pebble beds and incoherent sandstones and marls on which Perugia stands, and in which her ancient Etruscan tombs were excavated, are probably of miocene age. At all events they resemble the Superga series in mineral aspect, repose upon macigno and alberese, and at Ficullo, between Perugia and Orvieto, are succeeded by unquestionable and very shelly subapennine strata.

In the volcanic regions extending from Radicofani to Rome, there are no evidences of any stratum older than the blue subapennine marl. To find the equivalents of miocene deposits in the southern parts of the Papal States, we must either travel eastwards into the valleys of the Apennines, or, passing the axis, explore the rich deposits of that age with plants and shells which await the geologist, who will work out the data of which M. Orsini and Count A. Spada have given a sketch.

Not intending now to enter upon the consideration of the volcanic dejections of the Papal or Neapolitan States†, I would however say a very few words to show the connection which exists between the subapennine strata that crop out at Rome and their associated rocks, and thus indicate generally the succession of geological phænomena in the environs of the ancient

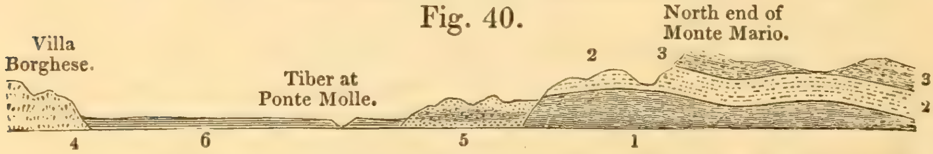
* Although applied to rocks of pliocene age at Siena and Volterra, the term "panchina" is used at Leghorn in reference to a marine tufa or shore deposit, covered by red earth, which is younger, and probably of the same age as the overlying travertines (3) of Siena and Colle.

† Monsignore Medici Spada and Professor Ponzi prepared and presented to me a map of the volcanic dejections of Latium, which they regard as terrestrial, in contrast with the subaqueous formations of the Campagna. They have indeed published a general section, "Profilo teoretico dei terreni della Campagna di Roma."

mistress of the world. The oldest beds visible (and these only in deep denudations to the north and west of St. Peter's and the Vatican, and at the foot of the Monte Mario*) are the blue shelly marls or clay, largely excavated for brick-earth. These are followed by sandstone, occasionally calcareous ("panchina" of Tuscany), by yellow sands, and finally by pebble-beds, the materials of which have nearly all been derived from the Apennine limestone. This is the subapennine shelly group of Brocchi, and in reference to its fossils I may state, that although many forms are common to the lower and upper beds, which are so strikingly distinguished from each other in lithological aspect, there are certain species, such as the *Cleodora lanceolata* and *C. Vaticani*, which pertain to the inferior blue marls only, and are never found in the overlying yellow sands. It may also be mentioned, that here, as at Siena, the greatest number of shells are found in the beds of junction of the two divisions.

The order in which the blue marls (the oldest stratum of the district) are overlaid by yellow sandstones and pebble-beds, and the manner in which the latter were first associated with and next covered over by volcanic materials and then elevated into land, and what changes the surface subsequently underwent, I would attempt to explain in this general woodcut, fig. 40. On the flanks of Monte

Fig. 40.



Modern .... 6. Alluvium of ancient valley of the Tiber.
Post-pliocene. .. 5. Regenerated pebble beds, gravel and travertine.
Subapennine or Pliocene .... 4. Volcanic tuff (massive).
3. Pebble beds, sands and volcanic tuff.
2. Yellow sands, panchina, &c.
1. Shelly blue marls (brick earth).

Mario, good evidences exist of the superposition to the blue marls (1) of the yellow calciferous sandstones and sands (2). In mounting to the overlying pebbly beds (3) we see the first commencement of submarine volcanic action in dejections of finely laminated peperino and tuff, which are dovetailed into the uppermost of the subapennine strata. Then follow those tuffs, peperinos and other volcanic rocks of the Campagna, which were so extensively spread out under a former sea, and of which the hills of Rome and the Villa Borghese afford examples and varieties (4). These are, in fact, the submarine accumulations which terminated the subapennine period.

After such masses had been raised into land, and when the valley of the Tiber became in the first instance either a lake or a broad river, detrital accumulations were, it would appear, formed out of the materials both of the pliocene strata (1 & 2) and also of all the subaqueous volcanic dejections (3 & 4) which had overspread them. The materials of the ancient gravel above Ponte Molle decide this

* It would appear that a good many species of shells have been detected at Villa Madama, the Vatican and other localities since Brocchi wrote. It is not my province to enter into these details.

point. Such terrestrial deposits, antecedent however to our own æra, there form low hillocks of gravel and sand, including fragments of the submarine volcanic rocks (4), and also a band of travertine. It is in these accumulations that numerous remains of the quadrupeds which inhabited primæval Italy are found. Professor Ponzi has clearly distinguished* them from their congeners in the older period (3) or upper strata of the Subapennines. In that preceding period the *Elephas primigenius* (Blum.), *Hippopotamus major* (Blum.), *Rhinoceros leptorhinus* (Cuv.), *Equus fossilis* and *Cervus primigenius* were inhabitants of the adjacent Apennines, from which their bones, with much pebbly detritus, were washed down into the adjacent estuaries and bays of the sea, and mixed up with its dolphins and shells. When the estuary formations had been raised into land and formed the banks of the ancient or broad valley of the Tiber, other quadrupeds appeared, and if the bones of the older period be found added to more recent remains, the former are always in a rolled and water-worn condition.

Among the animals of the post-pliocene or quaternary deposits (5) whose remains have been detected in such hillocks as those at Ponte Molle, are *Ursus, Meles antediluvianus, Felis brevirostris, Sus scropha fossilis, Equus fossilis, E. asinus fossilis, Cervus primigenius, Bos priscus, Bos primigenius,* with aquatic birds, frogs, eels, &c.

From that epoch, so recent as respects geological history, but so remote as respects man, we are ushered into our own æra by finding in the more modern alluvia of the Tiber, but when that stream was much broader (6), the remains of creatures, such as the *Dama Romana,* the *Ovis aries* and *Capra œgragus,* which, though comparatively recent and having disappeared from the peninsula, are in this last deposit associated with the usual modern types, including the *Bos bubalus* (Linn.), which shows that the Buffalo is indigenous in Italy.

In reviewing the vibrations and changes of relation which the tertiary deposits of Italy have undergone, it appears that though in many districts there are dislocations which affect one group and not another, there are, on the other hand, sufficient examples of transition which unite them. In this manner we have seen instances where true eocene, as proved by organic remains, passes up into miocene beds equally upheaved and conformable to them (Bassano, Asolo); whilst in the southern parts of Tuscany and in the north of the Papal States remains are seen in masses, which though much less fossiliferous are presumed to be their equivalents. Some of the miocene coal deposits of Tuscany follow all the flexures and dislocations of the older rocks on which they rest. M. Coquand compares them with those of Aix in Provence and other spots well known to him, and finding that they contain the same characteristic plant, *Palmacites Lamanonis,* he has contended that they should even be classed as eocene or with the gypseous beds of the Paris basin. In synchronizing freshwater with marine deposits, where there is not a continuous succession of many strata, there is always considerable difficulty; but

* See the Atti della ottava riunione degli Scienziati Italiani Genova, pp. 679 *et seq.*

as these lignites are manifestly posterior to any stratum of the nummulitic series, which I regard as the eocene of Southern Europe, I must consider them to be of miocene age, though in some instances representing perhaps the lower beds of that division. In the full and consecutive marine series of the Monferrato, and in the Apennines of Bologna, no doubt can remain of a perfectly equable and conformable transition from miocene into pliocene. Even in the convulsed region of the Tuscan Maremma and its flanks, it is manifest that beds of miocene are surmounted by the whole series of the lower gypseous marls, which in their turn, though often highly inclined, pass up into true subapennine blue marl.

Some geologists have indeed endeavoured to distinguish the miocene from the pliocene tertiaries of Italy by the inclination of the strata in the one and their horizontality in the other. But this method is fallacious; for although the great shelly masses of pliocene age, which occupy broad valleys or large troughs, are necessarily more or less horizontal, wherever they are removed from centres of disturbance, there are numerous districts in which they are highly inclined. Thus, without going back to the sections of Bassano, the Monferrato, Bologna, &c., we see both the blue marl and yellow sands, which are so horizontal along the banks of the Elsa in Tuscany, dip at 35° to the east of Volterra, whilst they are followed downwards at Specchiajolo and Pignano, on the road to Colle, by gypseous marls, which are still more highly inclined as they approach a ridge of elevation. Again, where the basaltic cone of Radicofani perforates the tertiary trough of blue marls which lie between the ridges of Monte Amato on the west and Monte Cetona on the east, these young strata are singularly dislocated. Even without quitting the environs of Rome, the most perfect horizontality of the blue marls and overlying sandstones may be observed near St. Peter's and the Vatican; and yet in following the uppermost of these strata to the summits of Monte Mario or westwards towards Civita Vecchia, they are found to undulate so rapidly with local breaks, that sections made in two detached spots would show an apparent unconformity, when in fact all is one continuous series.

On the shores of Italy, as in the valleys of the Arno and the Tiber, there are many proofs of a succession of deposits similar to that which has been alluded to near Rome, ascending from the subapennine or pliocene æra into the period when all the sea shells found in the raised beaches are those of the present sea. On this point I will now only add, that the oscillation to which the coast has been subjected in the historic period, when the temple of Serapis in the bay of Puzzuoli was depressed about twenty-five feet below its present level and afterwards raised, was by no means a mere local subsidence, but one which affected the whole of the adjacent coast of Italy. For, on the seaward face of the promontory of Gaeta, which is a mass of subcrystalline or hippurite limestone, I satisfied myself of the accuracy of the observation of Pilla* and other Italian geologists, that pholades of existing species had eaten into the rock at about the same height

* Trattato de Geologia di L. Pilla, vol. i. p. 334. Pisa, 1847.

above the water at which the perforations of these animals are observable in the columns of the temple of Jupiter Serapis; whilst subsidences of ancient Roman buildings beneath the sea are apparent in many adjacent places.

But although we thus learn that such oscillations of the land have been in operation during the historic æra, who will venture to compare the operations which gradually elevated and depressed the coast of Italy a few feet, with those mighty forces which evolved the more ancient upheavals, fractures and inversion of the Alps and Apennines? By no amount of gradual intumescence and subsidence can we explain the grand phænomena of those mountains, and the geologist cannot examine them without admitting, that they stand forth as monuments of much more powerful causes than any of which there is a trace in the modern period.

Concluding Remarks.

In recurring to the chief object of this memoir—the recognition of Eocene deposits of large dimensions in the South of Europe—it is unnecessary that I should here enumerate all the authors who have considered the nummulitic rocks of the Alps and Italy to be of cretaceous or secondary age; it being enough to state that in the works of É. de Beaumont, Dufrénoy, Studer, Escher, and others, and in nearly all published maps and tabular views, they are still so classed. Having now entirely abandoned the opinion which I once entertained, that nummulites are common to the cretaceous and tertiary rocks of the Alps, as explained in the preceding memoir, I will endeavour to generalize the result. But first let me pass in review those authors who have recently thrown light upon this subject by their surveys in the south of France, where, in proceeding from our northern countries, we find the eocene formation beginning to assume its Alpine and Mediterranean aspect, and what I consider to be its great and normal type.

Our associate Mr. Pratt, who has so well illustrated the case of Biaritz at the north-western foot of the Pyrenees, believes, that the nummulitic and shelly strata there exposed are tertiary*; but whilst a great number of the fossils (56 species) are identical with forms of the Paris basin, he conceives that the strata are of somewhat older date than the eocene of the north of Europe. This opinion is probably to some extent correct, since a portion of the beds in question may represent that interval of time which is marked in England by the great disruption between the plastic clay and the chalk. In examining the fossils collected by Mr. Pratt, M. d'Archiac detected only three cretaceous forms in 108 species†, and of these, two are individuals, *Ostrea vesicularis* (Sow.) and *O. lateralis* (Nilss.), which are repeated in other tracts in the lower stage of the nummulitic formation.

In dividing the nummulitic group of the basin of the Adour into three stages, M. Delbos shows that its inferior member, containing

* Bull. Soc. Géol. Fr. 2 Ser. vol. ii. p. 185.
† Mem. Soc. Géol. Fr. 2 Ser. tom. ii. p. 191.

the *Ostrea vesicularis* (associated, however, with the tertiary species *Ostrea gigantea, Terebratula semistriata* and *Cancer quadrilobatus*), reposes on strata charged with *Inoceramus Lamarckii* and *Ananchytes ovatus,* which he believes to be the true representative of the white chalk of Paris*. These, I would remark, are precisely the relations which exist both on the northern and southern flanks of the Alps. M. Delbos further indicates, that his second stage in ascending order, which had been also confounded with the chalk, is a limestone characterized by *Schizaster rimosa, Hemiaster complanatus, Nummulina millecaput* (*N. gigas,* Catullo), *Serpula spirulæa,* most of which fossils occur in the shelly eocene of the Vicentine. Lastly, he points out, that although, even in his third or uppermost band, the *Ostrea lateralis* and the *O. gigantea* of the lower beds are repeated, they are there associated with a profusion of tertiary species. This band is the great receptacle of nummulites throughout the neighbourhood of Bayonne, the Corbières, &c., which nummulites (I may remark) are all or nearly all of the same species as in the Alps.

The facts developed by M. Leymerie are in my opinion essentially the same as those described by M. Delbos ; for whilst he shows that the "terrain à nummulites" is connected with the chalk by help of certain fossils, still the great masses with nummulites are clearly superposed. But then this author has a theory to account for his "terrain épicrétacé." Seeing that these supposed secondary rocks of the south differ so much from those of the north of Europe, he explains this in his last memoir† by supposing that they were deposited in separate and distinct seas ; so that certain animals may have continued to live on in the one, which had ceased to exist in the other basin. In this way he is inclined to think, that the nummulitic rocks of the south may represent at the same time the upper part of the cretaceous and the lower part of the tertiary system of the north.

To this I would reply by positive data. It has been shown that in this southern zone, and notably throughout the Alps, the very beds of transition or union are positively underlaid by the true equivalent of the white chalk and a full complement of the cretaceous system. Again, strata which M. Leymerie considers cretaceous, merely from the presence of the *Ostrea lateralis* and the *Terebratula tenuistriata,* are in my estimate the intermediate or transition beds only ; and as the last-mentioned of these fossils is said to be undistinguishable from the *T. caput serpentis,* a species which mounts high into the tertiary deposits, nothing is gained by such an argument, particularly when the most secondary or cretaceous of the two species, the *Ostrea lateralis,* is stated to be associated with several well-known tertiary species.

In pointing out very clearly that the nummulitic rocks of Les Corbières are all posterior to the chalk, M. Talavignes‡ has endeavoured to divide the formation into what he calls two systems on account of their unconformity ; but as no author has recognised a general break

* Bull. Soc. Géol. Fr. vol. iv. pp. 557, 713.
† Mém. de l'Académie de Toulouse.
‡ Bull. Soc. Géol. Fr. vol. iv. p. 1127.

even in the Pyrenees, I am disposed to consider this a local phænomenon, similar to that described by M. Favre in a portion of the Savoy Alps. It is needless, however, here to speak of lines of dislocation or transgressive deposits which I have disposed of elsewhere, as we are now merely dwelling on palæontological data and regular order of superposition; and the result of the researches of M. Talavignes is, that, with the exception of one Gryphæa, all the fossils of his two systems of nummulitic rocks are of tertiary forms.

An argument used by M. Dufrénoy to sustain the opinion of M. de Beaumont and himself, that the nummulite rocks formed the uppermost stage of the great cretaceous system of the south, has, it seems to me, fallen to the ground*. That author had indicated that the highly inclined nummulite strata of St. Justin in the Landes were surmounted by horizontal beds of calcaire grossier. On a scrutiny of this point, however, MM. Raulin and Delbos have proved, that the supposed calcaire grossier is a true Bordeaux miocene, and therefore we have there simply such a hiatus in the tertiary series as occurs in many parts of the Alps and Italy. M. Raulin has, indeed, gone further, and has proved, through the species of echinoderms†, that in the same region (Dax) there *is* a true equivalent of the white chalk, and that the overlying nummulitic rocks are loaded with eocene species. He insists, that whenever the nummulite group occurs, there is no other representative of the eocene. Hence M. Raulin believes that the great upheaval of the Pyrenees took place after the eocene epoch; and this is just what has occurred in the Alps. M. Rouant has, indeed, described a "terrain eocene" in the environs of Pau, which is the very same as the nummulitic group elsewhere, and being in an intermediate position, it is most satisfactory to know that it contains thirty-four fossil species of the Paris basin and five of the Vicentine.

Now, whatever these deposits in the south of France may be called, they are unquestionably of synchronous date with the nummulitic group of the Alps; for nearly every one of the same species of nummulites and orbitolites, besides many echinoderms and shells, occur in both regions in strata occupying the same place in the geological scale‡.

* Bull. Soc. Géol. Fr. vol. iv. p. 561. † Ibid. vol. v. p. 114.

‡ See p. 195, and the note on M. d'Archiac's identification of the species I brought from the Alps with those of the south of France. That able author has written to me, that he sees no zoological reason why that which he has termed the Asiatico-Mediterranean nummulitic group, extending, as he says, from the Asturias to the banks of the Brahmapootra, may not be the true type of the lower tertiary formation, whilst that which we have hitherto regarded as such (Paris, London, &c.) may have been due to local causes, and circumscribed to some ancient gulf of north-western Europe. What he still requires, before he modifies the opinions he has already expressed, are, clear proofs of geological and stratigraphical relations, and he hopes to find this point sustained in my memoir. Whilst speaking of the zoological characters of the nummulitic group, I am also happy to say, that a number of its fossils, forming part of a large collection in the Woodwardian Museum of Cambridge, procured from Count Münster, and ticketed by that naturalist from various Alpine localities cited in this memoir, have all been classed as eocene tertiary by Mr. F. McCoy (the assistant of Professor Sedgwick) after a careful comparison of them with types of that age from other tracts.

To the very decisive opinion of M. Ewald of Berlin respecting the true tertiary character of the fossils of the Vicentine recorded in this memoir, I may add, that in a paper read before the Geological Section at Venice, he demonstrated that certain multilocular bodies in the hippurite limestone of Berre, near Marseilles, though resembling nummulites, were, in fact, quite distinct from them, both in structure and in the absence of the lenticular form. Abandoning his old opinions, like myself, M. Boué admits that as a whole the nummulites must be ranged in the eocene group, and he now the better understands why in certain parts of Turkey the miocene and younger tertiary at once succeed to nummulite rocks. It has indeed been stated by M. Constant Prevost, that nummulites occur with hippurites in the limestones of Cape Passaro in Sicily. That nummulite limestones immediately cover hippurite limestone in Italy, is a fact on which I have dilated; but whether the relations be the same in Sicily I cannot of course decide, not having been able to visit the spot. M. Coquand, whilst classing with the cretaceous rocks the nummulitic limestone and macigno of Morocco, shows at the same time, that the latter everywhere surmount the hippurite limestone; and this statement leads me to believe, that the general succession is the same in Africa as in Italy and in the Alps.

In casting our eyes eastward to the grand region of Northern Russia, we see how the deposits above the chalk preserve the type of our Northern Europe, and how in following them to the Carpathians and the Crimæa, they are found to assume the southern type. The sections of the nummulitic rocks of the south coast of the Crimæa, whether by M. Dubois or by M. de Verneuil, completely establish the fact, that the great mass of nummulitic limestone, with its *Ostrea gigantea* and other eocene fossils, is clearly superposed to the chalk. M. Dubois thinks, indeed, that one species of Nummulina there descends into the rock with true chalk fossils. But even if this be so, and that a true nummulite should also coexist with the uppermost hippurite rock of Cape Passaro in Sicily, it will only prove that the genus was called into existence a little earlier in those latitudes and longitudes than in the Alps and Apennines, whilst at the same time it would offer an additional proof of that very transition between the rocks called secondary and tertiary on which I have dwelt. However this may be, the facts remain the same, in relation to the *great masses of nummulites* that characterize the eocene of Southern Europe, which I have described. These, I repeat, are invariably supracretaceous; the nummulites being associated with a profusion of other animal remains of true tertiary character *.

* The superposition of true nummulites to the cretaceous rocks of the Asturias is announced to me by M. de Verneuil whilst these pages are passing through the press. The limestones and sandstones of that province which are charged with hippurites and radiolites, contain also abundance of *orbitolites*. The latter (which have been mistaken for nummulites) are fairly intercalated in the cretaceous system, and are surmounted by a yellowish limestone with spatangi, which may be the equivalent of the white chalk. This cretaceous group is distinctly overlaid by limestone abounding in true nummulites, which dips under sandstone and sands. This nummulitic band contains *Ostrea gigantea*, *Conoclypus conoideus*,

The nummulitic rocks which occupy large spaces in Egypt are all unquestionably of this same eocene age, as proved by their fauna. In a collection of fossils recently sent to the Royal Museum at Turin, M. Bellardi and myself recognized at a glance the eocene group of the Vicentine*.

Besides the *Nummulina millecaput* and *N. placentula*, well known in the Alps, these Egyptian rocks contain the *Bulla Fortisii*, Al. Brongn., *Turritella vittata*, Lamk., *T. imbricataria*, *Rostellaria fissurella* and *Nerita conoidea*, forms which are known in the Paris basin, in the Vicentine and at Nice. All the other Egyptian fossils, including Crustacea and Echinoderms, if not identical, are analogous to those of the supracretaceous group of the Alps and Italy. The same types of Pecten, of small, spinose Spondyli and Cardiaceæ, with Cassis and many univalves, complete the group.

Following this grand nummulitic formation from Egypt and Asia Minor† across Persia by Bagdad to the banks of the Indus, we long ago knew, from the communications of Capt. Grant, how in Cutch it is copiously loaded with fossils, which from the drawings and descriptions of Mr. James Sowerby‡ have all a tertiary aspect and relations. Subsequently the labours of Capt. Vicary, as recorded in our Proceedings§, have greatly added to our acquaintance with the range of these nummulitic rocks, which, in the form of limestones and sandstones, compose the great mass of the highly inclined strata of the mountain ranges of Hala and Solyman that separate Scinde from Persia, and extending from south to north, form the passes leading to Cabul. From collections recently sent home to me by Capt. Vicary it now appears, that some members of the same nummulitic group wrap round also from west to east in the Sub-Himalayan tracts in which Sabathoo is situated; and are said to reoccur, even in the kingdom of Assam. No geologist can view the fossils of this vast Eastern region (including nearly all the Punjaub, and even a large portion of Affghanistan) without being convinced that they belong to the same member of the series as the eocene of the Alps and Italy; for, with the same absence of ammonites, belemnites, hamites, or any cretaceous types, they exhibit six or seven species of num-

Serpula spirulæa, and other well-known eocene forms. The same order seems to prevail throughout Spain, even into the province of Malaga, and everywhere the nummulitic eocene, as in the Alps, has undergone the same flexures as the cretaceous rocks, whilst *the fossils* of the two formations are quite distinct.—June 1, 1849.

* Not more than half of this collection had been critically examined and compared when I left Turin in June 1848. I may here add, that a reference to Russegger's sections and description of the Mokattan Hills, near Cairo, would also lead inevitably to the inference, that the nummulitic rocks of Egypt are of eocene age (see Russegger, Reise in Europa, Asien und Afrika: Stuttgart; with fol. atlas). In short, this work affords evidence of the existence of true cretaceous rocks, followed by both eocene and younger tertiary deposits. Still M. Russegger, like most of his contemporaries, *classes the nummulite rocks with the chalk.*

† See Hamilton's Asia Minor, vol. i. pp. 405, 410, 500. M. Tchihatcheff will extend our knowledge on this point when he publishes the results of his recent travels.

‡ Trans. Geol. Soc. Lond. vol. v. Second Ser. p. 289 and plates.

§ Journal Geol. Soc. Lond. vol. iii. p. 331.

mulites*, four of which, the *Nummulina millecaput* or *polygyratus*, *N. planospira* or *assilinoides*, the *N. crassa* (Boubée), and the *N. Biaritzana* (D'Arch.), are identical with widely-spread and well-known forms of the South of Europe. Then again the same groups of radiata, conchifera and mollusca occur as in the nummulitic eocene of Europe. Some of the fossil shells of Scinde are, indeed, scarcely to be distinguished from the species of the Vicentine, particularly the so-called *Nerita conoidea* (Lamk.), or the *Neritina grandis* (Sow.), as well as one or two forms of Natica, the *Trochus agglutinans*, &c., whilst they have all a tertiary aspect, and if not identifiable with, are closely related to, our South European eocene forms†.

In comparing rocks of this epoch from distant parts of the globe, the amount of coincidence in their zoological contents is very remarkable, and in tracing their greater or less assimilation to our European types, we find, as might be supposed, that such is in a great measure dependent on the occurrence of similar or dissimilar conditions of deposit. Thus, in the Vicentine on the south flank of the Alps, where white limestones and marls abound, there are many more species common to that tract and the basin of Paris, than on the northern flank of the chain, where the deposits are more sandy and earthy, though their distance from the Parisian types is much smaller. Again, with the recurrence of strong resemblance to the lithological character of the Paris basin in the nummulitic rocks of Egypt and Scinde, we meet with a persistence of many identical or analogous forms, even at those vast distances. In the eyes of the geologist and palæontologist, therefore, the eocene type of Southern Europe extends through the heart of Asia, the differences in the fauna being simply characteristic of formations accumulated under varying conditions at the same time in distant seas. The surprise, indeed, is, that through the presence of certain species of nummulites, corals, echinoderms and shells, there should be so striking a resemblance in these widely separated deposits of so young an age as the eocene.

When we take the map of the world in hand, and view the enormous range of this nummulitic formation at intervals, *through twenty-*

* The researches of Capt. Vicary were undertaken by order of Lieut.-General Sir Charles Napier, after his brilliant conquest of Scinde. M. Leopold von Buch long ago recognized, in a letter to myself (see also Bull. Soc. Géol. Fr. vol. iv. p. 542), the identity of the nummulitic formation of Southern Europe with that which ranges from the Mediterranean and Egypt across Persia by Bagdad into Hindostan, and I much regret to have mislaid his short but pregnant sketch.

† Mr. Morris first examined these fossils of Scinde at my request, and seeing the close analogy which they present to the nummulitic group of Europe, had prepared a list of them. I have since submitted them to M. d'Archiac at Paris, in the hope that he may describe them in detail for the Geological Society of London, and compare them with the nummulitic fauna of Southern France, which he has well studied. The species named, with the aid of Mr. Morris, in the Table at the end as having a wide range, result in part from these examinations, and also from a comparison of the corals by M. Jules Haime (the associate of M. Milne-Edwards), who has stated that four species of that class derived from Scinde, are identical with forms published from Nice. I may also add, that I saw in the Royal Museum at Turin, a Cyclorite from the mountains between Scinde and Cabul, which M. Bellardi identifies with the *Cyclolites Borsoni* (Michelin) of Nice.

five degrees of latitude and *near one hundred degrees of longitude*, its northernmost ridge on the north flank of the Carpathians being clearly identifiable with its southernmost known limb in Cutch, and its western masses in Spain and Morocco being similar to those of the Brahmapootra, we at once see the vast importance which attaches to a right understanding of its true place in the geological series. And this assimilation of distant deposits is effected, it will be remembered, in spite of great local diversities of lithological and mineral character. The black subcrystalline schists and limestones of the summits of the Vallaisan and Savoyard Alps, with their Cerithia and Melaniæ, and the black fish-slates of Glarus ; the hard, calcareous, green sandstones of the Alps of Bern, of the four cantons, and of Bavaria, are all proved by their fossils and order of superposition to have been formed during the same geological period as the white limestones, marls and sandstones of Monte Bolca and the Vicentine, and by zoological inference, at the same time as similar rocks in Egypt and Hindostan. Nay more, we see in the Alps enormous thicknesses of overlying "flysch" and "macigno," which having often the aspect of the oldest secondary or even of transition rocks, are not of higher antiquity than our unconsolidated London clay and Bagshot sands!

In coming to my present opinion I regret to be compelled to dissent from my eminent friend M. Élie de Beaumont; for even in the last modification of his opinions, he views the "terrain à nummulites" as a member of the cretaceous rocks. In one essential point indeed, when he states that complete researches will probably make known passages or transitions between all conterminous formations, he gives the great value of his sanction to opinions I have long held and published*. I rejoice that he pointedly adverts to the error of those who believe in *general dislocations*, or revolutions which have neatly separated one great group of rocks and their imbedded animals from another; and that stating how all disruptions are local in reference to the surface of the globe, he admits with me, that even in two formations unconformable to each other, some of the same organic remains have been found to exist. Apparently, however, not sufficiently acquainted with the presence in the Alps of a full representative of the *chalk*, and believing that the nummulitic series there rests upon strata of the age of the greensand, he supposes that the nummulitic group and flysch of that chain may answer to the upper part of the cretaceous system, and may also fill up the interval so frequently observable in Northern Europe, between the surface of the chalk and the plastic clay. But he must forgive me when I state my belief, that this view cannot now stand in the face of the clearly-ascertained succession which has been pointed out. If it were valid, then the nummulitic rocks and flysch or "terrain épicrétacé" would surely somewhere be overlaid by a zoological representative of the calcaire grossier; whereas in every country where it is known, the nummulitic and flysch group is surmounted, for the most part unconformably, by deposits with miocene or pliocene shells. Even if

* See Silurian System and Russia in Europe, *passim*.

they were void of fossils, the enormous accumulations of finely-laminated beds, which overlie the true equivalents of the chalk, and are followed by the deposits which hitherto have alone been viewed as younger tertiary, must represent so long a period, that as physical monuments only they are in my mind's eye, full and complete equivalents *in time* of the eocene of geologists*.

And now a word upon the reform which the adoption of this view must introduce into geological maps. The truth is, that in previous classifications of the rocks of Southern Europe the eocene formation has been almost omitted, chiefly because it there usually forms the upper portion of a continuous and unbroken series of strata, of which the neocomian limestone or lowest member of the cretaceous system is the base. In some tracts it will doubtless be difficult, except the scale of the map be large, to indicate the separation of the eocene from such cretaceous rocks; but on the other hand, it will be as easy as it is necessary to mark this formation by a distinct colour over enormous spaces, separating it from the cretaceous on the one hand and from the younger tertiary deposits on the other. Even in the most general maps I conceive that this distinction may be effected. No geological division can, indeed, be more essential than that which distinguishes lower tertiary rock-masses from those of upper secondary age; inasmuch as, with the exception of certain beds of junction, the two groups have no organic remains in common, and afford the clearest proofs of having been formed at different periods of time, and when the submarine fauna underwent a total change.

Lastly, let me say, that without taking a comprehensive view of the whole question, and alluding to the works of my contemporaries, I should not have made apparent the value of the establishment of a clear order of secondary and tertiary succession in the Alps, Carpathians and Italy. In respect to my leading object, I repeat, that wherever true and full representatives of the different members of the cretaceous system occur, from the neocomian or equivalent of the

* In a letter recently received from M. Alcide d'Orbigny, he thus expresses himself: "For three years I have made the most extensive researches upon Nummulites; and in comparing all the stratigraphical and palæontological results, it is impossible not to recognize therein two distinct epochs, as represented by strata, superposed the one to the other, and having each its proper fauna. One of these epochs, which I have recognized in the French Alps, the Pyrenees and the Gironde, corresponds to the plastic clay of Paris and London, and which, belonging to the lower sands of Soissons, I have named 'Étage Suessonien'; the other, equally common in the Alps and the basins of the Gironde, and which includes the 'calcaire grossier' of Paris up to the gypsum of Montmartre and the London clay, &c., I designate 'Étage Parisien.' These divisions, based upon a considerable number of facts, are detailed in the work I am now printing, and the entire composition of their characteristic faunas is given in my 'Prodromus of Universal Palæontology.' The habit I have acquired of determining these fossils makes me regret that I cannot go to inspect your collections in London; but the portions of them I have seen in the hands of our friend M. de Verneuil have led me to recognize at once what I was already acquainted with in the Pyrenees and the French Alps. Again, the fossils I have examined in the collection of M. Tchihatcheff (recently brought from Asia Minor) confirm me in my opinion, and would lead me to extend the limits of these tertiary stages, as you have suggested, even to Hindostan."

lower greensand, upwards through the gault and upper greensand into the white chalk inclusive,—there also all the species of the genus *Nummulina* lie invariably above such strata; and further, that with the exception of one or two forms of Gryphæa and Terebratula (conchifers peculiarly tenacious of life, and which generally occur in the beds of transition above the chalk, and never rise above the lower beds of the nummulitic group), all the fossils associated with the nummulites are of eocene type. I am glad that these conclusions, derived from geological researches and absolute sections, are in harmony with the results obtained by the most eminent naturalists from their study of organic remains. Brongniart, Deshayes and D'Orbigny have long maintained that the nummulites of France are truly of tertiary age. Agassiz groups them as rather pertaining to a peculiar or lower tertiary. In his recent valuable tabular view of all known fossils (to which I specially invite attention), Professor Bronn of Heidelberg places the nummulitic group as the natural base of all the tertiary deposits. This concordance of physical geology with palæontology has indeed been everywhere established where patient researches have been carried out.

In conclusion, it is unnecessary that I should revert to all the deductions I have attempted to draw concerning the operations of metamorphism, contortion, and fracture by which the strata of the Alps and Apennines have been so powerfully affected; and I will now simply recapitulate the chief points which I have grouped together, in presenting to my countrymen a view of the normal order of the formations, as well as of the derangements they have undergone, in the Alps, Carpathians and Apennines.

1. That whilst evidences of Silurian, Devonian and carboniferous rocks exist in the Eastern Alps, the palæozoic group of Southern Europe nowhere exhibits traces of the Permian system of Northern Europe.

2. That these palæozoic rocks are succeeded in the Eastern Alps, and notably in the South Tyrol, by the "Trias," as characterized by known muschelkalk fossils and also by many species peculiar to the Alpine zone of this system; whilst none of these fossils have yet been recognized in the Western Alps.

3. That the Jurassic system of the Alps and Apennines is made up of two distinct calcareous formations; the inferior representing the lias and lower oolites, the superior the Oxfordian group, so largely developed throughout Russia, though in a very different mineral condition.

4. That the cretaceous system of Southern Europe is composed of hard subcrystalline Neocomian limestones (the equivalents in great part of the English lower greensand), of a band replete with fossils of the gault and upper greensand, and of red, grey and white limestones with Inocerami representing the chalk.

5. That where the sequence is full and unbroken, the cretaceous rocks of the Alps and Apennines graduate conformably and insensibly upwards by mineral and zoological passages into the nummulitic zone,

in which and in its great intercalated and overlying masses of flysch or upper "macigno" the secondary types have vanished, and an eocene tertiary fauna appears.

6. That by the presence of numerous fossils, and notably by its nummulites and echinoderms, this eocene group is known to extend from the Mediterranean through Egypt, Asia Minor and Persia to Hindostan, and there to occupy large regions forming the western and northern limits of British India.

7. That the names of Carpathian sandstone and Vienna sandstone, as well as of flysch and macigno, have been applied to rocks which are both of secondary and tertiary age; but that in the Carpathians, as in the Alps, those portions of them containing nummulites with certain overlying strata represent the eocene tertiary.

8. That the cretaceous and nummulitic eocene formations of the Alps having been successively deposited under the sea, have since undergone the same common flexures and fractures, by which the younger strata have been frequently folded under those of older date.

9. That the only general feature of independence in the formations of the Northern Alps, is that which is exhibited in the grand rupture and hiatus between the pre-existing nummulitic eocene with flysch and the subsequently-formed molasse and nagelflue.

10. That as the marine contents of the Swiss molasse, whether called younger miocene or older pliocene, exhibit a large proportion of living species of marine shells, whilst the associated and *overlying* strata of terrestrial origin, often called molasse, are loaded with forms all of which are extinct, the same terms cannot be applied as equivalents to define the tertiary strata which were formed contemporaneously under the sea and upon the land (see p. 237).

11. That although on the southern flank of the Venetian Alps the nummulitic eocene group is followed by younger tertiary deposits, which, also elevated at high angles, have a direction parallel to the older chain, it is believed that such external lower parallel (Bassano, Asolo) was produced after that chief elevation which raised the secondary and eocene rocks together, and has in many places left the latter upon the summits of the Alps.

12. That notwithstanding local dislocations, Northern Italy further exhibits conformable passages from what may be the uppermost eocene or lowest miocene high up into subapennine strata, in which most of the shells are undistinguishable from those now living.

13. That since the emersion of all the pliocene and youngest marine deposits and their addition to the pre-existing lands, the oscillations which the coasts of Italy have undergone, particularly during the historic æra, are symptoms of the remains only of that subterranean energy which was exerted with much greater intensity during former periods in the Alps, Carpathians and Apennines.

Species of the Nummulitic Eocene group having a wide geographical range.

Fossils.	Localities.
Nummulina millecaput, *Boubée*=*N. polygyratus*, Desh.	Alps. Pyrenees. Crimea. Egypt. Vicentine. Scinde.
—— planospira, *Boubée*=*N. assilinoides*, Rüt.	South of France. Pyrenees. Alps. Apennines. Carpathians. Mt. Gargano (Naples).
—— Biaritzana, *d'Arch.*=*N. atacica*, Leym.=*N. acuta*, Sow.=*N. regularis*, Rüt.	Alps. Biaritz. Vicentine. Cutch and Scinde.
—— rotularis, *Desh.*=*N. globulus*, Leym.=(*N. lævigata*, Pusch, t. 12. f. 16 *a*)?	South of France. Pyrenees. Alps. Crimea. Carpathians?
—— placentula, *Desh.* = *N. intermedia*, d'Arch.	South of France. Alps. Crimea. Egypt. Scinde?
—— globosa, *Rüt. & d'Arch.*=*N. obtusa*, Joly & Leym. (var. of *Biaritzana*).	Alps. South of France.
—— lævigata, *Lamk.*	London. Paris. Belgium. Lower Pyrenees. Vicentine. Mt. Gargano (Naples).
—— granulosa, *d'Arch.*..........	Dax. Pyrenees. Mt. Gargano (Naples). Asia Minor.
—— crassa, *Boubée* = *N. obtusa*, Sow.	Alps. Pyrenees. Cutch.
Orbitolites submedia, *d'Arch.*=*O. Prattii*, Michelin.	South of France. Pyrenees. (Matsee.) Alps.
—— discus, *Rüt.*	South of France. Alps. Scinde.
—— patellaris, *Brunner*	Alps.
—— stellaris, *Brunner*=*Calcarina stellata*, d'Arch.	Swiss Alps. Vicentine. Nice. South of France.

ZOOPHYTA.

Trochocyathus bilobatus, *M. Edwards and J. Haime, Ann. Scien. Nat.* 3 ser. vol. ix. p. 331.	Nice. Scinde.
—— multisinuosus, *M. Edwards and J. Haime, ibid.* p. 336.	Nice. Scinde.
—— near to *T. cyclolitoides, M. Edwards and J. Haime, ibid.*	Scinde.
Trochosmilia corniculum, *M. Edwards and J. Haime, ibid.* p. 240.	Nice. Scinde.
Stylocœnia emarciata, *M. Edwards and J. Haime, ibid.*	Paris. Scinde.
Ceratotrochus near to *C. exaratus, M. Edwards and J. Haime, ibid.*	Scinde.
Cyclolites Borsoni, *Michelin*	Rivalta (Bormida). Nice. Scinde.
Astræa radiata, *Lamk.*	Paris. Vicentine. Rivalta (Bormida).
Meandrina profunda, *Michelin*	Vicentine. Rivalta (Bormida).

Obs.—The greater number of the corals of the Vicentine have not yet been compared with those of other localities.

Fossils.	Localities.
RADIARIA.	
Pygorhynchus Cuvieri, *Münst.* sp. .	Paris. N. Alps.
—— subcylindricus, *Ag.*	Trent. Pyrenees.
Conoclypus conoideus, *Lamk.* sp.. .	N. Alps. (S. Alps.) Pyrenees. Asturias. Nice. Vicentine. Crimea. Egypt.
Echinocyamus profundus, *Ag.*	Trent (S. Tyrol). Swiss Alps.
Echinolampas politus, *Ag.*........	N. Alps. South of France.
—— subsimilis, *d'Arch.*	Pyrenees. Trent (S. Tyrol). Cutch.

Obs.—The number and variety of the species of Echinoderms, chiefly elongated, which are found in the nummulitic group in the Alps, Pyrenees and India, amounting to upwards of 100 species, eminently characterize this formation; not one of them being known in the cretaceous rocks. The greatest number of species belong to the genera Echinolampas, Conoclypus, Pygorhynchus, Eupatagus, Hemiaster and Schizaster (see Agassiz).

CRUSTACEA.	
Cancer Sonthofensis	Sonthofen, Bavarian Alps.

Obs.—Other species of Crustacea are also abundant in the Alps, Egypt, Scinde, &c.

ANNELIDA.	
Serpula spirulæa, *Lamk.*	Paris. Swiss and Bavarian Alps. Vicentine. Asturias.
CONCHIFERA.	
Cytherea elegans, *Lamk*...	London. Paris. Vicentine.
Venericardia acuticostata, *Lamk.*= *V. Lauræ,* Brong.=*Cardium semigranulatum,* Münst.	Paris. Vicentine.
—— minuta, *Leym.*	Pyrenees. Nice. Egypt.
Chama squamosa, *Sow*...........	London. Bassano.
Pholadomya Puschii, *Goldf.*......	London? South of France. Westphalia. Nice. Vicentine. Scinde.
Crassatella sulcata, *Sow.*	London. Schio. Vicentine.
Pecten corneus, *Sow.*=*P. suborbicularis,* Münst.	London. Kressenberg. Swiss Alps.
—— plebeius, *Lamk*.............	Paris. Kressenberg. Swiss Alps.
—— scutularis, *Lamk.*	Paris. Kressenberg. Swiss Alps.
Ostrea gigantea, *Dubois*=*O. latissima,* Desh.	London. Paris. South of France. Nice. Vicentine. Alps. Pyrenees. Asturias. Crimea.
—— multicostata, *Desh.*	Paris. Pyrenees. Nice. Egypt.
Terebratula bisinuata, *Desh.*=*T. subalpina,* Münst.	Paris. Kressenberg.
Spondylus cisalpinus, *Brong.*	Nice. Sardagna near Trent. (S. Tyrol.) Vicentine and Bavarian Alps.
MOLLUSCA.	
Conus diversiformis, *Desh.*	Paris. Scinde.
—— stromboides (=*C. concinnus,* Sow.).	London. Bassano and Vicentine.

Fossils.	Localities.
Ovula tuberculosa, *Duclos*	Paris. Crimea. Scinde.
Voluta Cithara, *Lamk.*	Paris. Scinde.
—— harpula, *Lamk.*	Paris. Bassano.
Bulla Fortisii, *Brong.*	Vicentine. Egypt.
—— striatella, *Lamk.*	Paris. Vicentine.
Terebra Vulcani, *Brong.*	Vicentine. Scinde.
Cerithium giganteum, *Lamk.*?	London. Paris. Venetian Alps. Nice. Crimea. Scinde, &c.
—— hexagonum, *Lamk.*=*C. pentagonum*, Fortis = *C. Maraschini*, Brong.	Paris. Cotentin. Vicentine.
—— cornucopiæ, *Lamk.* = *C. armatum*, Münst.	Paris. Cotentin. Vicentine.
Rostellaria fissurella	Paris. Nice. Vicentine. Egypt.
Strombus Fortisii, *Brong.*	Vicentine. Scinde.
Fusus longævus, *Lamk.*	London. Paris. Vicentine. Bassano.
—— intortus, *Lamk.*	Paris. Bassano.
Neritina conoidea, *Lamk.*	Paris. Pyrenees. S. Tyrol. Vicentine. Egypt. Scinde.
Natica sigaretina, *Lamk.*	Paris. Nice. Vicentine. Scinde, &c.
Pleurotoma semicolon, *Sow.*	London. Bassano. Possagno, &c.
—— undata, *Lamk.*	Paris. Bassano.
Melania costellata, *Lamk.*	Paris. Swiss Alps. Vicentine.
—— lactea, *Lamk.* = *M. Stygii*, Brong.	Paris. Vicentine.
Turritella Archimedis, *Brong.*	Paris. Pyrenees. Egypt.
—— imbricataria, *Lamk.*	London. Paris. Swiss Alps. Vicentine. Egypt. Crimea. Scinde.
—— vittata, *Lamk.*	Paris. Nice. Vicentine. Egypt. Scinde.
Trochus monilifer, *Lamk.*	Paris. Scinde.
—— agglutinans, *Lamk.*	Paris. Vicentine. Scinde.
Nautilus ziczac, *Sow.*	London. Kressenberg. Matsee.

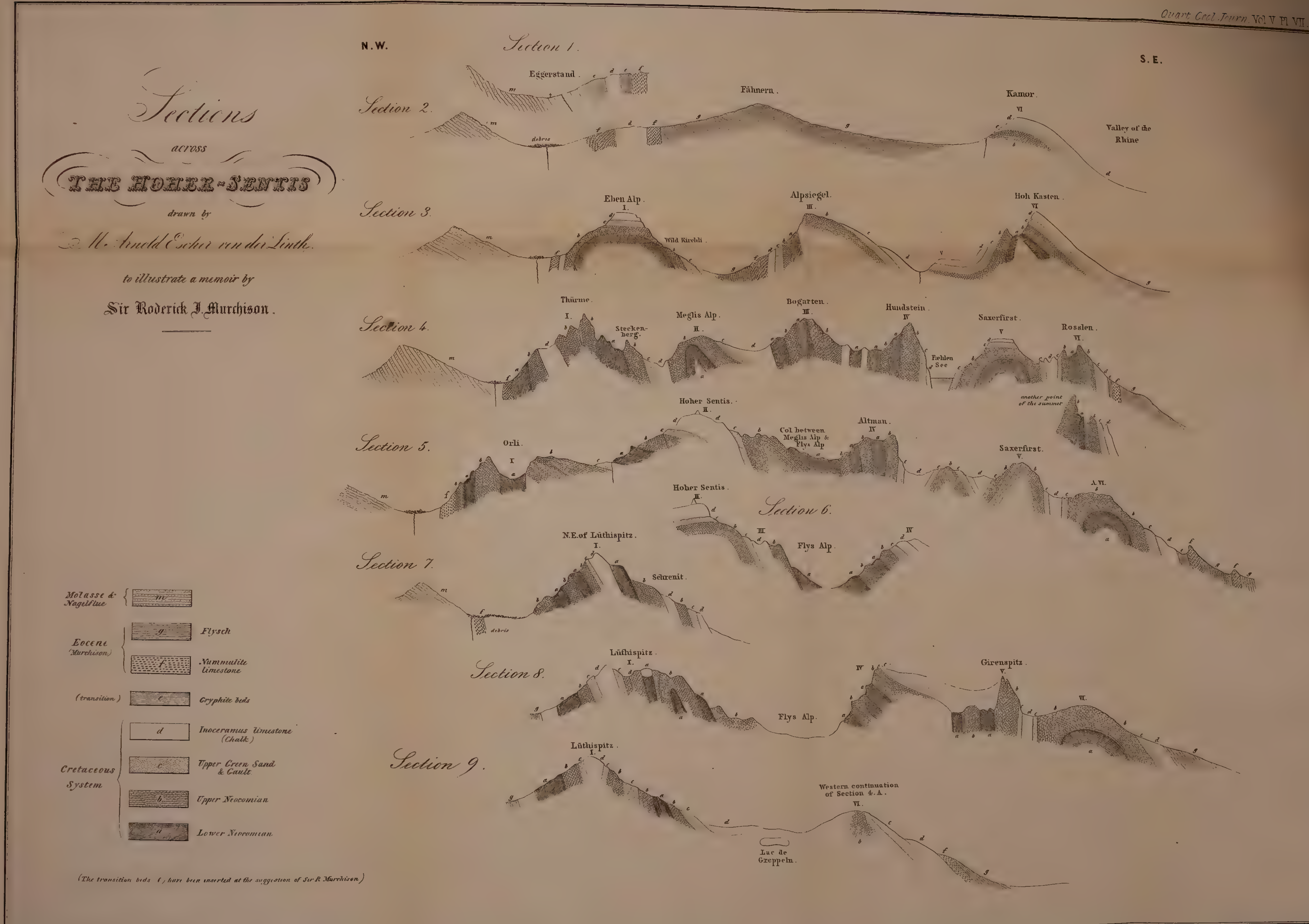
Obs.—Among the fossils recently sent to me by Capt. Vicary from Subathoo in Hindostan, are fragments of the lower jaw and teeth of a small gavial, of which Professor Owen says : "It seems to have rather rounder teeth than the modern species in India, and in this respect to resemble our old British eocene gavial of Bracklesham." None of the other forms from this Sub-Himalayan tract (according to Professor E. Forbes, to whom I referred them,) indicate the presence of rocks more ancient than the nummulitic eocene.

Under the term Scinde, &c. the reader may comprehend Cabul, the Punjaub, the valley of Cashmir, and the Sub-Himalayan range to the kingdom of Assam. Mr. Vigne, who explored Cashmir, has shown me limestone charged with nummulites from thence.

Postscript.—In addition to my own limited observations on the Trias of the Venetian and S. Tyrolese Alps (p. 165), I intended to have referred my readers to the illustration of the rocks and fossils of that age contained in the work of Professor Catullo, "Prodromo di Geognosia paleozoica delle Alpi Venete. Modena, 1847." Besides the common muschelkalk species cited in the preceding pages, Professor Catullo figures and describes several new species, and also the interesting triassic plant *Voltzia brevifolia* (Brong.). He further enumerates many fossils of the jurassic and cretaceous groups of that region, and figures their Cephalopoda. I cannot pretend to decide authoritatively a point on which this author insists—that certain species are common to the Upper Jura and Neocomian; but whilst I should be very sorry to do injustice to so experienced a naturalist as Professor Catullo, I must repeat, that wherever I have examined a tract in which there was a clear geological succession, there also the accompanying zoological distinctions indicated by M. de Zigno seemed to me to be equally clear. In cases of this nature everything depends upon correct definitions of the relations and order of the strata. Professor Catullo also describes five species of nummulites from the tertiary rocks of the Vicentine, but I must leave others to determine how far these forms have been named by previous authors. In another work ("Cenni sopra il terreno di sedimento superiore Venezia. 1847."), Professor Catullo figures a number of tertiary corals.

I have just received a new geological map of the environs of Vienna by M. Johann Czjzek, in which the author represents the "Wiener Sandstein" as older than the Alpine (jurassic?) limestone! I have not sufficiently re-examined that tract to be able to controvert this inference, but I firmly hold to the facts stated in the preceding memoir; and as the Bavarian "flysch" is unquestionably, like that of Switzerland, supracretaceous, it is for the Austrian geologists to show that their "Wiener Sandstein" is neither a prolongation of the same deposit, nor even an arenaceous development of any portion of the cretaceous system.


IV
Western conti
of Section
VI.



Reeve, Benham & Reeve, Lithographers.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

January 1st to March 31st, 1849.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

ACADÉMIE Royale des Sciences de Paris, Comptes Rendus de l'. Tome xxvii. Deux. Sem.

Agricultural Society of England (Royal), Journal. Vol. ix. pt. 2. No. 22.

American Academy of Arts and Sciences, Memoirs. New Series, vol. iii.

American Journal of Science. Second Series, vol. vii. No. 19.

Ashmolean Society, Proceedings, 1848. No. 25.

Athenæum Club, Rules and Regulations.

Athenæum Journal.

Chemical Society, Quarterly Journal. No. 5.

Cornwall, Royal Geological Society of, Annual Report, 1848.

Dublin University Museum, 3rd Report on the Progress of the, 1848.

France, Société Géologique de, Mémoires. Deux. Série, tome iii. partie 1. Bulletin, Deux. Série, tome v. f. 29–32, tome vi. f. 1–10.

Geographical Society (Royal), Journal. Vol. xviii. part 2.

Indian Archipelago, Journal. Vol. ii. Nos. 10, 11 & 12.

Neuchatel, Société des Sciences Naturelles, tome ii. 1846–7.

Newcastle-on-Tyne Literary and Philosophical Society, Catalogue of the Library, 1848.

Northumberland Natural History Society, Reports, 1846–7.

Philosophical Magazine. *From R. Taylor, Esq., F.G.S.*

Royal Society of Edinburgh, Transactions. Vol. xvi. part 4, and vol. xviii.

———, Proceedings. Vol. ii. Nos. 31 and 32.

St. Pétersbourg, Académie Impériale des Sciences, Mémoires, 6^{me} Série, tome vi. vii. & viii. Bulletin de la Classe Physico-Mathématique, tome v. & vi.

Torino, Reale Accademia delle Scienze di, Memorie. Serie 2, tomo vii. viii. & ix.

Vaudoise Société, Bulletin. No. 19.

Wien, Berichte über die Mittheilungen von Freunden der Naturwissenschaften, Band 4. Nos. 1–6, 1848.

——, Naturwissenschaftliche Abhandlungen, gesammelt und herausgegeben von Wilhelm Haidinger. Band 2.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Agassiz, Prof. L. Lectures on Embryology in 11 Nos. of the "American Traveller" newspaper. *From Sir Charles Lyell, P.G.S.*

Ansted, D. T. The Gold-Seeker's Manual.

Bellardi, Luigi. Monografia delle Columbelle Fossili del Piemonte.

Bunbury, C. J. F. Journal of a Residence at the Cape of Good Hope.

Carpenter, W. B., M.D. Shell.

Carvalho, J. P. R. de. Consideracões Geraes sobre a Constituição Geologica do Alto-Douro. *From D. Sharpe, Esq., F.G.S.*

Dent, E. J. Treatise on the Aneroid Barometer.

Howard, Luke. Barometrographia, parts 4 and 5. Edited by *E. W. Brayley, jun., Esq., F.G.S.*

Humboldt, Alexandre de. Essai Politique sur le Royaume de la Nouvelle-Espagne. 2 vols. and atlas. *From Alfred Tyler, Esq., F.G.S.*

Jerwood, James. A Lecture on the New Planet Neptune.

————. On some New Fossil Fish of the Carboniferous Period.

M'Coy, F. On some New Ichthyolites from the Scotch Old Red Sandstone.

————. On some New Mesozoic Radiata.

Oldham, Prof. Address at the Opening Meeting of the Geological Society of Dublin, 1848.

Palfrey, J. G. Statistics of the Condition and Products of certain Branches of Industry in Massachusetts. *From Prof. H. D. Rogers, For. M.G.S.*

Phillips, John. Thoughts on Ancient Metallurgy and Mining in Brigantia and other parts of Britain.

Ramsay, A. C. Passages in the History of Geology.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

JANUARY 3, 1849.

The following communications were read:—

1. *Notice on the Occurrence of Eocene Freshwater Shells at* BEAULIEU, LANGLEY, *&c., in* HAMPSHIRE. By J. C. MOORE, Esq., Secretary Geol. Soc.

BEING lately in the neighbourhood of Beaulieu, on the eastern boundary of the New Forest, I had opportunities of ascertaining that the fluvio-marine beds of the Isle of Wight and of Hordwell Cliff extend further eastward than has hitherto been noticed.

From the Beaulieu river to the Southampton Water, a distance of about four miles, the country is a low flat moor covered with heather: by following the coast from the mouth of the Beaulieu river to Eaglehurst, it will be seen that the lowest bed is a purplish clay covered by a grey sandy clay, both of which are nearly concealed at high-water; on these repose yellow sands, interstratified with pebbly beds, the whole being covered by a diluvium of flint shingle. The beds rise gently to the west, and more perceptibly to the north.

The yellow sands are without fossils, but the clays in the following localities contain them.

1st. On the west side of the Beaulieu river, between St. Leonard's and Bucklershard, I found casts of *Lymnæus longiscatus* in a grey clay, reposing on purple clay.

2nd. Across the river, in a brick-field about one mile above Exbury, I found fragments of shells in a similar grey clay, reposing on purple clay.

3rd. Close to Beaulieu, on the east side of the river, in a brick-field, I obtained the following section:—

Soil and diluvium; brown clay, 2 feet; sandy clay, 3 or 4 feet; yellow and light-coloured sand.

The sandy clay contained a seam, three or four inches thick, of very perfect specimens of *Cyrena obovata* and *Melania costata*, together with a few broken specimens of *Cytheræa incrassata* and an *Ostrea*. About a foot below this seam of shells was a very thin seam of broken fragments of the same Ostrea and Cytheræa.

4th. About one mile and a half eastward, near the village of Langley, a brook running parallel to the Beaulieu river affords the following section:—

Diluvium; ferruginous clay, 2 or 3 inches; greenish clay with vegetable impressions, 2 or 3 feet; sandy loam with vegetable impressions; stiff clay without fossils, 6 or 7 feet; bed of nodules of ferruginous clay containing casts of *Lymnæus longiscatus, Melania costata*, a Natica, Cyrena? and a Nucula? The lowest bed seen was a greenish marl with very perfect specimens of *Cytheræa incrassata*.

5th. About half a mile to the north, on the same brook, I found in an old marl-pit the same green marl with the Cytheræa.

Still further east, about one mile and a half from Hythe, on the road to Eaglehurst, a grey clay used for brick-making is seen covered by a considerable depth of the yellow sand; but I could not find any fossils in it.

I suspect these fluvio-marine beds do not extend much further to the north; for on the opposite side of the Southampton Water, half a mile below Netley Abbey, I found a low cliff consisting of grey sandy clay with marly concretions like septaria, abounding in shells of the genera *Turritella, Corbula, Pecten, Pinna, Rostellaria*?, *Fusus*?, *Voluta*?, *Pholadomya*?, and no mixture of freshwater shells,—a group which, by consulting Mr. Prestwich's lists of fossils, seems to belong to some part of the Bracklesham Bay series.

I have thought it worth while to mention the occurrence of these fluvio-marine beds over this tract, as it might otherwise have been referred to the upper and middle beds of the Bracklesham series, to which, judging by Mr. Prestwich's description, they have great resemblance. Both consist of a series of yellow sands overlying purplish clay and greenish sand: and as that geologist has shown that the lower and middle divisions of the series come to the surface at Southampton with a southerly dip, it might have been believed that the district to the south, which I have tried to describe, was part of the middle and upper members of that formation. The fossils, however, indicate that these beds are higher in the series, and make it probable that the upper Bracklesham beds crop out at some intermediate point; and of this there seem to be indications in the marine beds near Netley Abbey.

2. *Further Observations on the Geology of* RIDGWAY *near* WEYMOUTH. By CHARLES H. WESTON, Esq., B.A., F.G.S.

[*Abstract.*]

IN his former paper on this subject* Mr. Weston endeavoured to show the existence of the Hastings sand at Ridgway. He has since visited the various sections of the Wealden between Hastings and Lulworth, and then re-examined the railway cutting at Ridgway, and the result has been to confirm his former views. He finds that the variegated clays, loams and sands exhibited in the latter locality are by no means local, but occur also in Kent, in the south of Sussex, in the Isle of Wight and in Dorset; and he has recently observed them on the Brighton and London Railway near Balcombe. In Sussex these variegated clays form a very subordinate part of the formation, but are more developed in the counties to the west.

In his concise but masterly 'Geological Sketch of the Vicinity of Hastings,' Dr. Fitton notices the "greenish and purplish variegated clay" and sand visible at Leaness Point, between Hastings and Winchelsea. They lie beneath a stratum which Mr. Webster describes as a sandstone intersected by numerous veins of argillaceous iron ore, and rest on a dark-coloured shale also containing several layers of rich iron ore, formerly much worked in Sussex. These lowest shales are placed by Dr. Mantell in the upper part of the Ashburnham beds. Dr. Fitton also points out the anticlinal axis passing from the shore near Leaness through the highest point of Fairlight Down to Battle, the strata dipping away from it on both sides.

Mr. Weston has himself found similar ferruginous and variegated clays and sands in a hill beyond Ham Street on the Rye and Ashford Railway, and near Hastings at Bopeep, west of St. Leonard's, and at Bexhill. He next found them at Sandown Bay in the Isle of Wight, and also between Atherfield and Afton Downs. The clays contain no fossils but the *Cypris valdensis* and *Paludina* in some associated beds.

"The next appearance of the Hastings sand is at Swanage Bay in Dorset, emerging from under the very steep escarpment of Ballard Downs. The entire group was in this place more varied, and consisted of a greater number of alternations of sands and clays than I found in the Isle of Wight. It appeared in consequence to combine in miniature the more extensively-developed arenaceous deposits of Hastings and the almost exclusive argillaceous strata of the south-west coast of the Isle of Wight.

"The variegated clays are identical with those of the latter and of Ridgway. I could however discover no fossils in them.

"The Chalk Downs (of which Ballard Down forms the south-eastern extremity) run across the Isle of Purbeck and terminate in the fine bluff cliff of Purbeck Hill on the east of Lulworth. The sections below Purbeck Hill are those of Worbarrow Bay on the east

* Quart. Geol. Journ. vol. iv. p. 245.

of the chalk and Mewp Bay on the west, of which I only visited the former.

"The Hastings sands of Worbarrow Bay consist of a considerable admixture of clays and sandstones. The latter appear to abound here more than at Swanage Bay. The clays possess the peculiar character and colours of those at Ridgway, but some of their colours are rather more vivid. The colour of the sandstones, from the great abundance of the ferruginous base, is in many places intense. I could not discover any organized remains in these clays. I think no one who has examined this part of Dorset, and has traced the base of the chalk escarpment from Ballard Down to Purbeck Hill, can fail to be convinced of the correctness of Dr. Fitton's view, and to feel satisfied of the continuity of the Wealden formation right across the peninsula of Purbeck."

He next visited Lulworth Cove, where the general appearance of the Hastings sand is similar to the localities we have already described. Not far from this place is the last coast exhibition of the Wealden formation in Man-of-War and Durdle Coves. These are separated from each other by a short isthmus, which has been protected by a rock of greatly-inclined strata of Purbeck stone, and is composed of the Wealden very condensely and vertically developed. From this isthmus we see the eastern side of Man-of-War Cove, which appeared evidently to consist of Hastings sand. That point and the isthmus are clearly the remnants of a once continuous mass. The west side of Durdle Cove is composed of chalk which here abuts upon the sea, and runs uninterruptedly along the coast to the high point of White Nore, whence it trends inland.

In all these sections the variegated clays, loams and sands were identical in character with the Ridgway deposit. In this section, which he visited the following day, Mr. Weston "traced the Purbeck beds to their first uninterrupted termination, which consisted of calc grit with Purbeck fossils. Beyond this were clays, and then alternations of the calc grit and clays, and ultimately the Hastings bed exclusively. This section therefore exhibits the same features which Dr. Fitton has observed respecting other sections of the Wealden, showing, 1st, the continuity and sequence in the deposition; and, 2ndly, the quiet process of such deposition. Hence we have the most satisfactory evidence that the beds overlying the Purbeck followed in regular succession, and were in fact rather a continuation of them."

On the whole Mr. Weston concludes not only that the variegated clays of Ridgway Hill really belong to the Hastings sand formation, but that their geognostic position is in the lowest part of the Worth and Tilgate group, separating it from the inferior Ashburnham beds.

Mr. Weston also mentions that he found the Purbeck deposits to extend as far west as the end of the Corton Range, and therefore spreading co-extensively with the Portland oolite to the vicinity of Portisham.

In regard to the attempt to explain the singular interposition of

Lens Aldous, Del. Day & Son lith^rs to the Queen

Alcyonites parasiticum.

the Oxford clay between the Wealden and the cretaceous series as resulting from a drift, he remarks:—

"1st. That I could not perceive in the fossils those marks of abrasion which would indicate their having been drifted.

"2ndly. That the Oxford clay has considerable depth. It has already been penetrated to the depth of about sixty feet without reaching its termination.

"3rdly. That the vertical surface of the wall of chalk is hardly consistent with the natural results of previous diluvial action in that locality. And,

"4thly. In many places the theory of a drift may involve no physical difficulties. But at Ridgway this idea would involve serious objections. Whence, it might be asked, could the Oxford clay have been drifted? The Oxford clay of Ridgway is about 200 feet above that of Weymouth; and the next exhibition of that bed on a higher level would be at Little Bredy near Abbotsbury Common, at a distance of between five and six miles, and at a level, I apprehend, certainly far below that of Ridgway. Whatever difficulties may therefore be supposed to attach to the theory which I have ventured to propose, will not, I think, be diminished by the suggested explication of a drift. I have also satisfied myself by repeated and careful examination that the section contains no double fault."

---

3. *On a Siliceous Zoophyte,* ALCYONITES PARASITICUM. By J. S. BOWERBANK, Esq., F.R.S. G.S. &c.

PARKINSON in his 'Outlines of Oryctology' has applied the term Alcyonites to designate those fossils which were supposed to have been polypiferous animals allied to the recent genus *Alcyonium*. I have therefore adopted that name as being the best designation of the fosssil I am about to describe, although there is an objection to the term from the very indefinite and promiscuous manner in which it has been formerly used by authors; and Mr. Morris, possibly for the same reason, has judiciously excluded it from his 'List of British Fossils.' However that may be, in the present case it is applied strictly in accordance with the correct definition of the recent genus *Alcyonium* given by Dr. Johnston in the second edition of his excellent and beautiful 'History of British Zoophytes.'

The fossil which forms the subject of this memoir is not in its natural and unmutilated condition, but is a portion of the animal contained in a small slab of agate $1\frac{1}{2}$ inch long by $1\frac{1}{8}$ wide, such as are commonly mounted in ladies' brooches. I obtained it from a dealer along with a considerable number of specimens of what are generally designated as Moss Agates. It is represented of the natural size, Plate VIII. fig. 1, and a fibre magnified 100 diameters by fig. 2.

Alcyonites parasiticum.

Polypidom fleshy, parasitic, incrusting, mammillated. Cells numerous, protuberant, scattered. Polyp. Tentacula short, cylindrical, smooth, tapering to an obscure point.

At the first view of the agate my attention was arrested by the great size of the fibres contained within it, which vary from $\frac{1}{50}$ to $\frac{1}{12}$ of an inch in diameter, and on placing it beneath a microscopic power of 100 linear, I was at once struck by their extraordinary hirsute appearance.

The mass of the polypidom appears to have been of a fleshy texture, and semi-transparent like that of *Alcyonidium gelatinosum* of our own coast. It is built around the fibres of a species of *Verongia*, and the tubular fibres of the sponge are in many places in a beautiful state of preservation. A portion of one of these is represented by fig. 3. Plate VIII. Each fibre is not separately surrounded by the fleshy substance and cells of the parasite, as would be the case if it were a Gorgonia, but it often occurs that several fibres are included within one circle of polyp cells, and the contained sponge fibres frequently pursue a tortuous course, while the fleshy body of the Alcyonite does not follow their contortions, but surrounds them in the form of a large regular cylinder.

The surface of the polypidom presents a strongly mammillated or tuberculated appearance. The mammillæ are not arranged in any definite mode, but are scattered without order, thickly over the whole of the surface. They vary in diameter from $\frac{1}{400}$ to $\frac{1}{285}$ of an inch, and are usually elevated about half the amount of their own diameter above the outer surface of the polypidom.

Within each of the mammillæ, at a depth of about a fourth part of their own diameter, there is a somewhat irregularly-formed globular cavity, and usually within this there is a single small opaque black mass, which from its comparative size and uniformity has probably been the remains of the gizzard of the polyp*.

The outer surface of the mammillæ is usually more or less semi-globular, but it is frequently the case that its apex is flat and somewhat depressed in the centre, so that a section of it in the direction of its axis would present three sides of a right-angled figure, having the angles slightly rounded off and the centre of the upper line slightly depressed. Under these conditions it resembles closely the appearances presented by the polyp cells of the recent *Alcyonium digitatum* of our own coast, when the polyps are in a semi-extruded condition, and the semi-globular appearance would be the condition of the recent polyp when still further withdrawn within their polypidom. These states of the mammillæ of the fossil are represented by fig. 4. Plate VIII.

It is possible that this mammillated appearance of the surface of the

* As the nature of this body cannot be determined with certainty, I have thought it better to refer the animal to the established genus *Alcyonites* than to form a new genus for its reception.

polypidom is not its natural character, but has been induced by the exhaustion and subsequent death of the animal, having prevented their complete withdrawal within the polypidom.

Each of the mammillæ is furnished with a number of smooth cylindrical tentacula averaging $\frac{1}{850}$ of an inch in length; their diameter at the base is $\frac{1}{3333}$ inch, and they decrease gradually thence to the apex, terminating in a blunt point. No portion of the surface of the polypidom is furnished with these organs excepting the mammillæ.

The tentacula present every appearance of perfectly flexible organs; no semblance of rigidity exists, but they are bent and curved in an easy flowing manner in every possible form and direction.

The animal is similar in structure to Prof. Edward Forbes's genus *Sarcodictyon*, but it has not the regularity in the disposition of the cells which exists in that genus.

In the tuberculated surface of the polypidom it much resembles that of *Sarcochitum polyoum*; but the habit of the animal is exactly that of *Alcyonidium parasiticum* of our own coast, specimens of which I have frequently taken at Scarborough, surrounding the slender stems of *Sertularia* and other zoophytes.

Nearly the whole of the animal within the agate is in a beautiful state of preservation, but there are a few spots which present evidence of the commencement of decomposition, by the detachment of groups of cells from the mass of the polypidom; in these cases the remains of the tentacles, as might be expected, are very rarely to be seen; and the disrupted mass is totally without the sponge fibre.

The envelopment of a tooth, a bone, or of hard calcareous bodies such as shells, afford no definite information regarding the time necessary to accomplish such an operation. The investment even of such bodies as the rigid, endurable horny fibres of that tribe of sponges which are usually to be observed imbedded in flints, cherts, and moss agates, give also a considerable range of time to accomplish the fossilization; but when we see such a soft and perishable substance as the fleshy body of the living Alcyonidæ, and such delicate organs as the tentacula of the polyps, thus preserved with such evident appearances of freshness and perfection, I own that it excites in me the greatest astonishment that there should have been so rapid a deposit of siliceous matter as must evidently have taken place, thus to entomb the animal in such a condition as proves, that at the utmost but a few days must have elapsed before it was so far incrusted as to completely preserve the form and position of the animal, not by a sudden immersion in supposititious siliceous paste impounding it instantly in its full vigour, but after a slow and gradual decease; for this condition which I have described, of semi-protrusion of the tentacula, is that with which every one acquainted with recent zoophytes in a living condition, is so familiar as an indication of slow and undisturbed death by exhaustion. In this condition of semi-protrusion I have seen the animals of *Alcyonium digitatum*, *Alcyonidium parasiticum*, *Caryophyllea Smithii*, and numerous species of *Sertularia* and other zoophytes, die, if allowed to do so, without interference; but if touched or disturbed, the tentacula are slowly withdrawn and never again extruded.

It does not appear to me to be necessary for the production of a fossil that the whole of the silex should have been deposited immediately. We may readily imagine that after the rapid deposition of the first portion, induced by the full exposure of the animal matter, and the consequently strong elective attraction exerted by the animal for the earthy particles, that the remainder of the deposit, the filling-in of the interstices of the network, would be more slowly and regularly completed in accordance with the laws of crystallization, as we find that from the surface of this animal there are the same series of crops of radiating calcedonic crystals that characterize the structure of the great mass of the moss agates which I have described in my paper on those bodies published in the 'Annals and Magazine of Natural History,' vol. x. page 9. This prismatic semi-crystallization, if we may reason from analogies afforded by the phænomena of crystallization displayed by salts formed by acids with earthy or metallic bases, is a rapid and perhaps irregular operation, compared with the slow formation of the regular and well-defined crystals of the respective substances under consideration, and which crystals are probably produced without the interference of any other agent than that which is necessary for their own construction. However that may be, it is certainly quite a different operation from the merely mechanical deposit of the silex from the Geysers of Iceland or other such thermal springs, the waters of which are charged with a considerable quantity of the earth in solution. I have been favoured by Mr. C. C. Babington with specimens of the silex deposited by the water of the Great Geyser, which were procured by himself during a recent visit to Iceland, and I have carefully examined and compared it with numerous specimens of agates, cherts and flints, but this siliceous substance is not like the latter bodies, formed in every instance more or less of fibrous crystalline structure. Not a vestige of such an arrangement of its particles could be discovered: it was purely amorphous, like a mass of melted glass. In this form under some circumstances it is simply a deposit arising from the evaporation of the water, and in other cases it probably arises from the rapid disengagement of the excess of carbonic acid in solution; in either case it is most probable that the silex thus solidified would present only the glacial form of that deposited by the Geysers; but if, on the contrary, the deposit be induced by the modified and slow exertion of chemical affinity, then it is probable that the silex would assume a form which approaches that of its normal condition of crystallization; and that this would be the case is rendered most likely from the phænomena which we observe in the crystallization of nitrate of potass and other salts during slow evaporation beneath the microscope assisted by the apparatus for the polarization of light.

If we view solutions of salts under these circumstances, we do not observe the production of the crystals to be a slow and continuous operation; on the contrary, they are produced suddenly and at intervals. We observe a single long prismatic crystal rapidly produced before the eye, as if the blade of a sword were deliberately passed through the solution, and this under the influence of the polarizing apparatus exhibits perhaps a uniform green colour according to the thickness of the crystal; after this there is a cessation of action for a period, and then another layer of the substance of the salt passes over the surface of the crystal from its base to its summit, and it then becomes as universally and vividly pink as the first layer was green, and thus layer after layer is added and the colours continue to alternate until the action ceases.

Within the boundaries of the fossilized body of the Alcyonium there are no appearances of crystalline arrangement, but it is immediately on, or slightly without the outer surface, that the first crop of crystals is based, and the succeeding one follows from the apices of the first, and so on, crop succeeding crop, until the intervening spaces are entirely filled up. Sometimes the force of the projected crystals has been sufficient to thrust before them a considerable quantity of the substance of the organic matter in course of fossilization, which is finally crushed into a dense mass between the opposed crops of crystals, when their apices meet. Such is frequently seen to be the case in masses of fossilized wood, both siliceous and calcareous, and the force exerted by crystallization is evidently forward, and in no case that I have seen is it backward; for the tissues at the bases of the respective crops of crystals show not the slightest evidences of compression, while the cellular and vascular structures, at the junction of the opposed bodies of crystals, exhibit every evidence of having been forcibly driven forward, and finally compressed into a solid opaque mass, affording only sufficient evidence of structure to be certain of the nature of the material.

These phænomena, it will be observed, accord with the mode of the production of prismatic crystallization which I have described as occurring beneath the microscope; thus rendering it highly probable that the calcedonic crystallization of silex is an operation achieved in very much less time than may have been imagined.

After a period, the tendency to produce crops of calcedonic crystals appears to cease, and hollow spaces remain, which are completely bounded by the apices of the last crop of crystals; and these spaces, and the cessation of prismatic crystallization, are probably produced by the complete exclusion of further portions of silex in solution: but at other times, in lieu of the spaces, we find a solid mass of regular crystals of quartz; and in this case it is probable that the surrounding fluid, holding silex in solution, had access to the cavity, formed by the apices of the last crop of calcedonic crystals, through some minute opening, so that a continuous but slow change of the fluid took place in accordance with the laws of endosmose, as soon as the silex was deposited within.

These views, regarding the deposit of silex in solution, are to a considerable extent confirmed by an interesting fact communicated to me by my friend Mr. Warren De la Rue, who found minute crystals of silex deposited on the inner surface of a phial, which contained the residuum of an analysis in which there remained some of that earth in solution.

On examining these crystals by a microscopic power of 500 linear, I was much interested on finding that not only were regular crystals of silex present, but that the calcedonic form of deposit was also apparent in the form of filmy plates, composed of two and sometimes three distinct crops of the characteristic acicular crystals of that form of deposit*.

We are familiar with the solid condition of silex, as it exists in masses where the deposit has been induced by the presence of organic matters, as well as in those in which the influences are purely mineral, as in the agates of the igneous rocks; but in both cases to a certain extent the phænomena are identical, as far as regards the calcedonized portions of the masses. In the first instance, the solidified and encased organic matters form the nuclei whence the first crops of crystals spring. In the second, the parietes of perhaps an accidental cavity in the mass of the igneous rock, furnishes a base for a similar crop of crystals; and subsequently, in both cases, the deposit appears to progress uninfluenced by any other agencies than what are in accordance with those which are purely mineralogical.

But whence, it may be asked, come the enormous quantities of silex, which have entered into the structure of fossils during every geological period, and which still continue to be separated from the ocean? Various opinions have been offered to account for these phænomena, such as extreme heat, great pressure, thermal springs, and a peculiar gelatinous condition of silex, produced by chemical manipulation, but of which we have no authentic record in nature.

None of these, it appears to me, satisfactorily account for the vast deposits of silex that we have to deal with in connection with organic matter. Great pressure and high temperature, there is no doubt, are active agents in promoting the solution of silex in excess, with which some chemical springs are charged, and these causes are perhaps powerfully effective in the formation of certain mineral products in

* 7 St. Mary's Road, Canonbury, June 10, 1848.

My dear Sir,—Your having mentioned to me that you are at present engaged on some investigations respecting the deposition of silica in a crystalline form, has recalled to my mind a fact which I observed some time since, and now venture to communicate to you in the hope of its proving of interest in connection with your researches.

You are aware that the gaseous body fluoride of silicon ($Si\,F_3$) is decomposed by contact with water, one-third of the silicic acid being deposited in the form of a jelly, and silicated hydrofluoric acid ($3\,H\,F+2\,Si\,F_3$) produced; thus $3\,(Si\,F_3)+3\,(HO)=Si\,O_3$ (which deposits)$+3\,H\,F+2\,Si\,F_3$ (which remains in solution).

The deposited silicic acid is extremely soluble in water, and I have observed that the separated silicated-hydrofluoric acid always retains a portion of uncombined silicic acid in solution; this deposits after the lapse of some months in minute crystals of artificial quartz. The specimen I now send you was thus obtained: the crystals vary in size from the one nine-hundredth of an inch to the one seventy-fifth of an inch in length (from ·00111 in. to ·01333 in.); they depolarize light, and form a very beautiful microscopic object.

The case just cited is precisely analogous to those you were mentioning to me; in all, water is the solvent of the silica, which, when recently produced or separated from its combinations by the action of the atmosphere on the earthy silicates, is presented in the modification favourable for solution.

I remain, my dear Sir, very truly yours,

James Scott Bowerbank, Esq., WARREN DE LA RUE.
&c. &c. &c.

the interior of the earth; but as regards the supply of silex in the production of fossils, and in its appropriation by living organisms, I believe them to have infinitely less to do with these phænomena than has hitherto been supposed.

Modern chemistry has shed much light upon this subject, and has shown us that silex is very much more soluble than was formerly supposed. It has taught us that most sandstones contain, mixed with them, silicates with alkaline bases; and that in the decomposition of granite, porphyry, and other similar rocks, vast quantities of soluble silicates are liberated and poured into the ocean in solution; and thus, although in unappreciable quantities, silex must necessarily exist in sea-water.

For many years chemistry failed to demonstrate the existence of iodine in sea-water; but as the science advanced, it was found by Dr. G. Schweitzer, in his analysis of sea-water from the British Channel, published in the 'Philosophical Magazine' for 1839 *, that it did exist in it, although in so minute a degree as to form not more than one-millionth of its bulk in a given quantity; and this fact, from the peculiar qualities of the substance, was readily demonstrable. But the same peculiar qualities do not exist in silex, and its presence, although probably in greater proportional quantities, cannot be rendered apparent by any chemical test that is at present known to science; but that it does exist in sea-water is evident from the vast quantities of siliceous infusorial animalcules, which can derive, from no other imaginable source, the material with which they construct their cells. These minute and interesting creatures exist by myriads in the ocean in all quarters of the globe, forming no inconsiderable portion of the food of conchiferous mollusks, whence they are conveyed into the stomachs of fishes, which becoming in turn the prey of sea-birds, are thence conveyed by them and deposited in their excrements on rocks and islands, where amidst the guano they are found in a beautiful and perfect state of preservation. Vast quantities of them are also found attached to fuci and zoophytes, and I have them in this condition from the shores of Africa, Australia, Japan, China, and various parts of Europe. It is evident therefore, from the universal prevalence of these minute animals, that silex not only existed in former geological periods in solution in the waters of the ancient seas, but that it also exists in solution in all parts of the seas of the present period; and however minute and unappreciable the quantity may be to the science of chemistry, it is yet sufficiently large to admit of its continual secretion by the countless myriads of living creatures that need it for their protection and support.

If it be not so, what becomes of the enormous quantities of soluble silicates that are continually poured into the ocean by the decomposition of feldspar, granite, porphyry, and other similarly constituted minerals? Moreover it is a fact satisfactorily established by modern chemists, that these silicates are readily retained in solution by the

* Vol. xv. p. 51. I have since been informed, that previously to this date iodine had been noticed in sea-water from the Mediterranean by Balard, and in that of the Baltic by Pfaff.

presence of carbonic acid, a material which is known always to exist in sea-water. And so powerful is the effect of the presence of this acid when in contact with the silicates, that it was found by Poltorf and Wiegmann, that sand might be boiled in a mixture of nitric and muriatic acids, and then thoroughly washed, and yet after this purification, when left for thirty days immersed in water saturated with carbonic acid, the water was found to contain in solution, silica, carbonate of potass, lime, and magnesia; thus proving beyond a doubt the power of carbonic acid alone sufficient to take up and retain in solution this hitherto supposed to be insoluble earth*.

The continued attrition of the material of every beach throughout the world must necessarily also be reducing enormous quantities of silex to the state of impalpable powder, or into such a state of comminution as to render it soluble under favourable circumstances; and we know that in the state of extreme division, arising from precipitation by chemical action, it is readily soluble even in cold fresh water, containing no more than the usual quantity of carbonic acid.

The facility with which silex is held in solution under ordinary circumstances, is equally well proved by every corn-field that we pass through, in the well-known abundance of it secreted in the stalks of the plants. The rain-water no sooner permeates the soil, than it becomes charged with a sufficiency of that earth to afford the material for the secretion of a considerable coating of silex, by this as well as many other similar plants.

Thus it has ever been during our geological periods, and if we may judge by the similarity of the phænomena of fossilization, throughout a long series of geological formations from the Silurian upwards.

It is not only in plants and in the Spongiadæ that these deposits of silica have taken place; it is almost equally abundant in the fossil Corallidæ. Everything organic appears to have an active affinity for silex in solution, and no sooner have the waters of the ocean, or other agents, removed the carbonate of lime from shells, than the animal matter thus released from combination is immediately seized upon by the silex. It is thus in the oolites, the cretaceous groups, and in the clays of the tertiaries also; for as perfectly silicified shells are found in the London clay as can be obtained even from the greensand formation. Nor is it surprising that this should be the case, when we see that such delicate and ephemeral organs as the tentacula of polyps are invested with silex in so rapid and perfect a manner, as we observe to be the case in the polypiferous fossil that I have just described.

With these great sources continually in action in all parts of the world, liberating enormous quantities of soluble silicates, and the well-established soluble powers of carbonic acid, we may be content to throw aside the supposititious source of the gelatinous condition of silex,—to dispense even with thermal springs and high pressure in the

* I have learned since this paper was read, that Forchhammer has found silex in solution in sea-water, to the amount of 0·003, and that it has been detected by Pagenstecher in the water of the Aar, near Berne, and of the Rhine at Basle (see Berzelius's Jahresbericht).

formation of siliceous fossils, and content ourselves in endeavouring to comprehend the mysteries of these natural phænomena, by the agency of the laws in continual operation, and with the ordinary amount of pressure in the depths of the ocean around us. We see that animals have the power of quietly effecting within their tissues, that which in the operation of fossilization is effected by a species of attraction, which, for want perhaps of a more accurate knowledge of these natural operations, we designate elective attraction.

May not this attraction of organic matter for silex, so abundantly displayed throughout the whole field of geological science, shed some light on the chemistry of animal and vegetable assimilation or secretion? The laws of endosmose are continually equalizing the densities of the fluids within the cells of animals and vegetables; and if the views I have stated be correct, there needs in living animals, as well as in dead ones, but that the earth in solution should be brought in contact with organic surfaces under certain conditions, with which we are but very imperfectly acquainted, to be deposited upon the parietes of the cells or other organs into which the fluid has insinuated itself; layer after layer is then deposited, until the whole of the minute cavities are filled up. If we examine the structure of shells as exhibited in the prismatic cells of *Pinna*, *Ostrea*, and other allied genera, we always find the earthy deposits in the form of successive layers from the circumference to the centre. Such also is the form of deposit in both the siliceous and calcareous spicula of recent sponges; so it is also in bone and in every similar organic tissue with which I am acquainted. And such also is the form of deposit of silex, carbonate of lime, and pyrites, in the cellular and vascular tissues of fossils; and in no case is it better displayed than in the cells of many of the succulent fruits of the London clay, where we find their walls remaining in the form of thin films of carbon; upon the inner surfaces of these are deposited successive layers of pyrites; but the deposit is frequently found to have been arrested after several of these depositions, thus leaving the centre of each cell empty, and then we find the inner surface of the last coating of pyrites usually covered with a beautiful crop of minute crystals. It is the same in the fossilization of the Spongiadæ: in the substance of the animal matter there is no evidence of crystallization, and it is only at a short distance from each fibre that the radiating crystalline needles of the calcedonic form of deposit are seen to spring, and crop after crop succeeds each other, until the whole of the intervening spaces are filled.

Much weight has been attached by some writers to the probability of the spicula of the Spongiadæ acting as nuclei for the attraction of silex in the process of their fossilization; but it is a remarkable fact that the true Halichondria, in which the siliceous spicula abound, are exceedingly rare in a fossil state; while the remains of true Spongia, in which the animal fibre predominates, are very abundant. And moreover, whenever I have found the siliceous spicula preserved, they have always exhibited considerable erosion of the surface, as if they were very much more amenable to the action of the solvents to which they had been exposed, than to the chemical affinity of their kindred molecules in solution. The spicula so abundant in the greensand of Maidstone and its neighbourhood, and in the fossil sponges of Wiltshire, are never in an unaltered condition; their surface is always more or less eroded, and sometimes, in parts, nearly eaten through, by the solvent action of the water and carbonic acid; and I have never yet seen an instance in which a detached spiculum has formed the nucleus for a crop of the radiating crystals of the calcedony, but I have frequently found detached sponge fibres under such circumstances; and as we observe them when imbedded in the masses of flint or agate, the deposit most frequently assumes the form of a series of distinct centres of crystallization. Fig. 5. Pl. VIII. represents one of these cases from the interior of a flint, and in this instance the deposit has been arrested, and we therefore have the first crops of the crystals covering the fibre in such a form as to give it completely a moniliform aspect.

If the views which I have endeavoured to establish in this and my former papers on these subjects be correct, we may justly consider the attractive power of organic matter for silex, as one of the great agents established by nature for the consolidation of the soluble silicates, liberated and dispersed through the ocean by the gradual decomposition of the compound mineral masses which form the crust of the globe. Vast as these decomposing masses may be, the process appears to be so slow and modified as to render the results as regards the silex scarcely if at all appreciable in the waters of the great rivers, through the means of which it is poured into the ocean; and however continuous the supply, it is evident that the rapidity and extent of the process of fossilization and of animal assimilation are amply sufficient to preserve that wise and beautiful equilibrium, which is apparent throughout nature in everything connected with the decomposition and reconstruction of both animal and mineral forms.

January 17, 1849.

The following communication was then read :—

On the Geological Structure of the Alps, Apennines *and* Carpathians, *more especially to prove a transition from Secondary to Tertiary rocks, and the development of Eocene deposits in* Southern Europe. Part II. By Sir Roderick Impey Murchison, F.R.S. G.S. L.S., Hon. Mem. R.S. Ed., R.I. Ac., Mem. Imp. Ac. Sc. St. Pet., Corr. Mem. Ac. France, Berlin, Turin, &c. &c.

[Printed with Part I. in No. 19 of the Journal, p. 157, above.]

January 31, 1849.

The following communications were read :—

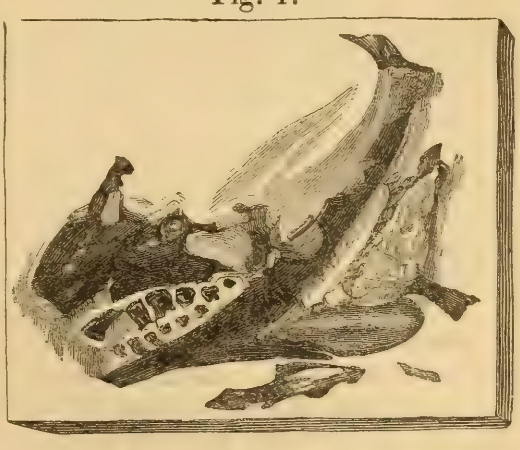
1. *Description of Remains of Fossil Reptiles from the Greensand Formation of* New Jersey. By Prof. Owen, F.R.S., F.G.S. &c.

[See an Abstract of this Paper, p. 380.]

2. *Palichthyologic Notes.* No. 2.—*On the Affinities of the Genus* Platysomus. By Sir Philip Grey Egerton, Bart., M.P., F.R.S.

Some of the earliest writers on Palæontology were acquainted with the Petrified Fishes not uncommonly found in the Kupferschiefer of Mansfeld and its vicinity, on which Agassiz established his genus *Platysomus.* Figures are given of these fishes under the name of *Rhombus diluvianus major* and *minor,* by Wolfart *, Scheuchzer †, Knorr and Walch ‡, and others. More recently De Blainville and Germar have described them, assigning them, in consequence of their deep and flattened forms, to the genus *Stromateus* §. Agassiz satisfied himself that this determination, founded on outward characters, unaccompanied by structural coincidences, could not stand ‖ ; at the same time the unusual combination of this form of body with a heterocerqual tail and other anatomical peculiarities evidently raised doubts in his mind as to the true position and affinities of the genus ¶. Mr. King of Newcastle-on-Tyne has recently submitted to me a specimen of *Platysomus macrurus* from the magnesian limestone of Ferry Hill, which clears up the obscurity that has hitherto enveloped the subject, and proves from the characters of the dentition that this genus should be removed from the *Lepidoidei* to the *Pycnodonti.* The dentary portion of the lower jaw, as shown by this specimen, fig. 1, is a dense triangular bone, very similar to the Pycnodont jaws found at Stonesfield and elsewhere. Two rows of teeth are seen, the outer one composed of eight or nine small tritores, the inner one containing five considerably larger than the outer ones. The teeth are all clavate in form. The crown is circular, slightly flattened on the grinding surface, and mounted on a pedestal of smaller diameter. Immediately beneath the crown is a deep constriction, beyond which the enamelloid coating of the tooth

Fig. 1.



* Wolfart (Peter), Historia naturalis Hassiæ inferioris, pars i. tabs. 13, 14.
† Scheuchzer, Piscium Querelæ, tab. 4.
‡ Knorr and Walch, vol. i. pl. 20.
§ Nouv. Dict. d'Histoire Nat. vol. xxviii. p. 18.
‖ Poiss. Foss. vol. ii. part 1. p. 161.
¶ Ibid. p. 162.

does not extend. No incisor teeth are visible, but it is probable, from the prominence of the anterior angle of the jaws, that they were furnished with teeth of more elongated form than those constituting the masticatory apparatus.

Having thus obtained a clue to the natural affinities of this genus, I was agreeably surprised to find, on a close comparison with the other members of the Pycnodont family, how closely they are allied both in form and structural details. Unwilling, however, to rely entirely on my own judgement in this matter, I communicated the facts to Professor Agassiz, and received from him the following corroboration of my views which I give in his own words:—"I quite agree with you in the propriety of combining the genus *Platysomus* with the Pycnodonts; for some time past I had, indeed, been impressed with the great difference there is between that genus and the others of the family in which it stands, and I now feel that my only reason for putting it there was the heterocerqual form of tail, a character which could not fail to produce a vivid impression upon my mind when first discovered, but which I now expect to find in fishes of various families in the oldest geological ages, as well as everywhere in the youngest state of our actual fishes in their embryonic growth. The teeth, as you mention, are conclusive evidence for placing *Platysomus* with the Pycnodonts. Let me now point out to you another evidence of this relation in the form of the skeleton, especially of the apophyses before the dorsal. The specimens of *Platysomus* in the museum in Munich show some good portions of the skeleton, and in my mind I can now compare them to the skeleton of the small *Pycnodus rhombus* *, without detecting any difference. Pray institute the comparison upon a safer ground than recollection, and let me know what you find. You know under what circumstances the fossil fishes have been worked out, and as a matter of course I must expect to see daily important additions made to the edifice of which I have laid only the foundation."

I had not neglected the important comparison above alluded to, and the result proved that the correspondence between the anatomical details of *Platysomus*, *Gyrodus* and *Microdon* is very remarkable. The peculiar features described by Agassiz as "apophyses before the dorsal" obtain in *Platysomus* as in the other Pycnodonts, but whereas in the genus *Pycnodus* they are restricted to the area in advance of the dorsal fin, in *Platysomus* and *Gyrodus* they extend over the hinder portion of the body. As to the nature of these so-called apophyses, I have arrived at a conclusion at variance with that advocated by Agassiz, and consider them as belonging to the tegumentary investment of the fish, rather than to the internal skeleton. It is scarcely necessary to repeat the minute and accurate description of these bones, given in the article in the 'Poissons Fossiles' on the genus *Pycnodus*, as they must be familiar to every student of this branch of Palæontology †. The conclusion Agassiz draws is, that he considers them as the analogues of the V-shaped bones in the *Clupeidæ*. My reasons for differing from this great authority are these:—First, they are

* Poiss. Foss. vol. ii. tab. 72. f. 5–7.

† Ibid. vol. ii. pt. 2. p. 183.

not restricted to the dorsal region of the fish, but extend uninterruptedly from the back to the belly, external to the vertebral column and apophyses. Secondly, they are continuous with, not articulated to, the external spines or scales before the dorsal fin. The dermal system of the Pycnodonts is very peculiar. Each scale bears upon its inner anterior margin a thick solid bony rib, extending upwards beyond the limits of the scale, and sliced off obliquely above and below, on opposite sides, for forming splices with the corresponding processes of the adjoining scales*. These splices are so closely adjusted, that without a magnifying power or an accidental dislocation they are not perceptible. When *in situ* and seen internally these continuous lines decussate with the true vertebral apophyses, and cause the regular lozenge-shaped pattern so characteristic of the Pycnodont family†. In all the species of *Platysomus* these structural peculiarities obtain to their fullest extent, corroborating the evidence already alluded to of the masticatory organs, in favour of the removal of the genus from the Heterocerque Lepidoids to the Pycnodonts. The explanation I have ventured to advocate as to the true nature of the enigmatical bones designated by Agassiz "apophyses," is shown to be correct as to the genera *Gyrodus* and *Microdon* by several perfect specimens of the former genus in my cabinet, which I owe to the kindness of the late Count Münster, and by a fine example of *Microdon radiatus* in the Hunterian collection. There is more difficulty with the genus *Pycnodus*, for in this the scales are much thinner than in the other members of the family, and the articulating border more delicate; the latter feature is nevertheless generally preserved, even when the other portions of the scales are wanting, and has great resemblance to a vertebral apophysis, more especially when slightly crushed, for then the compound nature of the bone is undistinguishable. Its real dermal character may, however, generally be ascertained by examining the impressions of the inner surfaces of the scales of the opposite flank. If it be true then that these bones form part of the cuticular investment and not of the internal skeleton, we have still the difficulty of explaining how it happens that this peculiar structure is restricted in some species to the anterior region of the body, while in others it extends to the insertion of the tail. It cannot be attributed to any imperfection of the specimens, for the scalpel of the most skilful zootomist could scarcely exhibit more beautiful dissections than Nature has placed before us in the Pycnodonts of Kelheim, Torre d'Orlando and Monte Bolca. The only solution I can suggest is this, that whereas in some recent fishes we find a stiff and rigid body furnished with a flexible tail, so a like compensation may have obtained among some of the denizens of the more ancient seas. Of the fossil Pycnodonts already known, the *Platysomi*, *Gyrodi*, *Microdon hexagonus*‡ and *Microdon analis*§ have the scales uniform, while *Microdon elegans*|| and *Microdon*

* Poiss. Foss. tabs. 68, 69. figs. 2, 3.

† Ibid. vol. ii. tab. 67.

‡ Ibid. vol. ii. tab. 69c. figs. 4 & 5.

§ Ibid. vol. ii. tab. 69c. fig. 3.

|| Ibid. tab. 69b.

*radiatus** agree with the *Pycnodi* in the limitation of the articulated scales to the anterior part of the body. I am inclined to consider this character of generic value; and I find it associated with other peculiarities in the position and form of the fins and tail, which suggest the propriety of adding *Microdon hexagonus* and *Microdon analis* to the genus *Gyrodus*. Count Münster has described a Pycnodont jaw found by Herr Althaus in the Kupferschiefer at Richelsdorf, which he named *Globulodus elegans*†. In alluding to this genus Agassiz says that it is probably founded on the dentition of the genus *Platysomus*‡, a surmise which is proved by Mr. King's specimen of *Platysomus macrurus* to be perfectly correct. The genus *Globulodus* must therefore be cancelled. It is probable from the small size of the oral aperture and the character of the dentition, that the *Platysomi* fed either on marine plants or on small shell-fish or zoophytes, and we trace in their dense tegumentary investment a kind of scale-armour to protect them against the aggressions of the *Acrolepides* and *Pygopteri* and other voracious Sauroids with which they co-existed; but that even this protection did not always avail is substantiated by the fact, that the *Globulodus* jaw of Count Münster was discovered in a Coprolite!!

---

3. *On* NERITOMA, *a fossil genus of Gasteropodous Mollusks allied to* NERITA. By JOHN MORRIS, Esq., F.G.S.

AMONG the fossil shells of the oolite hitherto referred to *Nerita*, there occurs a small group presenting characters of sufficient importance to justify their being separated, not only as a distinct section of the genus, but as forming a different generic type, probably belonging to the same family, for which I propose the name *Neritoma*.

The peculiar character to which I allude is, in the outer lip (which in all the typical *Neritæ* is entire) having two more or less deep sinuses, probably corresponding to a particular organization in the animal inhabitant; the form of the aperture and the columellar lip are also distinct from those of *Nerita*, and do not approximate it to any other described genus.

The above-mentioned characters of this genus,—certainly allied to *Nerita*, although aberrant from it,—are interesting under two points of view: first, as connecting the true *Nerites* with *Amphibola*, Schum. (*Ampullacera*, Quoy), also an aberrant form of *Ampullaria* and *Natica*; and secondly, as adding another instance to certain genera of Mollusca, which with analogous forms present a similar character in having a greater or less sinus in the outer lip. In this latter respect, *Neritoma* bears the same relation to *Nerita*, as the other genera first mentioned in the following list do to their respective analogous forms.

* Poiss. Foss. tab. 69[c]. figs. 1 & 2.
† Beiträge, &c. pt. 5. p. 47. pl. 15. fig. 7.
‡ Poiss. Foss. vol. ii. pt. 2. p. 203.

Genera in which the outer lip has	
A greater or less sinus.	*No sinus.*
Neritoma.	Nerita.
Amphibola.	Ampullaria.
Clithon.	Neritina.
Platychisma.	Trochus.
Pleurotomaria.	Trochus.
Acroculia.	Pileopsis.
Pleurotoma.	Fusus.
Murchisonia.	Cerithium.
Emarginula.	Patella.

In consulting the above table of the two groups, it will be remarked that *most* of those forms furnished with a sinus belong to extinct genera: thus *Acroculia, Murchisonia, Platychisma,* are found in the palæozoic series, *Pleurotomaria* and *Neritoma* in the secondary strata, *Pleurotoma* in the tertiary and also recent.

TRACHELIPODA, Lam.

Family *Néritacés,* Lam.

NERITOMA.

Testâ ventricosâ, crassiusculâ, læviusculâ, epidermide indutâ, non umbilicatâ, spirâ brevi obtusâ; anfractibus subcarinatis, ultimo ventricoso; aperturâ subovali, obliquâ; labro acuto, bisinuato; labio incrassato, planulato, supernè canalifero, non denticulato nec crenulato; impressione musculari elongato-ovatâ.

A ventricose and moderately thick shell, nearly smooth, or merely marked by the lines of growth, having a slightly elevated spire and three or four subangular volutions; not umbilicated; aperture ovately oblong, outer lip thin, sharp and bisinuate, with one angular sinus towards the middle of the shell corresponding to the carina and a rounded sinus near the base; inner lip broad, flat, and thickened, slightly depressed in the middle, and not crenulated nor denticulated.

The above characters sufficiently distinguish this genus from *Nerita,* in which also the inner lip is much less confluent with the outer one than in *Neritoma.* The flattened and expanded columellar lip, and not being umbilicate, remove it from *Amphibola.*

From *Neritopsis,* which connects *Nerita* with *Natica,* it is separated by the above-mentioned characters, as well as in not having a deeply notched inner lip, as in that genus. If with Dr. Grateloup and M. Pictet we exclude *Natica* as belonging to a distinct family, the *Néritacés* will be neatly limited to the following genera: *Navicella, Pileolus, Nerita, Neritina, Neritopsis,* and *Neritoma.*

The species belonging to *Neritoma* have at present only been found in the oolite. The shell from which the above generic description was formed, was obtained by Mr. Lowe from the upper beds of the Portland series, at Swindon, Wilts. This specimen is interesting, as exhibiting distinctly the coloured marking upon the surface.

Fig. 1.

NERITOMA SINUOSA.

Nerita, Sow. 1821, Min. Con. t. 217. f. 2.
Nerita angulata, Sow. 1836, Geol. Trans. vol. iv. t. 23. f. 2.

Testâ ventricosâ, sublævi, fuscescente, spirâ abbreviatâ, obtusâ, anfractibus quatuor convexiusculis, ultimo obtusè carinato, supernè depresso, aperturâ oblongâ.

A rather thick and ventricose shell with a slightly elevated and obtuse spire, the last volution carinated about the middle, the carina terminating in the shallow sinus at the edge of the outer lip. The surface is nearly smooth, although in some specimens the lines of growth are well-defined, and become more prominent as the shell approaches the adult state.

This species was first noticed by Mr. Sowerby, sen., as *Nerita sinuosa* in the 'Mineral Conchology,' where its peculiar characters are carefully described, from a specimen collected by Miss Benett at Chilmarsh, near Tisbury, Wilts.

A cast of this species was subsequently described by Mr. J. D. C. Sowerby, in Dr. Fitton's Memoir*, under the name of *Nerita angulata*, from specimens obtained at Swindon, Wilts, where in the state of casts this species is generally very abundant.

Locality, Swindon, and near Tisbury, Wilts, in the Portland oolite.

NERITOMA BISINUATA.

Nerita, Buvignier, Statistique Minéralogique et Géologique du Département des Ardennes, p. 535. t. 5. fig. 12, 13.

Testâ globosâ, sublævi, spirâ depressâ, obtusâ, ultimo anfractu carinato, ad suturam canaliculato, aperturâ ovali vel semicirculari.

A ventricose shell with somewhat angular volutions, marked by the lines of growth, and a depressed spire. The last whorl has a slight furrow at the suture. The aperture is nearly semicircular; the sinus at the edge of the aperture, corresponding to the carina, is narrow and deep in the adult stage, and only faintly marked in the young shell. M. Buvignier in the description of this species remarks,

* "Observations on some of the strata between the Chalk and Oxford Oolite," Geol. Trans. vol. iv. p. 347.

that it is with doubt he places this shell under *Nerita*; the double sinus appearing to indicate particular organs, which are not possessed by the animals of that genus. In breaking some specimens, M. Buvignier has also observed a depression under the columella, similar to that which receives the apophysis of the operculum of the *Nerites*.

Locality, Launois and Vieil-Saint-Remy, Ardennes, in the upper beds of the Oxford clay.

FEBRUARY 21, 1849.

The following communications were read:—

1. *Notice of the Gypsum of* PLAISTER COVE *in the* STRAIT OF CANSEAU. By J. W. DAWSON, Esq.

[Communicated by the President.]

THE Strait of Canseau is a narrow passage fourteen miles in length, separating Nova Scotia proper from Cape Breton Island. On the Nova Scotia side it affords an imperfect section of carboniferous strata, interrupted near the middle of the Strait by a mass of reddish syenite and disturbed slates, forming the promontory of Cape Porcupine, which is the abrupt termination of a hilly range extending far into Nova Scotia. On the Cape Breton side, the section exhibits carboniferous rocks; and nearly opposite Cape Porcupine is the small indentation, whose name of Plaister Cove is derived from the mass of gypsum to which the following remarks refer.

The gypsum of Plaister Cove, like other large masses of that rock occurring in this province, belongs to the lower part of the carboniferous system, and is associated with limestone and marls. The structure and accompaniments of the bed are, however, more perfectly exposed than in most of the larger masses of gypsum which I have examined. For this reason I shall endeavour, with the aid of the accompanying section fig. 1, and specimens, to give a somewhat detailed view of the appearances presented at this place, with the object of recording facts which may be useful in explaining the origin of the great beds of gypsum.

Fig. 1.

Coast Section at Plaister Cove.

1. Hard grey conglomerate. 2. Alternations of hard sandstone and grey shale. 3. Limestone. 4. Marl. 5. Gypsum. 6. Gypseous limestone. 7. Marl. 8. Dark shales with calcareous bands. 9. Brown and grey sandstone and shale.

(1.) At McMillan's Point, about three-quarters of a mile north of the Cove, are thick beds of grey conglomerate, in a vertical position. These beds form the base of the carboniferous system in this district; and, at a short distance inland, they have been invaded by trap and other igneous rocks, belonging to a great line of igneous disturbance extending to the north-eastward. The conglomerates near McMillan's Point have been thrown up along an anticlinal line connecting the igneous range last mentioned with that of Cape Porcupine, on whose flanks the same conglomerates appear. The valley now occupied by the Strait is in great part due to the want of continuity of the igneous masses at this point; though the distribution of the surface detritus shows that it has been subsequently deepened by diluvial waves or currents from the northward.

(2.) Between McMillan's Point and Plaister Cove, the shore is occupied by black and grey shales and very hard sandstones, in frequent alternations. The sandstones have been much altered by heat, and are traversed by veins of white carbonate of lime, sometimes mixed with sulphate of barytes. At the point immediately north of Plaister Cove, these beds dip at a high angle to the south-eastward.

(3.) Overlying these beds is a bed of limestone about 30 feet in thickness; it is of a dark colour, laminated and subcrystalline; its laminæ are in some parts corrugated and slightly attached to each other, and in other places flat and firmly coherent; it is traversed by numerous strings of white calcareous spar, containing a little carbonate of iron and small crystals of blue fluor spar, a mineral rare in Nova Scotia, and which I have found only in the lower carboniferous limestones. The limestone supports a few layers of greenish marl and gypsum, which appear in a small depression on the north side of the Cove; but beyond this depression the limestone reappears with a northerly dip. It is then bent into several small folds, and ultimately resumes its high dip to the south-east. I found no fossils in this limestone, except at its junction with the overlying marl, where there is a thin bed of black compact limestone containing a few indistinct specimens of a small species of Terebratula. In appearance and structure this limestone is very similar to the laminated limestones which underlie the gypsiferous deposits of Antigonish and the Shubenacadie.

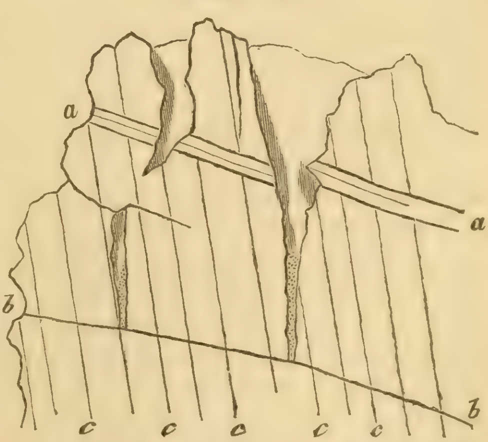
(4.) This bed is succeeded by greenish marl, traversed by veins of red foliated and white fibrous gypsum, and containing a few layers of the same mineral in a granular form; it also contains a few veins of crystalline carbonate of lime. In its lower part it has a brecciated structure, as if the layers had been partially consolidated and then broken up. Near its junction with the limestone it contains rounded masses of a peculiar cellular limestone, coloured black by coaly matter; and higher in the bed there are nodules of yellow ferruginous limestone with a few fragments of shells. The greenish colour of the marl seems to be caused by the presence of a minute quantity of sulphuret of iron. When a portion of the marl is heated, the sulphuret is decomposed and the colour is changed to light red.

(5.) On this marl rests a great bed of gypsum, whose thickness I estimated at 50 yards. Where the marl succeeds to the limestone, the shore at once recedes, and the gypsum occurs at the head of the Cove. The gypsum is well-exposed in a cliff about 80 feet in height; but, like most other large masses of this rock, it is broken by weathering into forms so irregular, that its true dip and direction are not at first sight very obvious. On tracing its layers, however, it is found to have the same dip with the subjacent limestone and marl. About two-thirds of the thickness of the bed consist of crystalline anhydrite, and the remaining third of very fine-grained common gypsum. The anhydrite prevails in the lower part of the bed, and common gypsum in the upper; but the greater part of the bed consists of an intimate mixture of both substances, the common gypsum forming a base in which minute crystals of anhydrite are scattered; and bands in which anhydrite prevails, alternating with others in which common gypsum predominates. It is traversed by veins of compact gypsum, but I saw no red or fibrous veins like those of the marl. In some parts of the bed, small rounded fragments of grey limestone are sparingly scattered along layers of the gypsum.

The exposed part of the mass is riddled by those singular funnel-shaped holes named "Plaister pits," sections of which are exposed in the cliff; they penetrate both the anhydrite and common gypsum, though they are contracted where they pass through harder portions of the rock, and especially the veins of compact gypsum, some of which are only slightly inclined, and look at first sight like layers of deposition. The pits of which I saw sections have evidently resulted from the percolation of water through the more open parts of vertical joints, and they were cut off where they were intersected by another slightly inclined set of open fissures, which afforded a passage to the water. The accompanying sketch (fig. 2) shows one of these pits, and its relations to the joints and stratification of the gypsum.

Fig. 2.

Plaister Pits.



a. Gypsum vein. *b.* Open joint.
c. Bedding of the gypsum.

(6.) Above the gypsum are a few layers of limestone, portions of which appear near the base of the cliff; one of them is studded with tarnished crystals of iron pyrites; another is a singular mixture of grey limestone and reddish granular gypsum. The portions of limestone contained in this rock do not appear to be fragments or pebbles, and they are penetrated by plates of selenitic gypsum. They may be parts of a bed of limestone broken up and mixed with gypsum when in a soft state, or the limestone and gypsum may have been deposited simultaneously and separated by molecular attraction. A rock of this kind is not rare as an accompaniment of gypsum, and it may be merely a result of the mixture of the soft surface of the gypsum with the mechanical detritus first deposited on it.

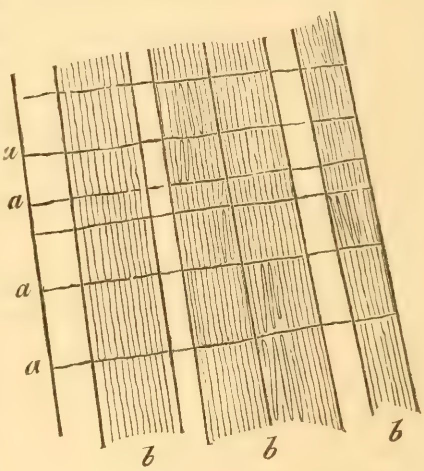
(7.) On the opposite side of the creek, which makes a small break in the section, is a thick bed of marl, whose dip appears to be the same with that of the gypsum. In general character it resembles the marl underlying the gypsum. In some parts it is greenish, and homogeneous in texture; in other parts it is brecciated, and some layers have a brownish colour and shaly texture. In some parts it is highly gypseous and contains layers of granular gypsum, one of which is black, its colour being due to a small proportion of coaly or bituminous matter.

(8.) Beyond the marl the shore is occupied for a short space by boulder clay. Beyond this it shows a great thickness of dark shales with calcareous bands, containing a few small shells; they dip to the E.S.E. at a high angle, and overlie the gypsum. They are succeeded by a thick band of very hard grey and brownish sandstones and shales, containing a few fragments of plants stained by carbonate of copper. These are again overlaid by dark shales, and these by an enormous thickness of grey and brown sandstone and shale. Some of the shales in this part of the section have assumed a kind of slaty or rather prismatic structure, which I have endeavoured to represent in the sketch, fig. 3.

At Ship Harbour, four miles distant from Plaister Cove, the series last mentioned is seen to contain thick beds of grey flag and finely laminated shale, and also a bed of black shale with shells of Modiola and Cypris. The coast sections show no beds higher in the series than these last; but farther inland they appear to be succeeded, in ascending order, by a great deposit of grey sandstone and shale* containing a bed of limestone and a smaller bed of gypsum, the former abounding in *Producta Lyelli* and other characteristic shells of the lower carboniferous system. These are followed by true coal-measures, containing Lepidodendron, Calamites, Sigillaria, Stigmaria, &c.

Fig. 3.

Shales with prismatic structure.



Dip of beds S. 75° East.
a. Joints, strike E. and W. Dip S.
b. Shale with prismatic structure.

In examining this section, an observer is struck by the contrast between the hardened and altered sandstones and shales, and the soft, light-coloured marls associated with the gypsum. Though not uncommon in the gypsiferous series, this contrast is, in the case of Plaister Cove, more striking than usual, in consequence of the comparatively high state of induration of the sandstones and shales. It

* The 'Millstone grit' of Mr. Brown: see his paper on Cape Breton, Journal of Geol. Soc. vol. i. p. 211.

shows how little susceptible of induration by heat are the gypseous rocks, and illustrates the reason of the absence of sections in the vicinity of many large masses of gypsum, in localities where the rocks in general are hard and well-exposed.

It must, I think, be evident from the facts above stated, that the mass of gypsum under consideration is a regular aqueous deposit, interstratified with the marls and limestone. This being admitted, the only cause which appears competent to its production is that suggested by Sir C. Lyell in his 'Travels in North America,' and subsequently illustrated by the writer, viz. the production of sulphuric acid by volcanic action, and its introduction into the basins in which calcareous matter was being deposited. On this hypothesis, the history of the deposit would be somewhat as follows:—

First, the accumulation of a vast number of very thin layers of limestone, either so rapidly or at so great a depth that organic remains were not included in any except the latest layers. Secondly, the introduction of sulphuric acid, either in aqueous solution or in the form of vapour; the acid being a product of the volcanic action whose evidences remain in the neighbouring hills. At first the quantity of acid was too small, or the breadth of sea through which it was diffused too great, to prevent the deposition of much carbonate of lime along with the gypsum produced; and its introduction was accompanied by the accumulation on the sea-bottom of a greater quantity of mechanical detritus than formerly: hence the first consequence of the change was the deposition of gypseous marl. At this stage organic matter was present, either in the sea or the detritus deposited, in sufficient quantity to decompose part of the sulphate of lime, and produce sulphuret of iron; and also to afford the colouring matter of the nodules of black limestone found in the marl. Thirdly, the prevalence for a considerable period of acid waters, combining with nearly all the calcareous matter presented to them, and without interruption from mechanical detritus. The anhydrite must have been deposited with the common gypsum; but, under the circumstances, it seems difficult to account for its production, unless it may have been formed by acid vapours, and subsequently scattered over the bed of the sea. Fourthly, a return to the deposition of marl, under circumstances very similar to those which previously prevailed; and lastly, the restoration of the ordinary arenaceous and argillaceous depositions of the carboniferous seas.

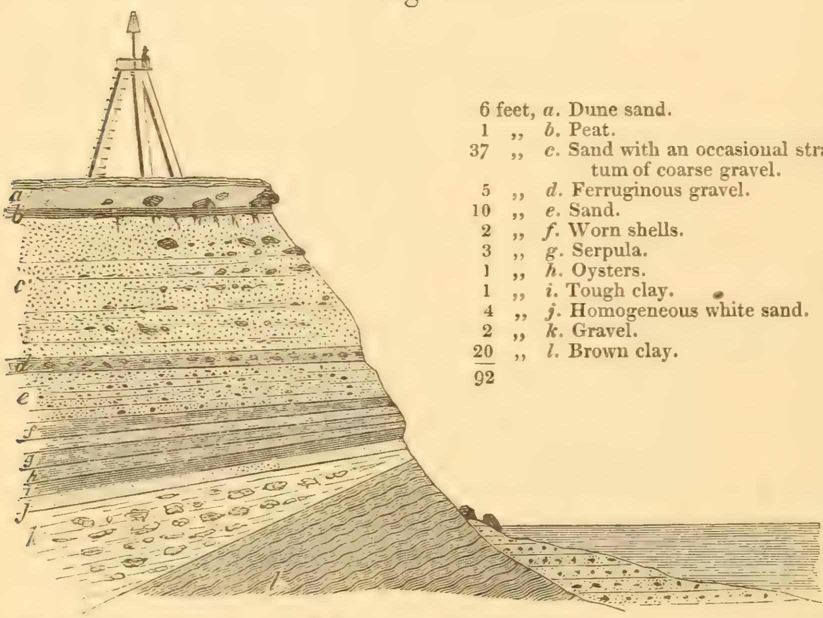
Of the gypsum veins found in the marls, those which are white and fibrous may have been nearly contemporaneous in their origin with the marl itself; those which are red and lamellar have been subsequently introduced. The granular gypsum is in all cases a part of the original deposit. The comparatively small quantity of red oxide of iron in these marls and other associated beds is the most important feature of difference between the deposit of Plaister Cove and those of most other parts of this province. There is however a large quantity of reddish and brown sandstone in the beds overlying the gypsum, though on the whole these colours are less prevalent than in the carboniferous system of Nova Scotia proper.

2. *On the Tertiary and more recent Deposits in the* Island of Nantucket. By M. E. Desor and Edward C. Cabot. (In a letter to Sir Charles Lyell, Pres. Geol. Soc.)

Knowing how much you are interested in all inquiries about the drift of this country, we take the liberty to forward to you some specimens of shells which we have lately collected from the cliffs of Sancati Head, in the island of Nantucket. Allow us to accompany them with some observations upon this locality.

The cliff of Sancati, as you know, constitutes the eastern border of the island of Nantucket, rising to a height of ninety-two feet above the beach. Although covered in a great measure with the loose sand that is carried by the wind from the beach, yet there are several points where the successive layers are to be seen, as for example near the tripod: fig. 1 will give an idea of their superposition.

Fig. 1.



At the base of the cliff is found a stratum of brown, very brittle and partly sandy clay (*l*), nearly twenty feet thick. Over this rests a bed of gravel several feet thick (*k*), which is overlaid by a stratum of homogeneous white sand (*j*). On this is found a layer of very tough clay (*i*), very similar in its aspect to the plastic clay near Paris, except that it contains a great many nodules of ferruginous sand. This clay-bed is overlaid by an oyster-bank (*h*) one foot thick, intermixed and covered by large masses of Serpula (*g*), which are, like the oysters, in their natural position. There are besides a great many other shells scattered through this bank, all of them in a most perfect condition, although it is difficult to preserve them entire when taken out from the layer. This oyster-bank is followed by another fossiliferous stratum (*f*), in which the shells are in a different state: they bear evident traces of exposure, the valves of the bivalves being generally isolated, and the Balanus disintegrated and more or less worn. There are besides no traces of dendritic (manganese) incrustations, which, as you will perceive, are very common on most shells of the oyster-bank beneath. Above this stratum of loose shells there is found a series of layers of sand and gravel, with a thickness of nearly fifty feet, in which every variety of materials may be seen, from the finest sand to the coarsest gravel. On the top of these sand layers lies a stratum of dry peat (*b*), filled with trunks and roots of trees, the remains of a peat bog that has been drained by the washing away of the cliff. Finally there is seen, covering this peat deposit, a stratum several feet thick of fine sand (*a*), which has been deposited by the wind, as is evident from its form, being everywhere bent according to the outline of the hill, and likewise from the fact that there is not a single stone to be found in it, but only such grains of sand as are capable of being transported by the wind, thus affording a striking instance of the action of wind in the formation of stratified deposits.

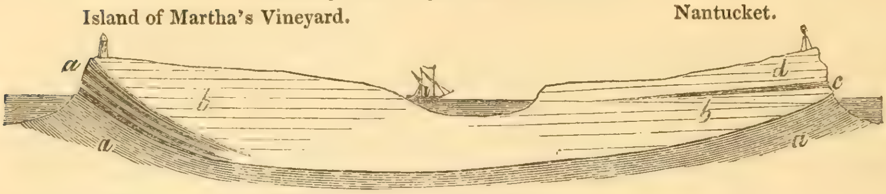
The strata thus enumerated seem at first horizontal, but in digging along their edges, we soon ascertained that they all dipped to the west, their inclination varying from fifteen to five degrees, the upper beds being generally less inclined than the lower ones. The inferior clay stratum, however, was found to differ considerably from the others, its dip being nearly thirty degrees to the south-west, and in some places even as much as forty degrees.

This circumstance induced us to examine this lower clay stratum more carefully. Having made out a spot where the overlying gravel bed was seen in immediate contact with the top of the clay, we could distinctly trace its unconformable deposition, the gravel being seen dying out towards the more inclined clay-stratum, as shown in the above section, fig. 1, taken on the side of a gully in the cliffs. Such differences in the inclination cannot be attributed merely to a difference in the mode of deposition. A considerable change of level must have taken place between the deposition of the clay and that of the gravel. And although no fossils have been found in this clay, yet its great resemblance to the clay of Truro in Cape Cod, which Mr. Hitchcock considers as tertiary, leads naturally to the idea that they may be contemporaneous, and probably of the same epoch as the clay of Gay Head, which you have proved to be miocene. Indeed there may be seen below the red clay of Gay Head, several layers of a brown sandy clay very similar to that of Sancati. Thus the tertiary cliffs of Gay Head should no longer be looked upon as an isolated fact, but the cliffs of Sancati may be considered as the opposite outcrop of a large tertiary basin, underlying the islands of Nantucket and Martha's Vineyard, fig. 2, and extending to the south below Long Island, and to the north as far as Truro. The edges of this basin having thus been raised, became, at the time of the deposit of the drift, a nucleus against which the tide-currents, according to the theory of Capt. Davis, deposited the mud, sand and gravel which they carried with them in their course along the eastern coast of the United States, just as they do at present. We are even in-

Fig. 2.

Section from Gay Head to Sancati.

Island of Martha's Vineyard. Nantucket.



a. Tertiary clay.
b. Stratified drift (sand and gravel).
c. Oyster-bank.
d. Stratified drift, sand overlying the oyster-bank.

clined to consider the tertiary itself as deposited by the same tidal agency, being formed from the detritus of the greensand of New Jersey; a supposition which seems the more probable as it would account for the great similarity of materials between the greensand of New Jersey and the tertiary of Long Island, a similarity which is so striking, that it led even Mr. Mather to consider this tertiary as identical with the greensand.

Concerning the drift overlying the tertiary clay at Sancati, it is obvious from the regularity of the strata, and from the very perfect state of preservation of the shells imbedded in it, that it has not undergone any violent disturbance since their deposition. The species collected by us in the above-mentioned oyster-bank are the following:

Venus mercenaria, plenty.
Mya arenaria, plenty.
Ostrea borealis, a bed several feet thick.
Arca transversa, very abundant.
Solen ensis, abundant, but very brittle.
Astarte Cartanea, rather rare.
Cardita borealis, rare.
Cumingia tellinoides, rather rare.
Crepidula fornicata, abundant.
Buccinum undatum, rather rare.
—— *plicosum*, abundant.
Nassa obsoleta, abundant.
—— *trivittata*, abundant.
Scalaria groenlandica, rare.
Balanus rugosus, very abundant.
Serpula, forming a layer several feet thick.
Pagurus pallicaris (claws).

Now these are, without any exception, the same species that are found living on the shore of Nantucket and Cape Cod, and as they are all in their natural position, the bivalves having almost always the two valves united, and the Venus being commonly half open, just as they are found on the beaches when the muscles have relaxed after death, we may fairly infer that in this part of the continent at least, the climate has not undergone any considerable change since the deposition of these fossils.

The presence of a stratum of disintegrated shells of the same species, resting upon the undisturbed oyster-bank, may easily be accounted for by a somewhat more violent action of the tides, which deposited in this irregular manner a part of the shells which were washed off, from the oyster-bank itself, in the same way as is the case now among the Nantucket shoals. Indeed there is to be found on the slopes of every shoal ridge, a region from which the dredge brings up nothing but loose and broken shells. This region is so characteristic and so constant, that one of us has designated it in his "Report on the Distribution of Animals among the Shoals*," under a peculiar name, as the *Region of Broken Shells.* According to Capt.

* See Proceedings of the Boston Natural History Society.

Davis's view, the shells are deposited in this way by the tidal current along the shoal ridges, which act as so many nuclei.

Until last year it was assumed by the geologists of this country that there were no fossils to be found in the drift, south of Lake Champlain and the State of Maine, when one of us had the good fortune to discover several species in the drift of Brooklyn near New York*. Similar fragments, especially of *Venus mercenaria,* have since been found in the cliffs of Point Shirley, in Boston Harbour. Now, as the fossil shells in both places are of the same species as those of Sancati Cliff, there is every reason to consider them as belonging to the same period, their more or less perfect state of preservation depending merely upon local influences. It ought further to be stated, that wherever the shells are worn or broken, and the strata which contain them coarse and irregular, it is either in such places where the tidal currents must have been violent, so as to carry and deposit promiscuously heavy pebbles and minute shells, as in the cliffs of Point Shirley; or in such places where we must suppose that floating ice was at work, carrying indiscriminately heavy materials, pebbles and boulders, together with oysters and other shells detached from the neighbouring flats, and heaping them up in the corners of bays and sounds. This seems to have been the case with the coarse deposits of Brooklyn, where oysters and Venus are generally found imbedded in a reddish loam intermixed with pebbles and boulders, many of which are distinctly scratched, thus reminding us of similar actions which you have described in Fundy Bay and in the St. Lawrence; whilst in other places, like Nantucket and the bays and fiords of Maine, a more quiet action prevailed, so as to allow the shells to be preserved in their natural place and position after death. [Among the drift fossils collected at Augusta, on the Kennebec, there are many which have preserved their colour in a most perfect manner, especially Astarte and Mytilus.]

Finally, the fossils of the drift of Nantucket bear such a striking similarity to those of the newer pliocene of the Southern States, that they become a natural link between the northern and southern deposits. Instead of considering these as so many distinct formations, we should therefore henceforth look at them as mere modifications of the same deposit, being the result of the same agencies, viz. oceanic tide-currents along the whole coast of the United States, combined with gradual and secular oscillations of the whole continent, the local strength of the tidal currents affording a sufficient explanation for local diversity in the arrangement and size of the materials in each locality.

Viewed in this light, the drift formation, heterogeneous as it may appear at first, can be cited as a fair illustration of that great principle of yours, that it is by the application of actual causes that we arrive at a true understanding of the origin and diversities of geological formations.

* E. Desor's Letter to M. de Verneuil, in the Bulletin de la Société Géologique de France, 1847. A most interesting collection of the drift fossils of Brooklyn has since been made by Mr. Redfield.

How far this theory of the tidal current applies to the more ancient geological formations of this country, we shall attempt to establish in another letter.

---

3. *Notes on some Recent Foot-prints on Red Mud in* Nova Scotia, *collected by* W. B. Webster *of* Kentville. By Sir Charles Lyell, P.G.S.

I beg to present to the Society some impressions of footsteps which Mr. Webster has sent me, at my request, from the mud-flats of Kentville in Nova Scotia.

In my 'Travels in North America,' vol. i. p. 168. plate 7, I have given a plate and description of some of these foot-prints made by the sandpiper (*Tringa minuta*), which I saw daily running along the water's edge in the Bay of Fundy. The deposit there consists usually of red mud, with which the waters are charged by the undermining of cliffs of red sandstone and soft red marl. The tides rise very high, and when they are lowest, large areas recently overspread with red mud are laid dry, and are often baked in the sun for many days, so that the mud becomes consolidated and retains permanently the impressions of rain-drops, and the tracks of birds and animals which walk over it.

Mr. Webster tells me, that the divisibility of the solid mud into layers arises from the deposit of each tide being separated by a layer of sand or loam thrown down when the tide first rushes along the bank. The sandy particles being the heaviest are first deposited, and then the thin layer of mud on which the birds walk when the tide recedes. On examining these specimens, I perceive that while some of the foot-prints standing out in relief on the under-sides of the slabs are casts of impressions made in a subjacent layer, and therefore do not correspond with the imprints on the upper side, some of the projecting feet-marks, on the contrary, which are almost equally sharp, are formed by the forcing down of the soft mud, beneath which there was a sandy layer.

On some of the specimens will be seen the foot-print of a cat, which was no doubt in pursuit of the birds, and which was walking with its claws drawn in. In this case the weight was so great that the foot has displaced several of the underlying laminæ of mud and sand, and has caused them to be uneven, without effacing the bird-tracks previously formed there. On other specimens, worm-like tracks, similar to those we often meet with on older rocks, are visible.

Some of the specimens are in their natural state, and have remained entire; but most of them have been slightly baked in an oven by Mr. Webster to enable them the better to bear their weight in travelling.

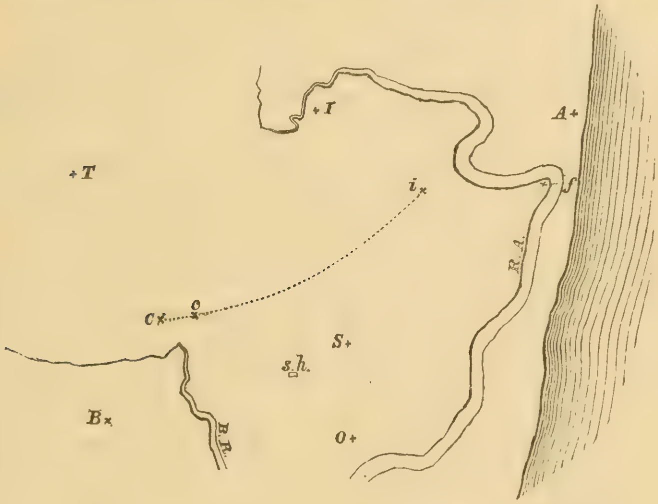
March 7, 1849.

E. T. Ravenshaw, Esq., and Henry T. Slack, Esq., were elected Fellows of the Society.

The following papers were then read:—

1. *On some Fossiliferous Beds overlying the Red Crag at* Chillesford, *near* Orford, Suffolk. By Joseph Prestwich, Jun., Esq., F.G.S.

Outline map of the district, showing the bearings of the principal places mentioned in the paper.



A. Aldborough church.
B. Butley church.
C. Chillesford church.
I. Iken church.
O. Orford church.
S. Sudbourn church.
T. Tunstall church.

c. Chillesford brickfield.
i. Iken brickfield.
s. h. Sudbourn-hall.
R. A. River Alde—ferry at "*f*."
B. R. The Butley River.
.... Line of section "fig. 3."
Scale 1 inch = 3 miles.

This paper is the result of a short excursion in the Crag district in company with Mr. R. C. Austen, Mr. J. Morris and Mr. A. Tylor, jointly with whom the following observations were made.

One of the objects which we had in view was to ascertain whether the distinction of age introduced upon palæontological grounds, between the crags of Norfolk and Suffolk, could be confirmed by visible superposition. With regard to the red and coralline crags of the latter county, their direct and distinct superposition had been satisfactorily proved both by Mr. Charlesworth and by Sir Charles Lyell on the evidence of several sections, whilst on the evidence of its fossils the mammaliferous crag of Norfolk has been assigned by them to a higher geological position than the red and coralline crags; but no direct superposition of the mammaliferous on the red and coralline crags had been detected, nor had these deposits been found developed together in the same district. This circumstance, combined with the fact of the mammaliferous crag exhibiting a group of fossils, a large proportion of which are of estuary, fluviatile, and land origin, whilst that of the red crag is in greater part marine, added to the very disturbed aggregation of strata of the latter, caused us to entertain some doubts as to whether the conditions under which they were respectively accumulated might not have so modified their faunas as to render conclusions, however able, drawn from a comparative estimate of such faunas, of uncertain value owing to the want of parallelism in the data. This therefore presented a case in which the test of superposition appeared desirable.

Small and ill-exhibited patches of the mammaliferous crag had been traced at distant intervals from the neighbourhood of Norwich to Thorp Common, two miles north of Aldborough, thus ending apparently near to where the coralline and red crags set in. We therefore here commenced our examination of this district, and in the course thereof we were fortunate enough to meet with a bed of a character unusual in the Crag districts, and which, although it does not settle the question we had proposed to ourselves, is of much interest both in its physical conditions and in its organic remains.

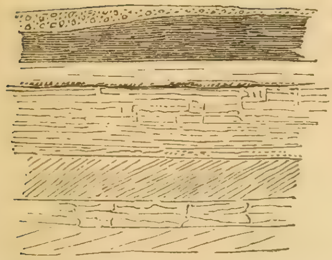
The course we first took was from Aldborough in a south-westerly direction towards the parish of Iken (see map, p. 345), and at a distance of a mile to a mile and a half from the ferry over the Alde, we reached several pits of the ordinary coralline crag, which here rose in a low ridge of hills on the borders of the sea-marshes. Thence turning northward we crossed a small valley, and in ascending the opposite hill noticed a pit in a field to our left, and close adjoining the eastern side of a farm-house which stands exactly by the Ordnance map two miles due west in a straight line from the Martello tower immediately south of Aldborough. At a short distance this pit presented the appearance of yellow sands overlaid by the common bluish grey great clay drift of the district, but on a nearer approach we found it to consist of finely laminated micaceous clays, with impressions of shells, overlying light yellow sands, also with impressions of shells of the genera *Mya*, *Tellina*, *Nucula* and *Cardium*; but the impressions, or rather casts, were so friable that they could not be removed, and only in a few cases were Mr. Morris and Mr. Austen able to determine, with some doubt, the species which apparently would agree with those we afterwards met with at Chillesford.

There were no beds of the red or coralline crag here exposed whereby the relations of this deposit might be ascertained. From the outline of the country, and from the occurrence of a pit of coralline crag at a short distance to the south-east and on a rather lower level on the hill, this latter deposit appeared to pass below these fossiliferous clays and sands,—a supposition shortly confirmed by another section at Iken brick-field, about a quarter of a mile further northward and on the same level. (See fig. 1, p. 347, and Sections, fig. 3, p. 349.)

We here have the direct superposition of the fossiliferous clays and sands "*b*" and "*c*" on the coralline crag "*e*." There is however no passage between them. Although in apparent conformable stratification, they are separable in structure. The surface of the semi-

Fig. 1.

Section at Iken Brick-field.



a. Flint gravel, 1 to 3 feet.
b. Laminated grey clays and sands with indistinct impressions of shells, 10 feet.
c. Yellow sands, 4 feet.
e. Light bright yellow coralline crag full of the ordinary fossils, chiefly corals, +30 feet.

compact calcareous coralline crag is slightly uneven and waterworn. The sands which repose upon it are more siliceous, and exhibit at their base occasional patches of rounded and angular gravel, in which, we were informed, blocks of hard stone of considerable size were sometimes found. Both in mineral structure and in organic remains there is evidence of a change of conditions. Of all the abounding corals of the coralline crag, none exist in this upper bed. Instead of the thick mass of peculiar zoophytes and mollusks of the former, we find a new and scanty fauna imbedded in a very different manner. In the crag both coralline and red, but more especially in the latter, the organic remains are accumulated generally in great confusion; the bivalve shells rarely have their two valves together, are often broken, and oftener still form whole beds of their comminuted fragments. Yet more rarely, apparently, do the remains occur in the position in which the animal lived. But in these overlying clays and sands such appears to be the usual condition, and not the exception. The bivalves which we found very constantly exhibited both the valves in contact, and often in the position in which the animal lived. We could, however, at this pit only note their forms; the shell had in all cases been removed, and merely a soft cast of clay or sand was left behind.

We thence proceeded southward to Sudbourn, examining on our way several pits which exhibited no traces of the beds "*b*" and "*c*," but afforded many very good and interesting examples of the superposition of the red crag on the coralline crag. Neither did we observe the newer beds in the neighbourhood of Orford or of Sudbourn Park. Taking thence a westerly direction to Chillesford, three miles by road north-west from Orford, upon arriving at the entrance of the village we turned off to the brick-kiln, which stands on the hill a quarter of a mile north of the main road, and there found another outcrop of fossiliferous clays and sands, forming partly the surface of the hill-top, and consisting of twelve feet of yellow and grey sandy clays more or less laminated, with numerous indistinct casts and impressions of shells, overlying five feet of yellow sand, with a few shells scattered in its lower part. The crag beds did not come to the surface in this pit; but in a well about thirty feet deep, sunk in the middle of the pit and through the yellow sands, the workmen informed us that the common red crag of the country was reached at a depth of eight to ten feet. They also stated that in the beds of clay they not unfrequently found large bones. (See Section fig. 3, p. 349.)

Half a mile westward from this brick-field is Chillesford Church, to the north-east of which and immediately adjoining the church-yard is a pit marked in the Ordnance map as a clay-pit, and presenting a section of much interest.

Fig. 2.

Section adjoining Chillesford Church.

a. Light grey conglomerate clay drift and traces of gravel.

b. Laminated light grey and yellow clayey sands passing downwards into beds more entirely of yellow sands (*c*). Shells disseminated irregularly throughout.

The shells of which we observed but the casts in the preceding pits we here obtained quite perfect, although in a very friable state; and few broken or imperfect shells were to be seen. Nothing could be more tranquil than the mode in which they were imbedded,—the larger bivalves commonly in their normal position as when living. The species were not numerous, but individuals of many of the species abounded. Those which were found in the greatest abundance were the *Cyprina islandica, Mya truncata, Tellina obliqua, Nucula Cobboldiæ, Leda myalis,* and *Turritella terebra.* We also obtained a few small vertebræ of fishes. In this pit the clays and sands do not form separate beds, but are more mixed and pass one into the other. No crag beds are exposed in this section, but lower down the hill, close to the main road and at a distance of about 150 yards to the south, is a pit of red crag twenty to twenty-five feet thick, presenting its most marked characters and full of its most common fossils. There is little doubt, I think, of the red crag passing under the beds of Chillesford Church pit at a depth of a few feet. (See Section fig. 3, p. 349.)

Here we were obliged to conclude our observations, having traced the fossiliferous sands and clays over a district from north-east to south-west of about three miles and a half. Beds of a very similar appearance, but without organic remains, we observed the following day at the brick-kiln one mile north of Aldborough. The coralline crag outcropped at a short distance from it, and on a lower level.

Early in this month (November 1848) I paid another visit to this district; but although I traversed it in several directions between Orford, Iken, Tunstall, Chillesford and Woodbridge, yet I met with no sections so illustrative as those I have now described. There were, however, many which would seem to corroborate and extend the structure we noted last spring. Thus in the two sand-pits between the Black Walks Woods and the keeper's house at Iken, the same laminated greyish clays from five to ten feet thick are seen overlying the yellow sands, at a short depth below which traces of the red crag have been dug up.

The excessive wet prevented me from making any complete examination of these clays. On Tunstall Heath these same laminated clays were visible in several pits. Neither had I the time necessary for a further research in this district, and I beg therefore to direct the attention of other geologists to this interesting field of observation.

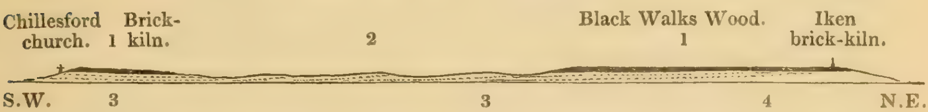
I have appended a list of a few localities where some illustrative sections of the several deposits are exhibited*.

Conclusions.

From the few facts above detailed it would at all events appear that the coralline and red crags are on the hills north of Orford overlaid unconformably by a deposit ten to twenty feet thick of a distinct mineral and palæontological character. In Iken parish this deposit clearly reposes upon the coralline crag, and at Chillesford the red crag is at one point shown to occur below it, and at another to outcrop at a short distance from it on a lower level. The red crag is also frequently found between these two places on the slopes of the hills, the summits of which are capped by the clays and sands. The following section would therefore, I infer, represent the structure of this part of the country.

Fig. 3.

Section from Iken to Chillesford.



1. Fossiliferous clays and sands ("*b* and *c*"). The clays are usually of a light bluish grey colour, are micaceous, and laminated commonly with yellow and ferruginous sands. Their organic remains are generally in casts, and only occasionally are the shells preserved. The sands "*c*" are very variable, and at their base are frequently patches of gravel.

2. Sands. 3. Red crag. 4. Coralline crag.

The distinctive peculiarity, in the Crag district, of such beds as those of Iken and Chillesford, consists in their argillaceous structure, their evidently tranquil accumulation, and in the rare circumstance that the organic remains are imbedded in them mostly in their normal position, and in a perfect state of preservation,—conditions not common in the coralline crag, and extremely rare in the red crag. The latter especially, as it is well known, presents every appearance of a most disturbed condition of the waters in which it was accumulated; there is scarcely a tranquil spot in its whole area. In these overlying beds, on the contrary, the state of quiet appears to have been most perfect. This is important, as we may hope to obtain, under these circumstances, clear palæontological proofs of their age. In the red crag period the currents and movements of the sea were apparently so strong and constant, and the extent to which the coralline crag was worn down and abraded by these causes is so evident, that the determination of the organic remains proper to the red crag is attended with some uncertainty, as it must at times be difficult to

* See Note at end.

determine to what extent the fossils of the coralline crag* may have been removed and re-imbedded in the red crag, especially as the lithological structure and composition of these two deposits presented every facility for such a transfer and assimilation. But in these clays we have the organic remains preserved on the spot where they lived, and in a condition to show that they did live there, and therefore present true and good records. The number of specimens which we collected was small, but I am glad to find that Mr. Searles Wood has since visited the locality and obtained from it a more extensive collection than we had time to make. He has had the kindness to furnish me with the following list of the specimens he procured:—

MOLLUSCA GASTEROPODA.

Buccinum undatum, *Linn.*
Natica catena, *Dacosta.*
Turritella communis, *Risso.*
Littorina littorea, *Linn.*

MOLLUSCA ACEPHALA.

5. Mytilus edulis, *Linn.*
Modiola discrepans†? *Mont.*
Nucula tenuis, *Mont.*
—— Cobboldiæ, *Sow.*
Leda artica, *G. Sow.*
(Nucula lanceolata, *Min. Con.*)
10. —— myalis.
(Nucula myalis, *Couthouy.*)
Cardium groenlandicum, *Chemn.*
Cardium edule, *Linn.*
Lucina borealis, *Linn.*
Cyprina islandica, *Linn.*
15. Tellina crassa, *Penn.*
—— lata, *Gmel.*
—— obliqua, *J. Sow.*
—— prætenuis, *Woodward.*
Mactra ovalis, *J. Sow.*
(M. elliptica, *Brown.*)
20. Abra alba, *Wood.*
(Mactra Boysii, *Mont.*)
Panopæa norvegica, *Spengl.*
Mya truncata, *Linn.*

Balanus communis.
Echinus ——?

Mr. Wood observes, in speaking of this deposit, that it "has an arctic character, and that he has very little doubt of its belonging to a period posterior to that of the red crag, and equivalent probably to the mammaliferous." He also calls attention to the large quantity of Foraminifera‡ which the sand contains. This opinion of an authority such as Mr. Wood we feel to be important, and our own observations with regard to superposition would, provided we had been able to give it greater extension northward, render this view of the age of these beds a probable one; for we have shown that these fossiliferous clays and sands immediately underlie the till or great conglomerate clay-drift, and overlie indiscriminately both the coralline and red crag, than both of which it must consequently be newer. But the palæontological evidence is, I think, far from being sufficiently decisive, although good and clear as far as it goes. We yet want to trace by superposition the connecting links between the different beds of this district and those of the neighbourhood of Norwich.

* See remarks on this subject by Mr. Charlesworth in his several papers on the Crag in the 'Magazine of Natural History' for 1835, and in the 'Lond. and Edinb. Phil. Mag.' for 1836.

† Specimen imperfect.

‡ Mr. Wm. Cunnington of Devizes, in a letter to me on this subject, observes, "I have not been able to examine the sand from Chillesford with the attention which I could have wished. Eight or ten species of these minute fossils, chiefly of the genera *Rosalina* and *Rotalina*, have been recognized. The genera are less numerous and less varied in the sands of Chillesford than in the sands of the coralline crag, but the individuals of each species are very abundant."

Should the identity of these beds with the mammaliferous crag of Norfolk be proved, then the evidence as given in this one locality by superposition will be in perfect accordance with the triple division of the crag established by Mr. Charlesworth. Still I would direct more particular attention to the precise relation which the red crag may bear to this deposit, and to the exact determination of the phænomena at their junction, of which we did not meet with a satisfactory exhibition.

Of the 23 species enumerated by Mr. Wood, I find according to Prof. Forbes's catalogue*, in his *Report on the geological relations of the existing fauna and flora of the British Isles*, that 10 occur in the coralline crag†, 21 or 22 in the red crag, 22 or 23 in beds of the age of the Clyde pleistocenes, and 22 exist in the present seas of Greenland or on our own coasts. Only 1 or possibly 2 species out of the 23, viz. the *Nucula Cobboldiæ* and one of the Tellines probably, do not occur recent.

With the Bridlington beds this group shows but few species in common, probably not more than 6 or 7. It thus appears that, with the exception of one or two, the whole of the species associated together in this bed, range from the period of the red crag to that of the present day; 8 or 9 were congeners at the period of the coralline crag with forms of a more southern character; but now the far larger proportion of the entire group are inhabitants of the northern seas, and a small portion of them only range to the Celtic, and still fewer to the Lusitanian regions. Altogether, the aspect of the fauna may be certainly considered as northern. This fact, however, as the period is probably the one immediately preceding the great northern drift, when there may have been open seas to the north, I should rather be inclined to ascribe to the lower temperature of the waters, arising from the existence of currents from the northern seas, than to consider it as evidence of a land temperature much different from that of the present day.

Further, although many of the species are very typical, the number common to several periods forms too large a proportion of the total for us to arrive at present at a very accurate estimate of the exact age of these beds. That they are comparatively of recent date, is indicated both by organic remains and by superposition, but our knowledge of their fauna ought to be considerably extended, and I believe that the means of doing so exists, before the exact position of these beds can be determined. It is, however, evident that they are more recent than the red crag, and older than the great northern clay-drift, which thus reduces the question to within comparatively narrow limits.

Since writing the above, I have been led to consider, from the want of a more general agreement between the fauna of this deposit and

* Memoirs of the Geological Survey of Great Britain, vol. i. p. 406.

† This includes the *Turritella terebra*, which Mr. S. Wood gives only from the red crag.

that of Bridlington, which is generally held to be the marine equivalent of the mammaliferous crag, and from the very small number of extinct species found in the Chillesford deposit, whether it may not possibly belong to a period one step more recent than the mammaliferous crag; whether in fact it may not be the marine representative of that thin marine freshwater and land series which on the north-eastern coast of Norfolk is spread over the patches of the Norwich crag, and immediately underlies the great northern clay-drift.

Note.—The following directions may be useful as a guide to a few of the best and most interesting sections in this district of the Crag; that is to say, in the small tract of country between the river Butley and the river Alde, especially as it is here that we have the fullest development of the coralline crag. The references are made by the Ordnance Map.

Coralline Crag Pits.

Sudbourn Hall,—in the park, one furlong north-west of the house: a large shallow section in the lower part of the coralline Crag, celebrated for the number and beauty of its fossils, especially its Conchifera.

Ditto,—one furlong north-east of the house: higher in the coralline crag; more unproductive in shells, but richer in corals.

Ditto,—half a mile north-east of the house; entrance of park at the junction of the Aldborough and Woodbridge roads: rich in corals; a fine and large section.

Iken parish;—Redlands covert, on the south-west corner of, on the borders of Iken marshes: a small field-pit;—thin beds, very compact.

Ditto,—three and a half furlongs west of Calton farm: a fine and large pit.

Ditto,—north side of Ferry farm-house, one mile south-westward from Aldborough Ferry. This pit exhibits a surface of crag strongly indented by drift-sands and gravel.

Pits of Coralline Crag, with a capping of Red Crag.

Sudbourn parish,—near the top of the hill, seven furlongs north-east by east from Sudbourn church. This is a very interesting pit, exhibiting a fine section of fifteen feet of red crag, reposing on twenty feet of coralline crag, both abounding with their characteristic fossils.

Ditto,—exactly intermediate by a line on the map between this last pit and Sudbourn church, by the side of a lane the first turning to the left in proceeding westward from Sudbourn church. This pit also exhibits an excellent section of the red and coralline crags.

Ditto:—adjoining and intermediate between these last two pits are several others, some of them of considerable size, but mostly excavated in the coralline crag only.

Pits of Red Crag.

Chillesford,—by the side of the road from Orford to Woodbridge, at the point where the lane (east side of it) branches off to Chillesford church: a fine large section*.

Ditto:—several small pits on the heath, about half a mile north-east from Chillesford brick-kiln.

Pits of Fossiliferous Clays and Sands (b & c) overlying the Coralline and Red Crags.

Iken parish:—brick-field. (See page 347.)

Ditto:—two small pits at the back of the keeper's house, seven furlongs west of the last pit.

Ditto,—on the edge of the wood, three furlongs south-south-west of the last pit. [In the last two pits the red crag occurs at their base; fossils scanty.]

Chillesford:—pit by the church, described at p. 348.

Ditto:—at brick-kiln, described at p. 347.

Ditto:—on the Tunstall-road, quarter of a mile from its junction with the Orford and Woodbridge roads.

Pits in Clays "b & c"; in places fossiliferous.

Iken parish:—pit described in page 346.

Ditto:—an old pit in a field quarter of a mile south-east from Yarn Hill.

Tunstall parish:—on the south side of the road leading from Tunstall to Iken Heath, one mile and three furlongs nearly due west of Tunstall church.

Ditto:—in a field quarter of a mile south of the same road, half a mile nearer Iken Heath†.

---

2. *On the Position in which Shells are found in the Red Crag.* By T. G. Ringler-Thomson, Esq.

[Communicated by Professor Ansted.]

[*Abstract.*]

The unvarying position of the bivalve and univalve shells in the red crag formation of Suffolk and Essex, in many localities, has not, that I am aware of, been ever publicly discussed. The inexhaustible stores of Pectunculi in this formation, as well as the other less numerous bivalves, are deposited in layers of various thickness, from six inches to as many or more feet, each shell having its inside or concavity downwards, and the umbones of the shells having in general an easterly direction.

* On the opposite side of the Butley river, in the parish of Butley, are several good pits of red crag. I would especially notice those about half a mile westward from the Old Abbey.

† The greater number of the numerous clay- and sand-pits in the parishes of Tunstall, Wantesden and Iken, are in the unproductive sands overlying the crag and in the great northern clay-drift. Around Orford are many of the former.

By repeated experiment it was found that water, whether quiescent or running, deposited all the separated bivalve shells with the inside or concavity upwards. The univalves are deposited with their mouths upwards. These experiments are so simple and easily made, that they need not be enlarged upon.

As these positions do not prevail among the bivalves and univalves of the crag, it may be observed that, although water may have transferred them to their present localities, it could not have been the cause of their actual position. It was suspected that wind might have effected this alteration. Shells being placed upon the ground as water deposits them, and being blown upon with a pair of bellows, immediately assumed their characteristic crag positions; moreover the umbo of each shell was turned in the direction of the current of air. Repetition of this experiment on the sea-shore showed that the shells were at first carried along the beach, their umbones being turned from the wind, till the shell was completely turned over, the place of the umbo being reversed and occupying that point in the circumference of the shell nearest the wind.

The univalves, whose deposition in water with their mouths upwards was noticed above, on being subjected to a current of air rolled over with their mouths downwards, the axis of their columellæ being generally at right angles to the direction of the wind. This experiment was tried as well on the shore as in the house, and with similar results in both cases.

If the experiments are allowed to be conclusive, which it is thought they fairly may, it will be evident that, as far as the observations go, the water must have left the shells dry, and that wind then forced them into their present position, and that no other wind than an easterly one would have placed the umbones, or the longitudinal axis of the univalves, as they are now found. This easterly wind must have prevailed for a lengthened period of time, and experiment would lead us to infer, with no inconsiderable force.

[This paper was accompanied by a table of observations on the position of the shells at various localities, and by an outline map showing the supposed direction of the wind at each when the shells were deposited.]

March 21, 1849.

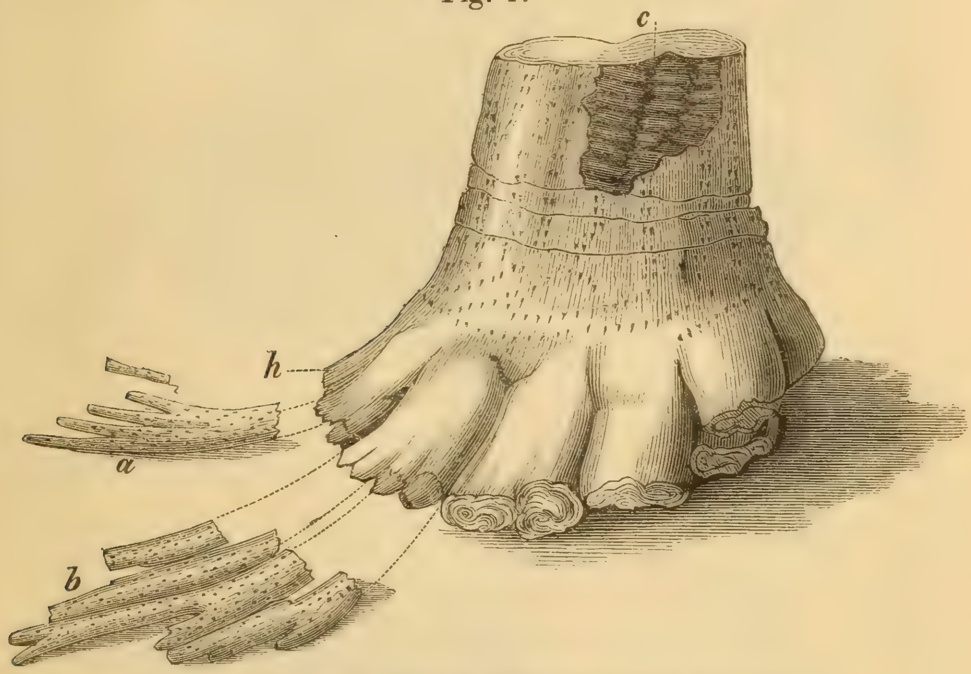
J. G. Lynde, Jun., Esq., Rear Admiral Sir Thomas Trowbridge, G.B., and M. Sylvain Van de Weyer, the Belgian Minister, were elected Fellows of the Society.

The following papers were then read:—

1. *Description of erect* Sigillariæ *with conical Tap Roots, found in the Roof of the* Sydney Main Coal, *in the* Island of Cape Breton. By Richard Brown, Esq.

In addition to the erect trees from the Sydney coal-measures described in the Journal of the Society, vol. i. p. 393 and vol. ii. p. 46, I have now the satisfaction of forwarding sketches and descriptions of two curious fossils from the roof of the main coal, calculated in my opinion to afford some interesting information concerning the habit and mode of growth of *Sigillaria alternans*; and at the same time to clear up all doubts respecting the true nature of the "dome-shaped fossil," figured and described in Lindley and Hutton's 'Fossil Flora,' vol. ii. pref. p. xiii.

Fig. 1.



Stump of Sigillaria alternans, *one-twelfth of the natural size.*

Fig. 1 is a sketch of an upright stump, sixteen inches in height and twelve inches in diameter at the top, which dropped from the roof of the seam some time after the coal had been removed; the greater part of the branching roots had fallen down and been stowed away amongst the rubbish of the mine before the stem was discovered; the few that remained are in external appearance true Stigmariæ, but being filled up with soft shale, no traces of internal organization can be observed, except occasionally a flattened central core. The upper part of the stem was covered with a coaly bark one-fifth of an inch in thickness, which was closely marked with irregular short striæ in a vertical direction, and by long projecting wrinkles running spirally round the stem as shown at *c* (fig. 1). A thin layer of hard shale which envelopes the bark, completely conceals the leaf-scars. Lower down the bark was thinner and very smooth, whilst that which covered the roots *a*, *b* was so exceedingly thin and friable, that it fell off on the slightest touch.

The leaf-scars on the decorticated stem are very sharp and distinct; they begin close to the ramifications of the roots, and run in single spiral lines over a zone three or four inches in width; above this zone, double rows of oval scars commence, which at first incline considerably to the right, but soon take a vertical direction and run exactly parallel to each other. There are no traces of longitudinal furrows, either upon the bark or the decorticated stem. The intervals between each pair of scars swell outwards, the raised spaces being exactly under the projecting wrinkles on the surface of the bark, as shown in fig. 2, which is a vertical section, of the natural size, in the direction of one of the double rows of leaf-scars, *d*, *e* being the bark, and *f*, *g* the deep indentations on the decorticated stem.

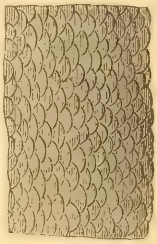
Fig. 2.

Fig. 4.

Fig. 5.

The inner surface of the bark is covered with minute scales, which, to the naked eye, appear not unlike the delicate rhomboidal markings of a very young Lepidodendron, but when viewed through a lens exhibit an oval outline, as shown in fig. 3, which is magnified three times the natural size. These scales are quite distinct as far down as the point *h* (fig. 1), a few inches below the first ramifications of the roots. The roots *a*, *b* are marked with irregular waving striæ, occasionally running one into another, as represented in figs. 4 and 5, the first being the upper, and the second the lower side, of the same piece of root. It will be observed that the areolæ on the upper side are squeezed into an oval shape, sometimes to such a degree that merely a black indented mark is visible, whilst on the under side they preserve their circular form with a minute black dot in the centre.

Fig. 3.



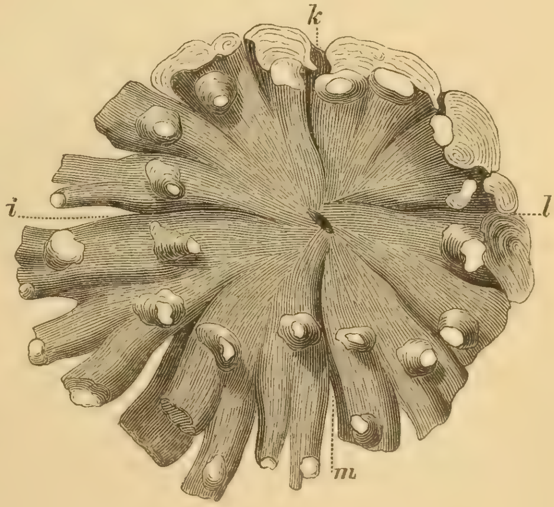
The exact position of the tree with reference to the underlying coal is shown in the section fig. 6. Immediately over the coal there is a

Fig. 6.

Coal seam.

bed of hard shale six inches in depth, in which no fossils are found; this is overlaid by a softer shale abounding in coal plants; all the upright stumps which I have examined are rooted in the six-inch shale; the crown of the base of that which I am now describing is just four inches above the coal; its roots dip gradually downwards until they come in contact with the coal at about eighteen inches from the centre of the tree, and then spread out over its surface. When this fossil was brought out of the mine, the under side was covered up with hard shale, to which about one inch of coal adhered; in cutting away this layer of coal I met with the termination of a perpendicular root immediately in contact with the coal, which I carefully developed; proceeding in this manner, my patience was amply rewarded by the discovery of a complete set of conical tap roots arranged in the order represented in fig. 7, which is an horizontal section of the inverted base or underside of the stump, on a scale of one-twelfth of the natural size. It will be observed that the horizontal roots branch off in a remarkably regular manner, the base being first divided into four equal quarters by deep channels running from near the centre towards the points indicated by the letters *i*, *k*, *l*, *m*; an inch or two further on each of these quarters is divided into two roots, which, as they recede from the centre,

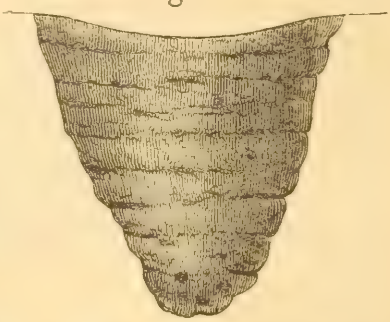
Fig. 7.



bifurcate twice in the quarter *i, m*, which is the only complete portion of the fossil. If the ramifications in the other three quarters were as regular as in *i, m*, which I have every reason to suppose was the case, having found a similar arrangement in two other trees of the same species, we should have thirty-two roots within a circle of eighteen inches diameter.

There are four large tap roots in each quarter of the stump, as shown in fig. 7, and about five inches beyond these a set of smaller tap roots striking perpendicularly downwards from the horizontal roots, making forty-eight in all, viz. sixteen in the inner and thirty-two in the outer set; and, what is a still more remarkable feature in this singular fossil, there are exactly thirty-two double rows of leaf-scars on the circumference of the trunk. This curious correspondence in the numbers of the roots and vertical rows of leaf-scars, surely cannot be accidental. I am not aware that any similar correspondence has ever been observed either in recent or fossil plants. The inner set of tap roots vary from two to two and a half inches in length; the diameter at their junction with the base of the trunk being about two inches, as shown in fig. 8, which is one-half the natural size. The outer set are much smaller, being about one inch in diameter at their junction with the horizontal roots, and from one to one and a half inch in length. Very few of either set are strictly conical, although they probably were originally of that shape; some are squeezed into an elliptical, others into a triangular form; all have been wrinkled horizontally, as shown in fig. 8, by the shrinkage due to vertical compression. A thick tuft of broad flattened rootlets radiates from the terminations of the tap roots, and a few indistinct areolæ are visible on their sides; the length of these rootlets does not appear to exceed three or four inches, their width being one-fourth of an inch; a raised black line runs down the middle of each, similar to that observed in the rootlets of Stigmariæ. These short thick tap roots were evidently adapted only to a soft wet soil, such as we may easily conceive was the nature of the first layer of mud deposited upon a bed of peat, which had settled down slightly below the level of the water.

Fig. 8.



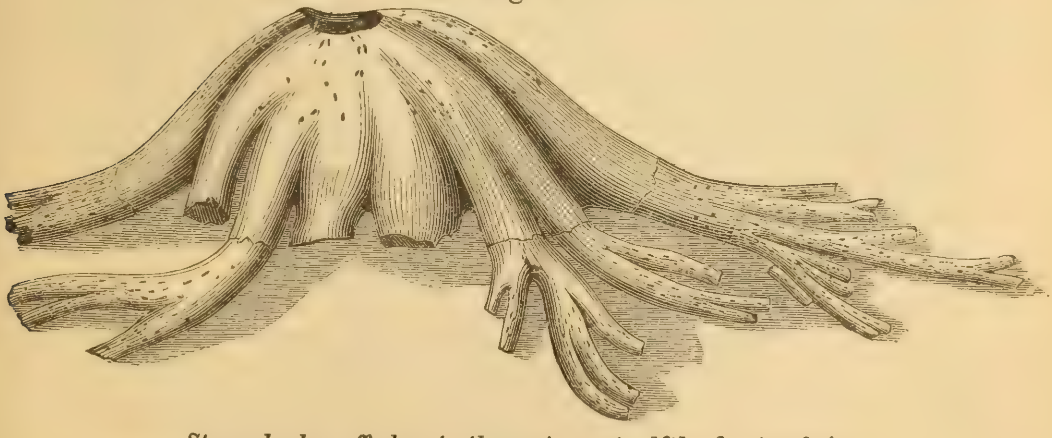
We may infer also, from the existence of a layer of shale without fossil plants, immediately over the coal, that the prostrate stems and leaves which occur in such large quantities in the next superincumbent bed, fell from trees growing upon the spot, and were entombed in layers of mud held in suspension in water, which at short intervals inundated the low marshy ground on which they grew; for had the plants been drifted from a distance, we should find them in the first layer of shale as well as in those higher up.

Although the main coal is generally overlaid by shale, yet occasionally the shale thins out, and the thick sandstone, which is the next stratum in the ascending order, forms the roof of the coal. In such cases the surface of the peat bog could not have been level when the shale was deposited upon it, some small patches having been still above water; and as no upright trees are found in the sandstone roof, it may reasonably be inferred that plants would not vegetate upon the bog itself, a layer of soft mud being necessary in the first instance for germinating the seeds; but when a plant had once taken root in this mud its rootlets penetrated downwards into the peat, and furnished an abundant supply of nutriment for the rapid growth of the tree, from the rich mass of decaying vegetable matter beneath.

I may here observe that the quality of the upper part of the seam appears invariably to be influenced by the nature of the roof, the coal being highly charged with iron pyrites under a sandstone, but quite free from it under a shale roof*. And since no upright trees are found in the sandstone roofs, is it probable that the luxuriant forest of Sigillariæ growing in the mud above the peat bog has taken up the sulphuret of iron, and thus produced such a beneficial effect upon the quality of the coal? Both sulphuric acid and the oxide of iron are inorganic constituents of plants, and it has been ascertained that natural and artificial waters that have a sulphureous taste, when employed in irrigating meadows, give birth to a very luxuriant vegetation†, but whether the growth of a forest of Sigillariæ upon the surface of the peat bog, is an adequate explanation of the absence of iron pyrites from the upper part of the coal seam, I must leave to more skilful botanists to determine.

Having shown that *Sigillaria alternans* was provided with roots peculiarly adapted for flourishing upon a soft muddy soil, and thus furnished additional proof that coal seams have been formed from beds of peat or other decaying vegetable matter accumulated on the surface, it only remains for me now to direct attention to the fossil represented in fig. 9, which it will be observed, in its external aspect,

Fig. 9.



Stump broken off close to the root, one-twelfth of natural size.

* Mr. Buddle states in the Trans. of the Nat. Hist. Society of Newcastle, vol. i. p. 217, that the coal seams in Northumberland are always more or less intermixed with iron pyrites under a sandstone roof.

† Johnston's Agricultural Chemistry, p. 273.

is a perfect specimen of the "dome-shaped fossil" figured by Lindley and Hutton, and in reality a Sigillaria of the same species as that just described, whose stem has been broken off near the root, the hollow cylinder of bark having, after the decay of the lax cellular tissue, been bent down and doubled over by the pressure of the accumulating mud outside, so as effectually to close up the aperture, leaving only a few irregular cicatrices of three or four inches in length converging at the apex. The whole fossil was covered with a thin bark of coal which soon crumbled off, and exposed leaf-scars scattered at random over the sides, but arranged in double rows near the summit. If this stem had been broken off three inches lower down, none of the double rows of scars would have been visible; the scattered single scars would then have precisely corresponded with the "indistinct dots" in Lindley and Hutton's fossil.

Fortunately about one-half of the roots were collected from the roof of the coal after the truncated stump had fallen down; they cannot be distinguished from the roots of the tree represented in fig. 1. The underside or base of the stump is in like manner divided into four quarters, each of which ramifies twice, thus making sixteen main roots, from each of which a tap root descends perpendicularly. The sixteen main roots are again subdivided, and a second set of tap roots shoot off from them; in short, the resemblance to the first described tree is so perfect in every feature, except the accidental closing up of the stem, that it is quite unnecessary to repeat the description already given of that fossil. Judging from the length and position of the cicatrices at the apex where the bark has been squeezed together, the diameter of the stem must have been about ten inches. Its position with respect to the underlying coal was precisely analogous to that of the first tree.

The roots of the preceding fossils repeatedly ramify as their distance from the stem increases, and ultimately terminate in broad flattened points. The whole of the spreading roots of these trees cover only an area of thirty square feet each, whilst the roots of the Lepidodendron figured in vol. iv. p. 46 of this Journal, whose stem is only two or three inches larger in diameter, covered an area of two hundred square feet. Since it is well known, from numerous examples, that the Lepidodendra were lofty trees with spreading branches, which required wide supporting bases, may we not reasonably conclude that Sigillariæ of the species described, judging from their comparatively small bases, were on the contrary trees of low stature, without heavy branches?

---

2. *Notice of Researches in* Asia Minor. By M. Pierre de Tchihatcheff.

[Extract of a letter to Sir Roderick I. Murchison, F.R.S., V.P.G.S., &c. &c., dated Paris, February 26, 1849.]

It is a month since I arrived in Paris from Constantinople, after an absence of two years and a half in Asia Minor. Though some portions of my scientific collections were unfortunately lost, still the remainder, now safe in Paris, is so rich and valuable, in regard to geology, palæontology and botany, that I have all possible reason to be satisfied, and to consider myself well repaid for my long and painful exertions. I shall not tire you by enumerating my various journeys, which form a complete network over the whole Anatolian peninsula, from the Mediterranean to the Black Sea, and as far east as a line from Trales to Tarsus. The following are a few of the more important results of my researches :—

1. In 1848 I discovered two important palæozoic localities in Asia Minor ; the one at its eastern extremity composing the extensive range of the Antitaurus ; the other only two days' journey from Constantinople forming the northern shore of the Gulf of Nicomedia. Both are Devonian, as they contain *Terebratula fusca, Productus subaculeatus, Spirifer speciosus*, and other species, as determined by M. de Verneuil. The ignorance of geologists regarding the former is not wonderful, as I was the first person who ventured to explore this lofty and picturesque chain, situated on the borders of Kurdistan and inhabited by savage and fanatical tribes only imperfectly subject to the Turks, and among whom I lost two of my men, one shot at my side, the other killed by a sword-cut in a contest with thirty horsemen who plundered us of all our property. But the other deposit, in the very vicinity of Constantinople, might have been expected to be better known, as most of the geologists who have explored this district have visited Ismid or Nicomedia, and had they only gone there by land instead of by water, could not possibly have missed it. This is probably the reason why Mr. Hamilton and others marked the northern shore of the Nicomedian gulf as cretaceous, and the remainder of the peninsula between it and the Black Sea as Silurian. The prolongation of the Silurian? system on the other side of the Bosphorus, as given in your map, is also very arbitrary, as neither M. Hommaire de Hell, M. Visquenel nor myself, could ever find any fossils in the Giant's Mountain, where Mr. Hamilton says they occur. In the southern part, marked as cretaceous, Devonian fossils are however abundant, and the whole peninsula therefore probably belongs to this formation.

2. It would be tedious to notice other errors, but I may say that the valley of the Kizil Irmak, coloured on your map as tertiary, certainly belongs to the enigmatical "formation of gypsum and red sandstone," developed on a very large scale in Asia Minor, which Mr. Hamilton in his 'Travels' supposes to belong to the Permian system. Before my researches this deposit had never yielded a single fossil, but in the red sandstone of Yuzgat I discovered numerous Alveolina, of a large size and probably a new species, associated with nummulites and a few bivalves. Hence this rock belongs to the "terrain nummulitique," which, if we suppose all the red deposits in this country to be of the same age, is probably the most extensive formation in Asia Minor*.

* The chief differences of opinion between my zealous friend and myself will be pointed out by Mr. W. Hamilton ; but in reference to the statement concerning the nummulitic rocks, I cannot avoid expressing my conviction, that a more

3. I leave my palæontological collections, which fill three large boxes and are of great value, to the care of our friend De Verneuil. I cannot, however, refrain from mentioning some jurassic ammonites found at a distance of eight hours to the south of Angora. These prove the existence in this place of a patch of Oxford clay, as M. Alcide d'Orbigny at the first glance recognized all the ammonites as characteristic of this formation.

4. The results obtained in my ascent of Mount Argæus are very interesting, but I shall not trespass further on your patience with details. It is sufficient to say that I returned four times to Kaisaria, and spent five months in investigating the structure of this remarkable volcanic giant and the surrounding country, which I have completely delineated on a large geological map.

I have not only determined the altitude of above 500 localities by means of the temperature of boiling water, but have also established meteorological observations, furnished with the best instruments, barometers, thermometers and hygrometers, procured at great expense from Paris, at Constantinople, Kaisaria, Smyrna, Trebisonde and Tarsus. From Constantinople and Kaisaria I have already a continuous series of observations for two years, and from Trebisonde for six months, and I intend that they shall be kept up for at least three years longer.

April 4, 1849.

The Rev. E. Prout, John Bentley, Esq., and Lieut.-Colonel Reid, C.B., were elected Fellows of the Society.

The following papers were then read:—

1. *Observations on the Geology of* Asia Minor, *referring more particularly to portions of* Galatia, Pontus *and* Paphlagonia. By W. J. Hamilton, Esq., Sec. G.S.

Before I proceed to the chief object of this memoir, I consider it an act of justice to my fellow-traveller Mr. Strickland and to myself, to offer a few observations to the Society on some of the statements contained in the recent notice of M. Tchihatcheff.

These statements refer mainly to two points, viz. the palæozoic rocks in the neighbourhood of Constantinople, and the age of the red sandstone and overlying formations in the more eastern districts of Asia Minor.

1°. With regard to the palæozoic rocks near Constantinople, M. Tchihatcheff first states that I have called them Silurian instead of

thorough development of the subject (*and M. de Tchihatcheff has again returned to Asia Minor on this account solely*) will, I trust, prove a striking confirmation of the general view I have put forth concerning the tertiary eocene age of all the "terrain nummulitique" in Asia as well as in Africa and Europe.

Rod. I. Murchison, Sept. 27, 1849.

Devonian, and then doubts the existence of fossils on the Giant's Mountain opposite to Therapia. In answer to the first objection, I have only to say that they have been described by Mr. Strickland in the 5th vol. of the Transactions of the Society, where a list of the fossils is given on the authority of Mr. James Sowerby. I might also observe, that the mineralogical character of the rock, so closely resembling that of some of the argillaceous schists of the Lower Silurian rocks as exhibited in North Wales, is also a justification of their having been so named at a time when the Devonian system was unknown*.

With regard to the existence of fossils on the Giant's Mountain, I also appeal to Mr. Strickland, and at the same time I can assure the Society that every one of the specimens we have exhibited came from that locality and from near the summit of the hill; indeed, we obtained the best *in situ*, from the fresh-cut side of a new road which was then in process of construction. We also found the same formation on the European side of the Bosphorus between Therapia and Constantinople, but no other locality afforded so many fossils. On a subsequent occasion too, I had an opportunity of ascertaining that the hill of Boulgourlou behind Scutari consists mainly of the same formation, interstratified with beds of quartz rock, probably altered sandstone; here also I found a few imperfect traces of organic remains. With regard to what M. Tchihatcheff says, of no one else having since been able to detect these palæozoic fossils on the Giant's Mountain, Mr. Strickland has already well remarked, that although the geology of this mountain has been noticed with more or less exactness by Andreossy, Fontanier, and the author of the 'Sketches of Turkey,' not one of them has noticed its numerous and interesting fossils.

The only other point I have to notice respecting the neighbourhood of Constantinople, is the statement of M. Tchihatcheff, that "Mr. Hamilton and others have marked as *cretaceous* the northern shore of the Nicomedian Gulf," whereas the Devonian system is, as he says, there clearly displayed. As I did not visit the Nicomedian Gulf either by land or by water, I never have or could have ventured to pronounce an opininion as to whether the northern shore of the gulf was Devonian or cretaceous.

And here it is to be observed, that by reference to the last edition of the Map of Russia published by Sir R. Murchison, in which the geological structure of the neighbourhood of Constantinople is laid down from the best authorities he could then refer to, it will be seen that the north side of the Gulf of Nicomedia is coloured as palæozoic, and therefore the proposal of M. Tchihatcheff to erase the cretaceous rocks, which were partially inserted in the first edition of that Map (but not on my authority), has long since been anticipated. Finally, as to whether these palæozoic rocks be Silurian or Devonian it is not for me to pronounce. It is possible that both formations may there be found to exist, and in calling these Silurian, Mr. Strickland and myself were simply guided by the best opinions we could then obtain;

* See Bulletin de la Société Géologique de France, vol. viii. p. 268, "Notice Géologique sur les environs de Constantinople, par M. de Verneuil."

and I repeat, that at the period when we published our memoir, the Devonian system had not been established nor its fossils defined. At the same time, as M. Tchihatcheff and his friends have not been able to detect fossils in the locality where we found them, viz. the Giant's Mountain, he can scarcely venture to pronounce definitively upon the age of these rocks, from his having found Devonian fossils in the more southern portion of the promontory, viz. on the northern shore of the Gulf of Nicomedia. Until more precise researches be made, it is not clear that both Silurian and Devonian fossils may not exist in the palæozoic rocks of that region.

The other observations of M. Tchihatcheff relate to the valley of the Kizil Irmak and to the age of the red sandstone formation of the eastern parts of Asia Minor.

1°. M. Tchihatcheff states that the Valley of the Kizil Irmak, instead of being tertiary as it is marked in Murchison's Map of Russia, "belongs to the enigmatical formation of gypsum and red sandstone developed on a very large scale in Asia Minor, and which Mr. Hamilton supposes to belong to the Permian system."

2°. M. Tchihatcheff considers this red sandstone formation to belong to the terrain nummulitique.

I am at a loss to understand where M. Tchihatcheff has ascertained that I have described the Valley of the Kizil Irmak as tertiary, or that I have called the red sandstone formation Permian. With regard to the latter statement, it must be remembered, that when my work on Asia Minor was published the very name was not known, nor was it used as a geological expression until after Sir R. Murchison's researches in Russia in 1844.

And with regard to the nummulitic group, I shall be enabled to show in the course of this memoir, that I was fully aware of its existence in this part of Asia Minor, and had already noticed its connection with the red sandstone formation.

I now proceed to lay before the Society a statement of the geological observations which I made in this part of Asia Minor, comprising portions of Pontus and Galatia, commencing on the shores of the Black Sea near the ancient site of Sinope, and extending in a S.E. direction to Tocat, and thence in a W.S.W. direction as far as Sevrihissar on the frontiers of Phrygia. I will only observe, that as the vividness of memory has been somewhat impaired by length of time, I cannot attempt to fill up the lacunæ of my journal so satisfactorily as I might have done if undertaken at an earlier period; and, that as not many sections were observed in this part of the country showing the natural superpositions of the different formations, it would be useless to attempt to give a complete section of the geological features of the whole district. I must therefore confine myself, with few exceptions, to describing the different formations I observed, and pointing out some of the principal localities where they occur. Much subsidiary information will be found in the various papers published in the Transactions of the Society by Mr. Strickland and myself,—

1. On the Geology of the Thracian Bosphorus, by Mr. Strickland. Vol. v. p. 385.

2. On the Geology of part of Asia Minor (Cappadocia, &c.), by Mr. Hamilton. Vol. v. p. 583.
3. On the Geology of the Western part of Asia Minor, by Messrs. Hamilton and Strickland. Vol. vi. p. 1.

Respecting that portion of Asia Minor now more immediately under consideration, I must also refer to a paper by Mr. Ainsworth on Asia Minor in the Journal of the Royal Geographical Society, vol. ix. p. 267 *et seq.*

No idea can be formed of the general features and character of this country, without taking into consideration the extent and variety of igneous rocks by which it is everywhere penetrated and disturbed. These are of every possible variety—granite of various qualities, greenstones, domites, trachytes and trachytic conglomerates, like those described in my former paper on the Geology of Cappadocia. One distinctive feature however is, that the remarkable volcanic tuffs and peperites, so abundant between Mount Argæus and Hassan Dagh, do not occur so frequently in this part of Asia Minor, from which we may, I think, conclude that it is of an older date.

The line of country to which my present remarks apply extends from Tocat (lat. 36° 50′ E.) to Sevrihissar (lat. 31° 35′ E.), and in a general direction from E.N.E. to W.S.W. 280 miles; its extent from N. to S. is irregular. The principal igneous rocks which I observed in this district are granite, greenstone, porphyritic trap, serpentine, trachyte and trachytic conglomerates, domite, basalt, and black volcanic tuff and peperite; and I propose briefly stating the chief localities where these different rocks came under my notice.

1. *Granite**.—An elevated ridge of fine-grained grey granite, sending out ramifications in several directions, surrounds the town of Sevrihissar in a semicircular or elliptical form. At the eastern extremity of the igneous region about Angora, the red sandstone beds repose against a mass of a dark granitic or rather syenitic rock.

2. *Greenstone and green trappean rocks.*—It is difficult to draw any precise line with regard to the distinctive characters of these rocks, passing as they do in this district by such gradual changes into so many various forms. Generally speaking, rocks of this character occur in the promontory of Sinope; in the castle hill of Boiavad; in the centre of the mountain range between Sinope and Boiavad; in the valley of the Iris six miles east of Tocat; near the village of Boyeuk ten miles east of Barsek Dere, and in the deep and precipitous gorge of Barsek Dere itself.

3. *Porphyritic trap.*—By this term I propose to designate those igneous rocks which consist of small crystalline masses set in a homogeneous matrix of a darker colour. They occur a few miles west of Amasia, between Ladik and Sonnisa; in the valley of the Lycus below Niksar, and in the vicinity of Angora, forming the base of the rocky cliffs through a narrow gorge of which the stream of Angora flows; also a few miles east of Angora, apparently gradually passing into the granitic rock described above, in the deep ravine of Barsek Dere.

* From the general abundance of hornblende this rock frequently passes into syenite in this district.

4. *Serpentine or Ophiolitic rocks.*—This is generally an irregular mass of crystallized matter, closely resembling the Verde di Prato found in the neighbourhood of Florence. Its chief locality is in a deep ravine between Alajah and Yeuzgatt; I also observed it in the valley of the Sepetli between Ladik and Sonnisa.

5. *Trachyte and trachytic conglomerate.*—This rock, varying much in colour and in degrees of asperity as also in its structure, being occasionally compact and hard, sometimes exfoliating, and at others breaking into rhomboidal and wedge-shaped masses, is of very constant occurrence throughout Asia Minor. Some of the varieties abound with masses and crystals of glassy felspar. The following are the principal localities where I observed it:—the neighbourhood of Vizier Keupri; the plain of Tashova between Sonnisa and the junction of the Lycus and the Iris; the isolated peak of Karahissar near Tchorum; the castle hill of Kalaijik; the neighbourhood of Angora, and the hill of Assarli Kaiya twenty miles south of Angora.

6. *Domite.*—The only locality where I observed this rock was in the deep gorge of Barsek Dere; it may indeed be doubted whether it should not rather be described as a white variety of trachyte.

7. *Basalt.*—This occurs in the valley of the Lycus between Niksar and Tashova; at Baluk-kouyoumji and in the vicinity of Yeuzgatt.

8. *Amygdaloid.*—The only place where this rock occurs in this district is in the north part of the Haimaneh, between Angora and Baluk-kouyoumji.

9. *Trap dykes* are seen in the vicinity of Barsek Dere, and between it and the Halys, rising above the surface and crossing each other in every direction.

10. *Volcanic tuff and peperite* are seen in the hills west of Amasia associated with trappean rocks.

Stratified Rocks.

The stratified rocks of this district are generally so deficient in fossils, that it is at present almost premature to attempt any complete or even general classification of them. I shall, however, here bring together the different observations I have made, which will I trust tend in some degree at least to give an idea of the general characteristics of this country. I did not observe in this part of Asia Minor any formations which could with certainty be referred to an older epoch than the secondary; I therefore propose, for the present, to adopt the usual subdivision of secondary and tertiary formations.

1. *Secondary Rocks.*

In considering the secondary rocks of this region I have been induced to divide them into two formations, chiefly if not entirely from their lithological appearances, and also from having, on several occasions, found those beds which I refer to the more recent formation overlying the others, sometimes indeed dipping in the same direction and at nearly the same angle, but leaving no doubt of their belonging to a later period, and thus constituting perhaps the different elements of different ages. I was nowhere fortunate enough to meet with them in immediate contact, so as to decide upon their degree of conformability or separation. All that I was enabled to observe beyond what I have just mentioned was, that in that which I assume to be the oldest, the schistose beds abound in masses and veins of quartz, and assume a more indurated and grauwacke-like appearance, the limestone beds becoming at the same time more crystalline and of a darker hue, and sometimes giving out a very fœtid smell on being struck or fractured, while those which belong to the newer formation graduate upwards into a compact cream-coloured scaglia. They may be described as follows:—

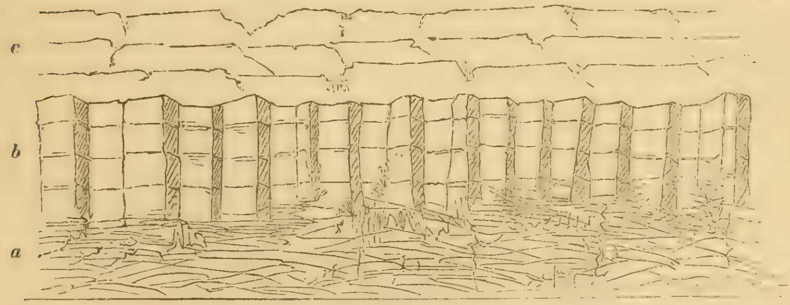
1. The Lower Secondary, probably the representative of the Jurassic or Oolitic system.

2. The Upper Secondary, probably corresponding with the Cretaceous system.

1. *The Lower Secondary.*—This formation consists of crystalline limestone of various colours, sometimes associated with micaceous schists, or with argillaceous and arenaceous beds penetrated by veins of quartz; the sandstones sometimes assume a compact and very grauwacke-like appearance, while the argillaceous beds are often altered into jasper. In the limestone beds no traces of stratification are generally visible, and no fossils were found in any of the beds attributed to this system; it occurs in the following localities:—generally speaking the whole of the mountainous district which extends along the southern shore of the Black Sea from Sinope to Samsún, and between it and the valleys of the Kizil Irmak and the Lycus, or rather through which those rivers have forced their way, consists of this crystalline limestone and its subordinate beds of sandstones, shales and schists more or less altered according to their vicinity to the igneous rocks (see fig. 1).

Fig. 1.

Sandstone altered by underlying Trap.



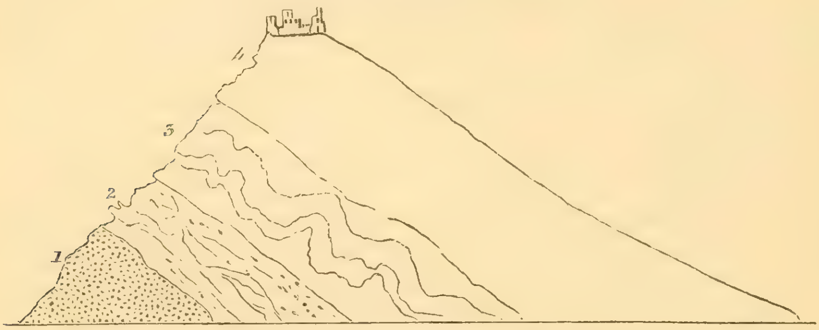
a. Trap rocks. *b.* Altered sandstone. *c.* Micaceous sandstone.

At Boiavad the castle hill consists of this limestone associated with beds of red and yellow talcose schists much contorted and in places penetrated by veins of quartz (see fig. 2). The gorge of Kara tepéh, about ten miles east of Boiavad, is a narrow defile through the same formation; the hills are chiefly limestone, thick-bedded, black and white veined, emitting a rather fœtid smell on being fractured.

About a mile to the west of Ladik is a low ridge of grauwacke-looking sandstone dipping S.S.W. Immediately behind, *i. e.* to the south of, Ladik, is a range of limestone hills, an outlier apparently of the lofty chain of Ak Dagh which forms the watershed between

Fig. 2.

Section of Castle Hill, Boiavad.



1. Igneous rock.
2. Igneous rock, very fissile.
3. Schistose beds contorted.
4. Pink-coloured scaglia, without traces of stratification.

Ladik and Amasia; the dip of these beds is nearly vertical, and towards the S.E.; the general strike of the hills is from E.N.E. to W.S.W. The limestone is a hard, semicrystalline black and white marble, and below it is a thick formation of irregularly bedded grauwacke sandstone, very hard, breaking into rhomboidal masses, and containing in some places veins of calcareous matter, but no organic remains. Further eastward the grauwacke sandstone is seen dipping 70° S.S.W.

Proceeding eastward towards Niksar, a spur of this same formation stretches across in a N.E. and S.W. direction between the plains of Tashova and Niksar, connecting the mountain-chain of Ophlimus on the south with that of Paryadres on the north.

Between Niksar and Tocat, passing from the valley of the Lycus to that of the Iris, thin-bedded argillaceous schists occasionally occur, dipping S. 70°; and on reaching the valley of the Iris and approaching Tocat, a fine crystalline grey marble is associated with these same schists.

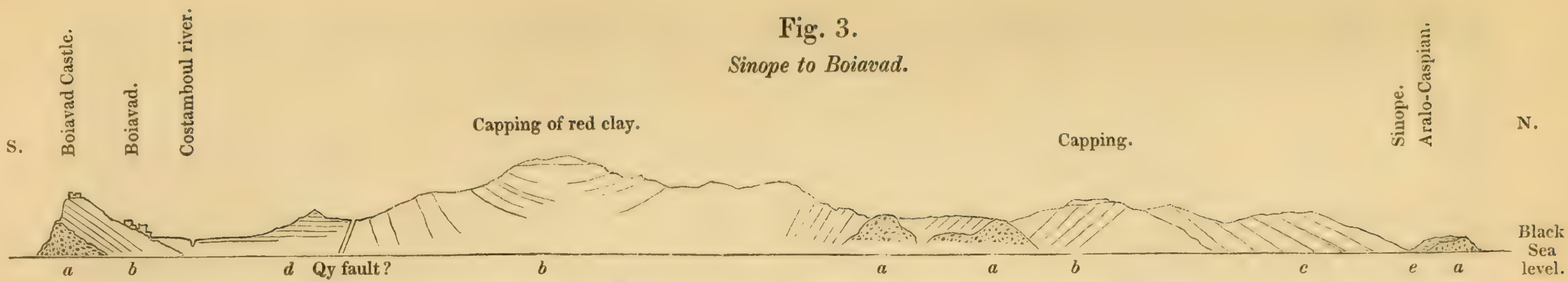
The lofty mountains which surround the town of Tocat are of the same highly crystalline character, a true marble traversed by red veins, and associated with beds of schists, some of which are extremely hard and slaty, breaking off in large slabs and used as gravestones by the Turks. In the marble beds no signs of stratification are visible, but the schistose rocks show a considerable dip to the S.W.

The same formation occurs between Kalaijik and Angora, and also to the eastward of Angora near the commencement of the igneous or trappean district. These schistose beds evidently belong to the oldest formations of the district, inasmuch as they appear to have been disturbed previous to the deposition of the red sandstone.

Immediately to the eastward of the granitic outburst of Sevrihissar is a very remarkable ridge of hills extending almost from north to south, and terminating at its southern extremity in Mount Dindymus,

Fig. 3.

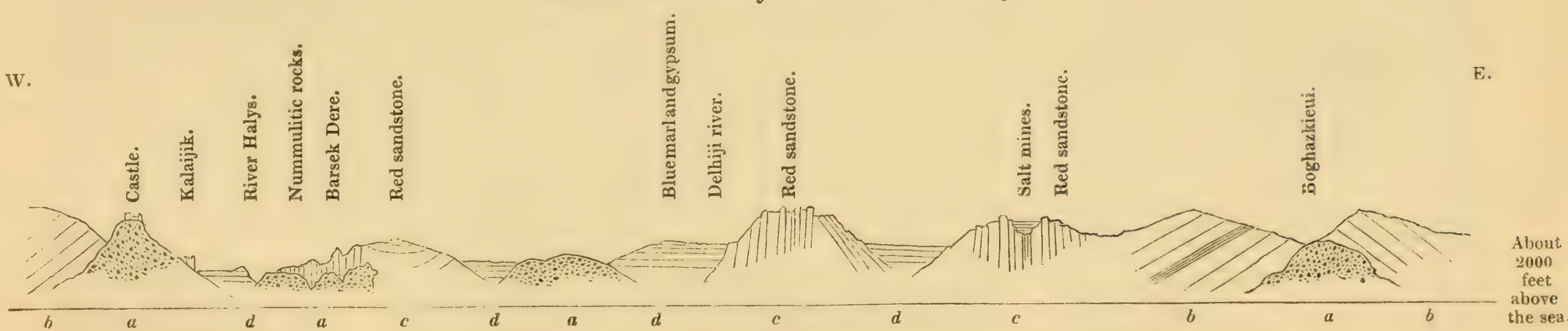
Sinope to Boiavad.



a. Igneous rock, trap, granite, &c. *b.* Older cretaceous. Jurassic? *c.* Younger cretaceous. Scaglia? *d.* Tertiary lacustrine. *e.* Aralo-Caspian formation?

Fig. 4.

General Section through Red Sandstone country.



a. Igneous rocks. *b.* Older cretaceous. *c.* Nummulite and red sandstone. *d.* Blue marl and gypsum.

which overhangs the classic site of Pessinus. This ridge consists of green and yellow micaceous or talcose schists, with an almost vertical stratification and interstratified with crystalline limestone; in the shale are also found veins and nodules of quartz.

2. *The Upper Secondary.*—The rocks which I refer to the scaglia, or equivalents of the chalk of the south of Europe, are less crystalline than the former. The limestones are associated with beds of a soft, yellow, marly character, and occasionally contain a few nodules of coarse flint of a darkish colour, and in some instances I detected on the surfaces, impressions of branching fucoidal stems. They appear along the coast of the Black Sea, to the south and south-east of Sinope (see fig. 3), dipping to the N.E. at an angle of 45° or 50°; also between the hot baths of Cauvsa and Ladik, and in the neighbourhood of Zilleh and of Amasia, in the mountainous district between these two cities.

To the westward of Amasia, towards Tchorum, the same rocks occur in various places in an almost vertical position, penetrated by trappean or igneous rocks, forming the mass of the hilly country and mountain chains to Tekia and Tchorum. West of Tekia the hills consist of blue argillaceous shale, very much contorted and penetrated by veins of crystallized carbonate of lime. Between Tchorum and Yeuzgatt are two mountain ranges, the northernmost of which consists of this same compact grey limestone and schistose rocks. In some places the rocks have assumed the appearance of red jasper, particularly near the centre of the ridge, probably the effect of metamorphic action occasioned by the many outbursts of igneous rocks which occur in the neighbourhood. The southern chain also consists, in a great measure, of the same formation, and is still more frequently penetrated and disturbed by igneous rocks.

In the neighbourhood of Boghaz Kieui, twenty miles north-west of Yeuzgatt, this limestone formation is underlaid by trachytic and porphyritic rocks, which have been partly forced up through the indurated shales and jasper and partly underlie them. The limestone rocks have been much broken up, and are thrown about in large masses, giving a singular appearance to the scenery, and serving in some cases as the site of an ancient acropolis. This is probably the most western extension of the secondary limestone in this district; it is here succeeded on the west by the red sandstone or nummulitic formation.

About sixteen or twenty miles E.S.E. of Angora, near the village of Baluk-kouyoumji, is an outburst of slightly columnar trachyte, which has elevated and thrown off in every direction a mass of thin-bedded compact scaglia limestone; this is in part extremely siliceous, and contains both tabular and nodular flint. In some places too the flint occurs regularly stratified and alternating with the limestone, resembling the appearance of some of the beds in the island of Corfu. To this same formation I refer the semicrystalline or coarse-grained saccharine limestone which occurs nearer Angora on this same line. It rises in a low round boss above the surface of the undulating plain, and proved on examination to contain several species of marine bivalves, amongst which the following have been ascertained, and which on the whole confirm me in the opinion that these rocks should be referred to the cretaceous system; viz.:—

Terebratula, two species, but hardly enough remains to decide the species; one of them, being plicated, is decidedly not of the eocene or nummulitic period, in which such a form does not occur.

Pecten, two species, one of them finely ribbed, and resembling *Lima* in general form.

2. *Tertiary Rocks.*

The beds belonging to this formation may, for the present at least, be classed in the following manner:—

1. Nummulitic limestone and red sandstone (eocene?).
2. Basins of rock-salt, blue marl and gypsum (miocene?).
3. Marine or brackish water formation, probably belonging to the Aralo-Caspian system.
4. White lacustrine limestone with freshwater shells.

1. *Nummulitic Limestone and Red Sandstone series.*

Sir R. Murchison's paper on the Alps and Apennines lately read before the Society*, in which he has shown that the nummulitic beds are the lowest group of the eocene formation, has given me a clue to the geology of this part of Asia Minor. It is not improbable that as the red and yellow sandstones are linked on to, and overlie the nummulitic limestones, they stand in precisely the same place as the great overlying flysch of the Alps or upper macigno of Italy, which Sir R. Murchison has classed with the eocene group. With regard to the nummulitic limestone, I only discovered it in one locality in this part of Asia Minor, viz. in the steep and broken gorge of Barsek Dere, a few miles east of Kalaijik (see fig. 4), where the narrow road winds down a steep and rocky glen, between almost perpendicular or vertical beds of red sandstone, broken up and penetrated, as I have observed, by numerous igneous rocks. These vertical beds rest against another vertical bed of yellow limestone, which I at first took for a trap dyke, so remarkably did it stand out in relief against the softer and more easily decomposing red and yellow sandstones. The limestone bed contains, or rather is almost entirely made up of, many nummulites of small size with other organic remains, some of which appear to be bivalve shells. Mr. Morris is of opinion that there are two distinct species of nummulites; portions of Terebratula are also visible.

This bed is overlaid by beds of red conglomerate and blue shale, and is the lowest, or at least one of the lowest, members of the red sandstone or older tertiary formation.

Another locality of this formation is indicated by the fossils on the table from the neighbourhood of Beyjayes, thirty miles south-west of Angora. I did not indeed trace them to their parent rock, but collected them from the bed of a deep ravine in the white earthy limestone; but judging from the numerous fragments, the parent rock, although concealed, could not be very far distant.

* Since published in the Quart. Journ. Geol. Soc. vol. v. p. 157–312.

They consist of a remarkably thick Ostrea, which Mr. Morris considers to belong to the nummulitic rocks, and a portion of a Cerithium resembling the small end of *C. giganteum*.

As M. Tchihatcheff has already observed, this red sandstone formation is extensively developed in a particular zone of Asia Minor, extending from north to south between 32° and 35° of latitude; I am not aware of its existing either to the east or west of this zone, although the overlying and unconformable gypsum, sand and marl formations, hereafter to be described, have a far greater extension both to the north and south. In a paper published in the 5th vol. of the Transactions of this Society, I have described the red sandstone formation as it occurs between Mount Argæus and the great salt lake of Koch Hissar, and have there left the question open whether it should be referred to the secondary or to the tertiary formation. In another place*, alluding to its existence in the districts now under consideration, I have stated that although in its general appearance it is the counterpart of the red sandstone districts of England, it must, geologically speaking, be of a much more recent date, inasmuch as it contains many pebbles of the scaglia limestone, considered to be the equivalent of our cretaceous beds, and must therefore be posterior rather than anterior to the age of our chalk,—a conclusion which is confirmed by its connection with the nummulitic limestone, to which it is evidently posterior.

The section fig. 4, constructed from the notes of my journal, will show the relative position of this formation where I crossed it, for both to the north and to the south of that line it extends further to the east. It is everywhere much contorted and disturbed, being in some places vertical, thus showing the comparatively recent age of many of the igneous outbursts of this region; and consists of a great variety of beds of different degrees of hardness and of different shades of red and yellow, the yellow being generally harder than the red. Independently of its connection with the nummulitic limestone, one cause of the interest attached to it is owing to the numerous mines of rock-salt which appear to be associated with it; one of them I visited near Soungourli; two others have been visited and described by Mr. Ainsworth.

To the north of Soungourli, towards the salt-mine of Chayan Kieui, the hills consist first of alternating red and grey marls dipping W.S.W. 20°; some of them contain beds of gravel and pebbles of secondary limestone, red jasper and trap; proceeding to the north-west are beds of hard red sandstone with an easterly dip, which gradually increases until in the centre of the ridge it becomes almost vertical. In the detritus in the valleys and plains are found many masses of selenite; and where the red sandstone rock becomes vertical, I observed in the sides of the ravines many thick veins of selenite, with smaller ones running in every direction and intersecting each other.

Proceeding westward down the valley from Soungourli, the southern prolongation of this line of vertical beds is seen on either side. A wide plain then intervenes, beyond which the escarpment of another

* See Researches in Asia Minor, vol. i. pp. 405–6.

line of hills of red sandstone rises, having an easterly dip of 50°, which soon increases to 70° E., and then becoming gradually vertical continues so for more than two miles; the beds here consist of alternating red and grey sandstone, the grey being the hardest, and from its greater power of resistance to the effects of weathering constituting the highest ridges of the hills; the strike is here also from N. to S. On reaching the Delhiji Su, the waters of which are highly saline, the red sandstone rocks which are still vertical suddenly cease, and are succeeded unconformably by low hills of marl full of selenite and horizontally stratified. Still proceeding to the westward, along the line of section, the red sandstone beds with their associated marls and conglomerates again appear about fifteen miles further west, and about two miles east of their junction with the underlying nummulitic limestone. They are here seen dipping west at an angle of 45°, immediately to the west of a great outburst of trap rock, by which they have been probably elevated and broken off; as we ascend the hill the angle of inclination of the red sandstone beds gradually diminishes, until on reaching the summit of the ridge it is almost horizontal.

On descending into the deep gorge of Barsek Dere the beds are again found after a short distance to be almost vertical, evidently forming the western side of a deep synclinal trough. To the north the red sandstone hills are conspicuously seen extending to a great distance, whilst on the line of section they are cut off by the igneous rocks which now become the predominating beds towards Angora.

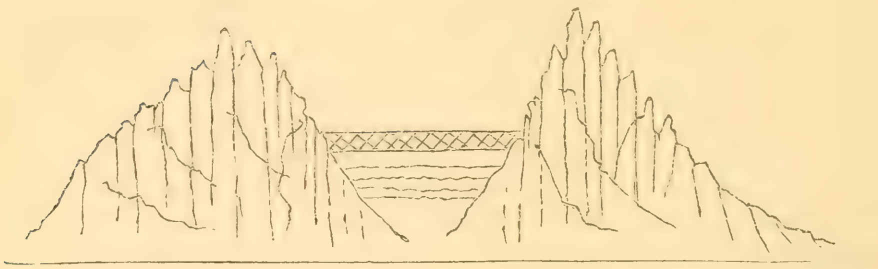
2. *Basins of Rock-Salt, Blue Marl, Sand and Gypsum.*

Although the basins of rock-salt, so far at least as I had an opportunity of examining them, do not occur in immediate connection with the gypseous beds of this formation, I have considered it more correct to class them together on account of the uniform horizontality of both formations, in contradistinction to the upturned strata of the underlying nummulitic and red sandstone beds; and I call this the gypseous formation, although selenite undoubtedly occurs abundantly in some of the red sandstone beds, in order to distinguish it from the underlying unconformable formations.

The rock-salt occurs in small basins in the centre of the vertical beds of red sandstone, the strike of which is north and south, and by which it is entirely surrounded. The salt itself is perfectly horizontal, very hard and compact, and is obtained by blasting it with gunpowder; the thin laminations or strata are slightly wavy and undulating as well as its upper surface. It is overlaid by a thick bed of horizontal blue clay four or five feet thick, over which is another bed of clay, gravel and sand. The position of this salt is certainly very remarkable; it must have been formed not only subsequently to the deposition of the red sandstones, but even subsequently to their having been raised into their present vertical position (see Section fig. 5).

Fig. 5.

Beds of Rock Salt in Red Sandstone.



Nor is it an easy matter to account for its occurrence, for not only is it in a very elevated position, but the basins themselves are too isolated and of too limited an extent, to allow us to attribute the formation of the salt to the evaporation of the water of the ancient sea, on the elevation of these rocks above the surface. A more probable solution is, that these basins became the receptacles of salt springs which flowed into them from the surrounding hills, in which the saline matter may have been chemically produced by the effect of gases entering the red sandstone in consequence of igneous or volcanic agency. Not being a chemist, I throw out this suggestion with much hesitation, but I cannot account for the phænomena in any other way. May we not imagine that muriatic vapours, coming in contact with the soda contained in the felspathic elements of the marls, would enter into combination with that basis and produce the requisite saline matter? I must also observe, that wherever I have had an opportunity of examining the analyses of natural saline springs, I have invariably found that the chlorine or muriatic acid enters into combination with the soda, but not with the potass even when it is present. Thus, whatever may be the opinion of chemists as to the greater affinity of the chlorine for potash than for soda, it would appear that in the great laboratory of nature such is not the case.

The other principal element of this formation consists of a yellowish sandy marl containing numerous masses and crystals of selenite, sometimes passing into distinct beds of sands and clays equally full of similar small crystals. Mr. Ainsworth describes this formation as constituting very extensive uplands, and evidently saw it developed on a larger scale than I did. In the neighbourhood of Vizier Keupri it forms the low undulating hills of the plain, which rest against the older semicrystalline limestone. The low hills which surround the plain of Tchorum also consist of it, containing masses of calcareous marl besides the crystals of selenite. I nowhere had an opportunity of discovering any fossils in this formation.

It also occurs to the west of the elevated and vertical ridge of red sandstone west of Soungourli, where it forms low hills, horizontally stratified, on the left bank of the Delhiji Su. Again, to the south-west of Sevrihissar, after entering the great horizontal formation of Central Anatolia, beds of crystalline gypsum and selenite crop out in the hills of white earthy limestone which there contains a few beds of flint both tabular and in nodules.

3. *Aralo-Caspian Formation?*

Another tertiary formation remains to be described, although from its isolated position, it is impossible to determine its exact relations to the nummulitic and gypseous deposits of the Halys, from which it is separated by the intervening range of the jurassic and cretaceous deposits. It occurs on the promontory of Sinope, and forms the crest of the hill to the north-east of the Greek town (see fig. 1). Here are first seen thin horizontal beds of a loose calcareous sand intermixed with, and overlaid by, hard beds of limestone with a few impressions of shells. This is again overlaid by a bed of shelly limestone twenty or thirty feet thick entirely made up of bivalve shells. The different parts of the bed differ somewhat in consistency, and the shells are in different degrees of preservation, some being hollow and crumbling, while others are more filled up. They appear to belong chiefly to the genera *Cyrena* and *Cardium*. Above this shelly limestone is a hard compact calcareous rock, without fossils, but conformably stratified to those beneath. These beds, and particularly that of shelly limestone, had been extensively quarried by the ancient inhabitants, as appeared from the quarries themselves, and the numerous blocks occurring amongst the ancient ruins.

It was after an inspection of these fossils by Prof. E. Forbes soon after my return to England, that Sir R. Murchison inserted suggestively in his Map of Russia and the surrounding lands, that the limestone of Sinope might prove to be a remnant of his large Aralo-Caspian brackish deposit; and I may here observe, that another instance of the same deposit occurs further to the east at Platana, a few miles to the west of Trebizond. Whether this conjecture be correct or not, or whether this formation ought rather to be connected with the older and purely marine miocene limestone of Southern Russia, more accurate researches can alone determine. The Sinope limestone may possibly indicate a transition from one of these conditions to the other.

4. *White Lacustrine Limestone with Freshwater Shells.*

It only remains for me to say a few words respecting the formation of white earthy, marly limestone which occupies such an extensive area in the centre of Asia Minor, and which I believe to be the most recent of all its formations. It has not inaptly been already called a lacustrine formation, and has been described by Mr. Strickland and myself as occurring in large masses in many of the valleys of Western Anatolia. It overlies that portion which I have described near Sevrihissar as containing selenite, and extends south of Angora and Sevrihissar into the great central district of the Haimaneh, a district corresponding in great measure with the Axylus or woodless country of the ancient geographers (see Strabo). It contains in a few places freshwater fossils, amongst which *Planorbis, Limnæa* and *Paludina* are the most frequent. It occasionally contains nodules of flint, which in some cases in the vicinity of igneous rocks have acquired an opaline character.

I cannot conclude these remarks without expressing my regret that the observations are so desultory and unconnected; at the same time I trust, that until we get the full result of M. Tchihatcheff's more extensive discoveries, they will afford some clue to the complicated geology of this part of Asia Minor; at all events they show the extent to which the different formations have been disturbed by igneous agency at various periods. I look forward with great interest to the publication of M. Tchihatcheff's promised work.

---

2. *On* TYLOSTOMA, *a proposed Genus of Gasteropodous Mollusks.* By DANIEL SHARPE, Esq., F.G.S.

AMONG the organic remains of the beds belonging to the cretaceous system in Portugal are many casts of univalve shells, which have certain common characters entitling them to be classed together and distinguishing them from any described genus. Few of the specimens found retain any portion of the shell, and in no instance was I fortunate enough to find the shell perfectly preserved, so that the specific descriptions are necessarily imperfect; but there are among them materials to show the generic characters nearly complete.

These shells are either globose or ovate, with a spire of moderate elevation, and resembling in form either the *Globiconchæ* or certain *Naticæ* and *Phasianellæ*. The surface is nearly smooth. The mouth is nearly semilunate, with the lips united in a regular curve anteriorly and meeting above at a sharp angle. The outer lip is thickened internally by a callosity which reaches along its whole extent, and which, in some of the species, is slightly toothed: this internal callosity is repeated at regular intervals, which differ according to the species, the most frequent repetition being twice, and the most distant being once in a volution. The inner lip is expanded over the body-whorl, and almost conceals the columella, which is probably solid. At the periods of forming the internal callosity, the form of the mouth is temporarily modified by the outer lip being somewhat constricted, and by the aperture being lengthened at its upper extremity by a gradual rising of the upper edge of the whorl. A little in advance of the callosity the aperture returns to its previous form; the outer lip expands again to its former dimensions, and the top of the whorl slopes down gradually to its former level. Thus, at each of these periods of growth the shell presents an external constriction of the whorl, an internal thickening of the whole extent of the outer lip, and a temporary rising of the upper edge of the whorl. These changes become more marked as the shells increase in age: in the young state, the shells show such slight traces of these peculiarities that they can scarcely be distinguished from species of *Globiconcha* or *Natica*.

The recurrent changes in the level of the upper edge of the whorl give a peculiar unsymmetrical appearance to the spire, by which the shells of this genus may be instantly recognised: in this respect they bear some resemblance to several species of *Ranella*, with which genus, however, there is no danger of confounding them, as they have no canal nor notch to the aperture.

M. D'Orbigny's genus *Pterodonta*, which belongs to a very different family of Gasteropods, presents some strong analogies to the shells before us in having a longitudinal callosity within the outer lip.

These shells are abundant in Portugal in all the calcareous beds of the upper and middle parts of the cretaceous system, and form a most useful guide to the geologist in that country. It is remarkable that they should have been rarely noticed elsewhere. One species is figured without a name in a curious old Spanish work on Organic Remains, 'Apparato para la Historia Natural Española,' by Joseph Torrubia, Madrid 1754; I have in consequence named it after that author. The only other allusion to these shells which I have met with occurs in the 'Bulletin de la Société Géologique de France,' of the 15th of May 1843, vol. xiv. pp. 505–512, where they form part of the subject of a rather warm controversy between M. Charles Desmoulins and M. Alcide D'Orbigny, which I am forced to touch upon, as the subject would otherwise be left incomplete.

M. Desmoulins objects to the genus *Globiconcha*, D'Orb., that it is founded on imperfect specimens belonging in reality to *Dolium*, and states that he possesses specimens of the *G. Marrotiana*, D'Orb., some of which have a longitudinal constriction (*enfoncement longitudinal*) bounding the outer lip, and proving the existence of an internal callosity, followed by an external enlargement of the lip. Other specimens show that the callosity of the mouth is repeated at intervals; and others, that the columella is hollow; while certain of his specimens show that the *G. Marrotiana* has not always the sunk spire represented in the figure of the 'Paléontologie Française,' pl. 170. fig. 1, 2, but has sometimes an elevated spire like that of *G. rotundata*, pl. 167. fig. 17 of the same work.

There can be no doubt, that some, at least, of the specimens thus referred to by M. Desmoulins belong to the genus *Tylostoma*; and if the whole of the specimens mentioned by him really belong to *Globiconcha Marrotiana*, there can be no necessity for a new genus; but the characters of the genus *Globiconcha* must be modified so as to admit the species described in this paper. It is, however, impossible to suppose that so acute an observer as M. D'Orbigny, in describing the genus *Globiconcha*, should have assigned to it a "*labre mince, sans dents*," if it really possessed the more important characters which are found in the genus *Tylostoma*, and that his artist should also have omitted them entirely in the figures. Such an omission might occur with small shells of the size of the *G. rotundata* and *G. Fleuriausa*, l. c. figs. 17 & 18, which might be too young to show the callosity of the lip; but in the larger specimens figured of *G. Marrotiana* and *G. ovula*, pl. 170. figs. 1, 2 & 3, these characters could not have been overlooked by the most inexperienced observer. We must conclude, that M. Desmoulins, in drawing his remarks from different specimens, has confounded together shells of different genera, and applied to *Globiconcha* characters which do not belong to it. This supposition is strengthened by his placing together shells with a sunk and an elevated spire, which are obviously of different species. Unfortunately, M. D'Orbigny's answer in defence of the place assigned to his genus *Globiconcha* in the family of the *Acteonidæ*, is not sufficiently explicit as to its true generic characters to clear up all doubts respecting it.

I have been forced to enter into the above details, to explain why I cannot follow M. Desmoulins in uniting to the *Globiconchæ* the species to be here described: a single remark will explain why they should not be placed in the genus *Dolium*, as proposed by him, namely that they have no canal nor notch to the aperture, and therefore belong to the Phytophagous division of Gasteropoda.

The callosity inside the mouth has suggested the name *Tylostoma* for the genus, from τύλος, *a callosity*, and στόμα, *a mouth*: it may be thus defined:—

Tylostoma. Shell ovate or globose, thick and nearly smooth, with a moderately elevated spire: aperture ovato-lunate, the lips meeting above at a sharp angle; outer lip furnished internally along its whole extent with a thickened edge, which is repeated at regular intervals and accompanied by a temporary lengthening upwards of the aperture; inner lip callous and spread over the body-whorl so as almost to conceal the columella.

Tylostoma Torrubiæ, nobis.

Torrubia, l. c. pl. 10. fig. 4.

Shell ovate, slightly flattened, with a produced spire formed of about 8? volutions; whorls evenly convex. Internal callosity of the outer lip broad and flattened, repeated every half volution, and accompanied with a slight elongation of the mouth upwards.

Length 4 inches; breadth 2 inches in one direction, $2\frac{1}{2}$ inches in the other.

Spiral angle about 65°.

From the thickening of the lip occurring at about every half volution, the shell has somewhat of the flattened form of *Ranella*: in other respects this is less irregular, and shows the peculiarities of the genus less strongly than any of the other species. I have only seen internal casts.

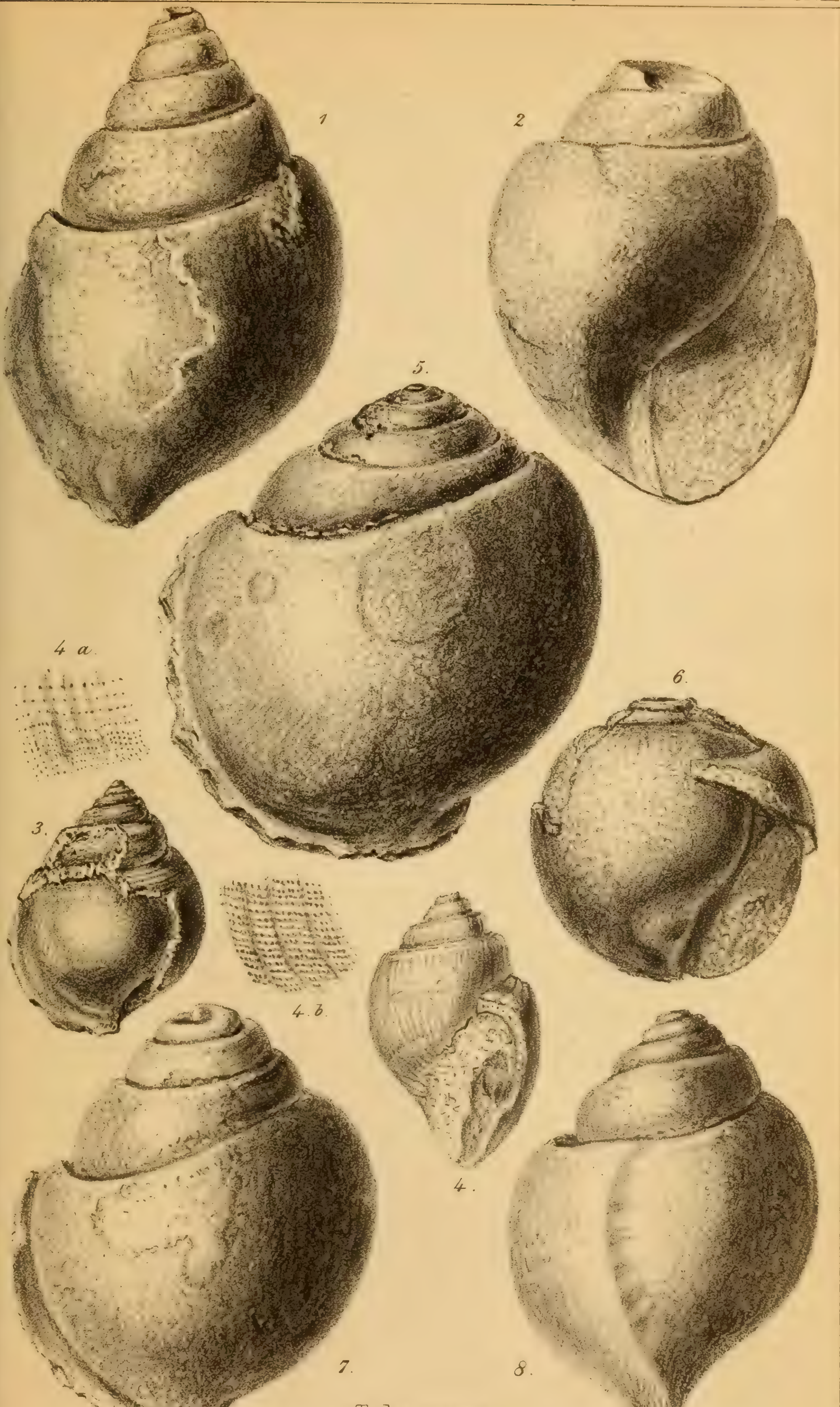
Very abundant in the limestones of the subcretaceous series, in which it has been found at the following localities:—Condeixa; San Fagundo, about $1\frac{1}{2}$ league west of Coimbra; Sarjento-mór, about $1\frac{1}{2}$ league north of Coimbra; Figueira; Mamarosa, on the road from Aveiro to Coimbra; and in the cliffs north of Cintra at the Praia de Maçams.

Plate IX. fig. 1. Internal cast.

Fig. 2. The same on the side of the mouth.

Tylostoma punctatum, nobis.

Shell broadly-ovate, with a pyramidal spire formed of about 6 volutions: whorls convex, tabulated above, giving a step-like outline to



Tylostoma.

Sowerby, del et lith.

the spire. Surface ornamented with numerous transverse rows of minute punctations set in shallow furrows, which are crossed by fine lines of growth: the rows of punctations are rather distant in the upper part of the whorl, but are crowded closely together near its base. Mouth ovate, the upper angle somewhat rounded: outer lip with a very broad, thick, internal callosity, which is repeated once in each volution.

Length $1\frac{1}{2}$ inch; breadth $1\frac{1}{8}$ inch.

Spiral angle about 70°. Sutural angle about 60°.

Abundant in limestone of the subcretaceous series at the village of Sarjento-mór, $1\frac{1}{2}$ league north of Coimbra on the road to Oporto.

To the naked eye this shell appears nearly smooth, and it requires a lens to show clearly the minute punctations which cover it: these closely resemble the markings of *Natica cassisiana*, D'Orb. Terr. Cret. pl. 175. fig. 3, but the shells may be readily distinguished by the more tabulated outline of the Portuguese species.

Fig. 3. A specimen with the shell partly broken off.

Fig. 4. Another specimen on the side of the mouth.

Fig. 4 *a*. Portion of the surface of the upper part of the whorl, magnified.

Fig. 4 *b*. Portion of the surface of the lower part of the whorl, magnified.

Tylostoma globosum, nobis.

Shell globose, with a very short spire formed of about 6 volutions: whorls rounded, nearly smooth, marked only with very faint lines of growth. Mouth narrow: outer lip with a thick subdenticulated internal longitudinal callosity, which is repeated at intervals equal to $\frac{5}{8}$ths of the volution, and accompanied by a considerable rise in the upper margin of the whorl.

Length $2\frac{1}{2}$ inches; breadth $2\frac{1}{4}$ inches in one direction, $1\frac{3}{4}$ inch in the other.

Spiral angle rounded, between 100° and 110°.

Sutural angle varying in different parts of the whorl from 120° to 140°.

Abundant in limestone beds of the subcretaceous series at the following localities:—Figueira; one league west of Montemór velho; San Fagundo, $1\frac{1}{2}$ league west of Coimbra; Sarjento-mór, $1\frac{1}{2}$ league north of Coimbra. Rare in the upper beds of the hippurite limestone on the west side of Lisbon.

Perhaps *Globiconcha rotundata*, D'Orb. Terrains Crétacés, pl. 169. fig. 17, may be the young of this shell before it has begun to form the callosities inside the lip.

Fig. 5. A cast from the subcretaceous beds.

Fig. 6. Another specimen from the same beds, with a portion of the shell preserved.

Tylostoma ovatum, nobis.

Shell broadly-ovate, with a moderately produced spire formed of about 6 volutions: whorls convex: mouth subovate: outer lip with a very thick, subdenticulated, internal callosity, which is repeated at intervals equal to about $\frac{5}{8}$ths of the volution, and is accompanied by a very considerable rise in the upper margin of the whorl.

Length $2\frac{3}{8}$ inches; breadth 2 inches in one direction, $1\frac{3}{4}$ inch in the other.

Spiral angle between 70° and 80°, rounded.

Sutural angle varying in different parts of the whorl from 100° to 130°.

Common in the upper beds of the hippurite limestone on the west side of Lisbon. Abundant in the limestone beds of the subcretaceous series at Condeixa; San Fagundo, $1\frac{1}{2}$ league west of Coimbra; Sarjento-mór, $1\frac{1}{2}$ league north of Coimbra; in the cliffs of the Praia de Maçams near Cintra.

This species is so close to *T. globosum*, that it is doubtful whether they may not be identical; but as we have only the casts to compare, and there is a marked difference in the proportions of the two shells, I have not ventured to unite them. *T. ovatum* is less globose, has a higher spire and a broader aperture than *T. globosum*: there is also less difference of breadth between its two diameters than in the latter shell.

Fig. 7. A cast from the subcretaceous beds.

Fig. 8. A cast from the hippurite limestone.

Notes on Remains of Fossil Reptiles discovered by Prof. Henry Rogers *of* Pennsylvania, U.S., *in Greensand Formations of* New Jersey. By Professor Owen, F.R.S., F.G.S. &c. &c.

[Abstract of paper read January 31st; see p. 329.]

The paper descriptive of the series of fossils submitted to me in November 1848 by Prof. Rogers, and read at the meeting of the Society on the 31st of January 1849, has been unfortunately lost; the rough notes taken on the inspection of the fossils have likewise been mislaid, and I am compelled, therefore, in order that the benefit designed by Prof. Rogers to English palæontologists, by bringing over the above collection of rare and valuable instructive fossils, should not be wholly lost, to give now such notes as my restricted leisure will permit of the specimens which have been selected for the subjects of Plates X. & XI.

Figures 1 to 4, in Pl. X., are of cervical vertebræ of a Crocodile or Alligator, constructed upon the same (procælian) type as those of the existing species: *i. e.* having the anterior surface of the body or centrum concave and the posterior one (*c*, figs. 1 & 3) convex.

The numerous vertebræ, cervical, dorsal, lumbar and caudal, of this type, brought over by Prof. Rogers, were divisible into two series; and one of the most characteristic specimens of each of these series is here selected to illustrate the difference, which shows that there were two species of the same genus as the modern Crocodiles or Alligators, which left their remains in the greensand deposits of the United States. The vertebra in question is one of the middle cervical, probably the fourth or fifth, in which the parapophysis (*p*) is still near the lower part of the side of the centrum, the diapophysis (*d*) wholly developed from the base of the neurapophysis (*n*), and in which also a hypapophysis (*hy*) is developed from the under surface of the centrum.

The most marked difference between the vertebræ figs. 1 & 3 is presented by the latter process: in fig. 1 it is double, or divided by a median longitudinal cleft; in fig. 2 it is single, broad, flattened and smooth below. These characters are well and accurately shown in the figs. 2 & 4 of the inferior surface of the vertebræ selected. A corresponding modification of the hypapophysis was presented by other cervical and anterior dorsal vertebræ of each series respectively. But the specific distinction of the two is manifested by other characters. The cervical vertebra, figs. 3 & 4, is longer in proportion to its breadth than figs. 1 & 2: the parapophysis, *p* in fig. 1, comes off from the middle of the side of the centrum: in fig. 3 its origin is more advanced, and extends to the border of the anterior articular cup. And these characters were not those distinguishing different positions of the vertebræ in the same cervical series, any more than those of the hypapophyses, but were characteristic of the other cervical vertebræ of each series respectively.

Two species therefore, of Crocodile or Alligator, were thus established, equalling in size the existing *Alligator lucius* of the Southern States, or the *Crocodilus acutus* of Jamaica.

Neither these, nor any other existing Crocodile of which I have had the opportunity of examining and comparing the vertebræ, presents the same characters of the hypapophyses which have been described and figured in the above fossil vertebræ. I regard the species, therefore, to which these vertebræ respectively belonged as extinct, and agreeably with actual knowledge, the oldest of the modern Crocodilian family.

For the species characterized by vertebræ of the type of that depicted in figs. 1 & 2, I propose the name of *Crocodilus basifissus*; for the species with the inferior process single, short and flattened, that of *Crocodilus basitruncatus*: these specific names refer, of course, to the characters of the basal or inferior process (hypapophysis): as the names *Lamna gracilis*, *Otodus obliquus*, &c. relate, not to the proportions or direction of the whole body of the sharks so-called, but of that part which is most characteristic of the extinct species, and most commonly found in the fossil state. It is interesting to observe that the same kind of modification varies the hypapophyses of the cervical centrums of these Crocodiles, as the corresponding processes from the centrum of the last cranial vertebra of the reptiles figured in figs. 6 & 7, Pl. X.

The proportions of the vertebræ of the *Crocodilus basifissus* resemble those of the vertebræ of the *Alligator*: the longer vertebræ of the *Crocodilus basitruncatus* seem to me to have belonged rather to a true Crocodile: in neither species are they so long and slender as the corresponding vertebræ of the Gavials or long-nosed procælian Crocodiles.

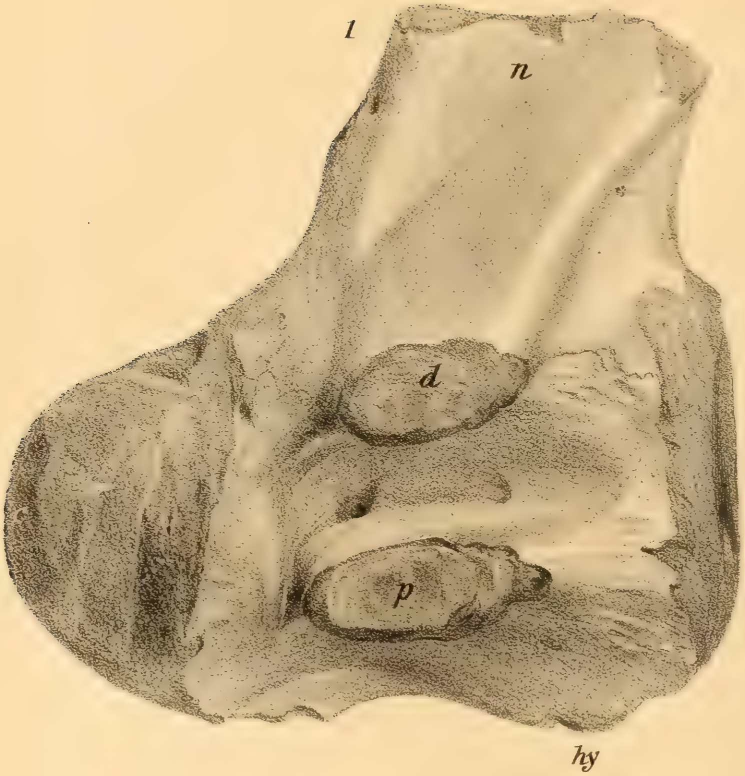
The vertebræ figs. 1–6, Pl. XI., also appertain to the procælian type, and in the degree of the anterior concavity and posterior convexity of the centrum most resemble the vertebræ of the *Mosasaurus*. They are, however, longer and more slender: the character of the caudal vertebræ of the *Mosasaurus*, with their anchylosed hæmal arch, is well-known and sufficiently marked. That the vertebræ in question have not formed part of a tail of a reptile, is shown by the entire absence of hypapophyses as well as hæmapophyses from the under surface of their centrum (see fig. 2); from the side of which, however, a large transverse process, probably a parapophysis (*d*, fig. 1), has projected. That they had not come from the cervical or abdominal regions of the spine of the Mosasaur was satisfactorily proved by examples of vertebræ of the true *Mosasaurus Maximiliani*, from both those regions of the body, which were obtained by Prof. H. Rogers from the same deposits and locality, and formed part of the collection compared. The difference in the forms and proportions of the vertebræ in question with corresponding ones of the *Mosasaurus* having diapophyses from the sides of the centrum, and no hypapophyses, is so great, that I cannot refer them with any probability to the same *genus*: they might belong to the Mosasauroid genus *Leiodon*; but in the absence of the confirmatory evidence of the teeth, it seems preferable to refer the vertebræ in question to a new genus, which I propose to call '*Macrosaurus*,' from the length of the body indicated by the proportions of the vertebræ. I have no doubt, however, that it appertains to the Mosasauroid family of Lacertian reptiles, not to the procælian Crocodilia.

The remains of the true Mosasaurus in Prof. H. Rogers's collection included teeth, numerous vertebræ, bones of the extremities, and the characteristic part of the cranium figured in Pl. X. fig. 5. The teeth and the vertebræ showed the species to be identical with that so well defined from the European *Mosasaurus Hoffmanni* by Prof. Goldfuss, under the name of *Mosasaurus Maximiliani*. The lacertian affinities of this singular genus of gigantic Sauria are well illustrated by the basioccipital, Pl. X. fig. 5—a bone of the cranium of the Mosasaur which has not before been described or figured. It presents, as in other Sauria, a convexity towards the atlas, but sends downwards from its under surface two diverging hypapophyses—a character met with only in the Lacertian Sauria, and not in any of the Crocodilians. The difference between the Crocodilian and Lacertian Reptiles in this respect will be understood by comparing the figure of the basioccipital of the Iguana (Pl. X. fig. 6) with that of the same bone in the Alligator (fig. 7), in which, as in the Crocodiles and Gavials, the occipital hypapophysis is a single, broad and thick process.

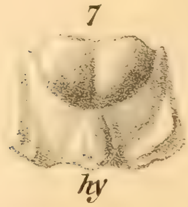
I regret much the loss of the MSS. containing the results of a very careful study of the rich series of Mosasaurian fossils kindly submitted to my examination by Prof. Rogers: they are alluded to by Sir H. De la Beche in his 'Anniversary Address,' p. 27, where he quotes one of the remarks relative to certain metacarpal or metatarsal and phalangial bones, viz. that "they indicate the extremities of that great Saurian to have been organized according to the type of the existing Lacertia, and not of the Enaliosauria or marine lizards."

I conclude this unavoidably brief account of the greensand saurian fossils by a notice of the very remarkable and well-defined form of amphicælian vertebra figured in Pl. XI. figs. 7—10. The subjects of these figures are two vertebral centrums from the anterior part of

1

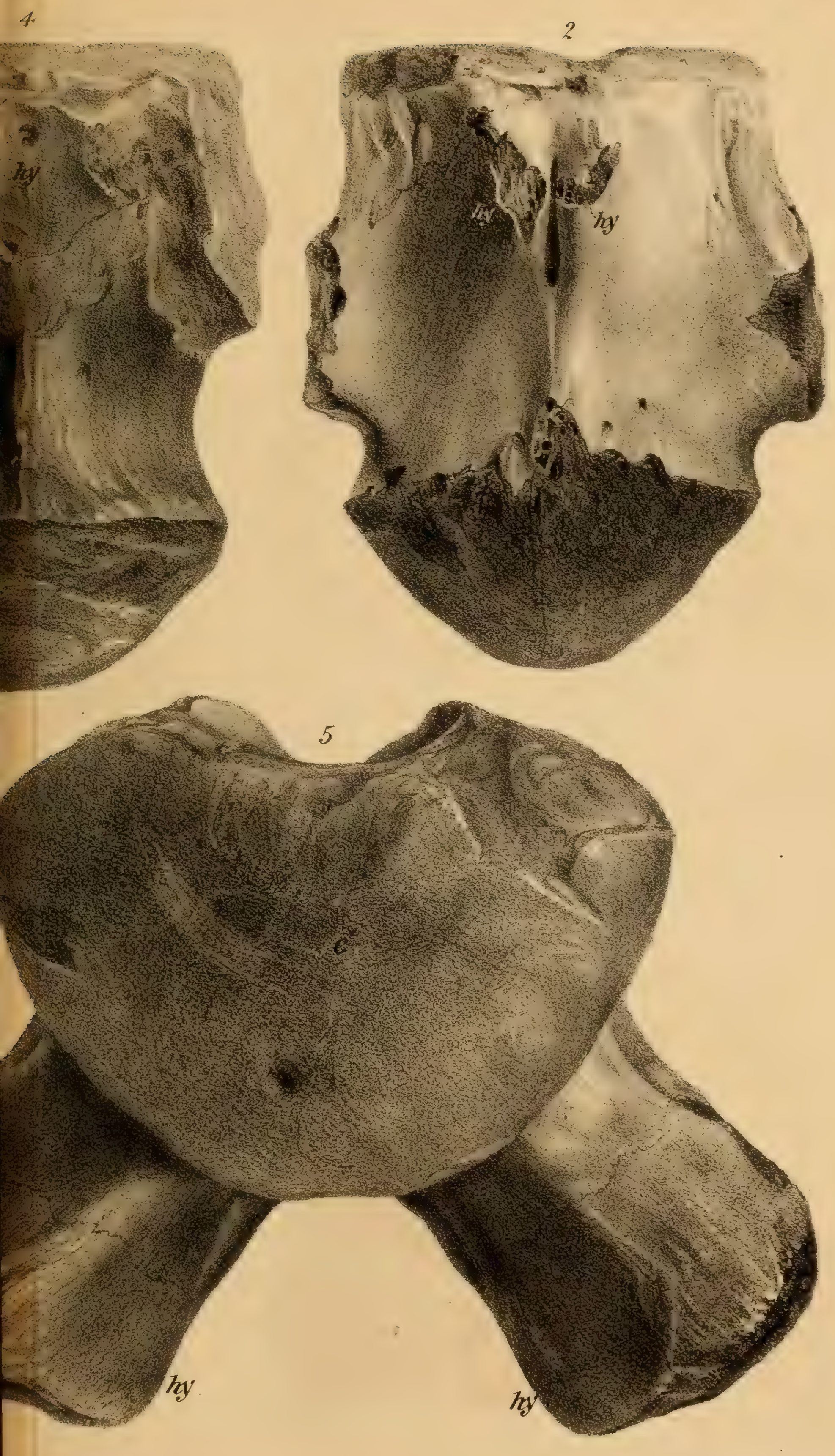


7



6

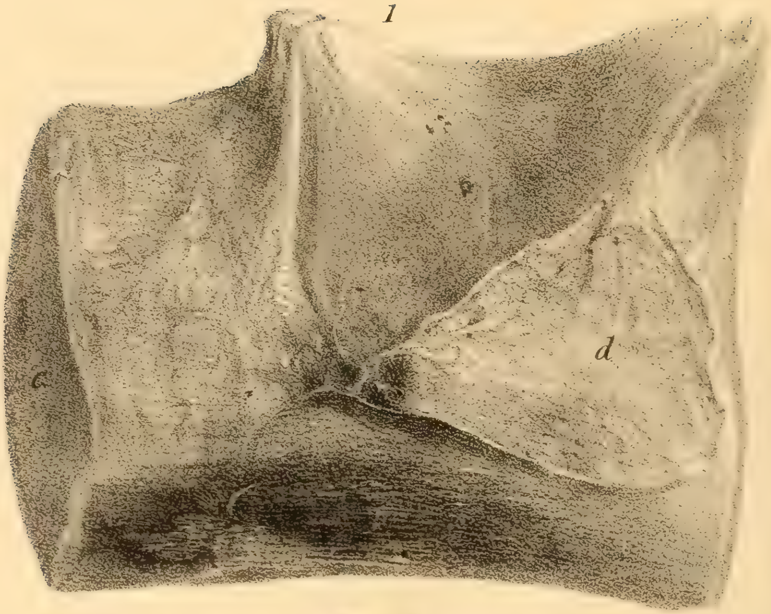
3



Day & Son, lithrs to the Queen

Day & Son, lith.rs to the Queen

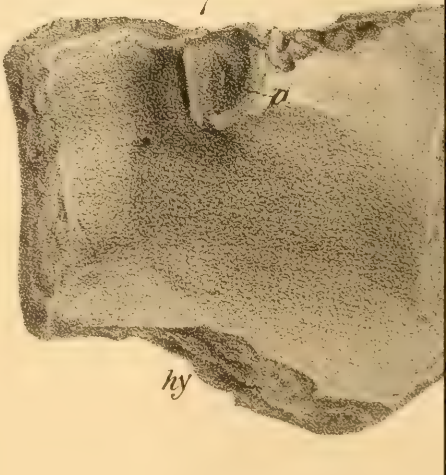
1



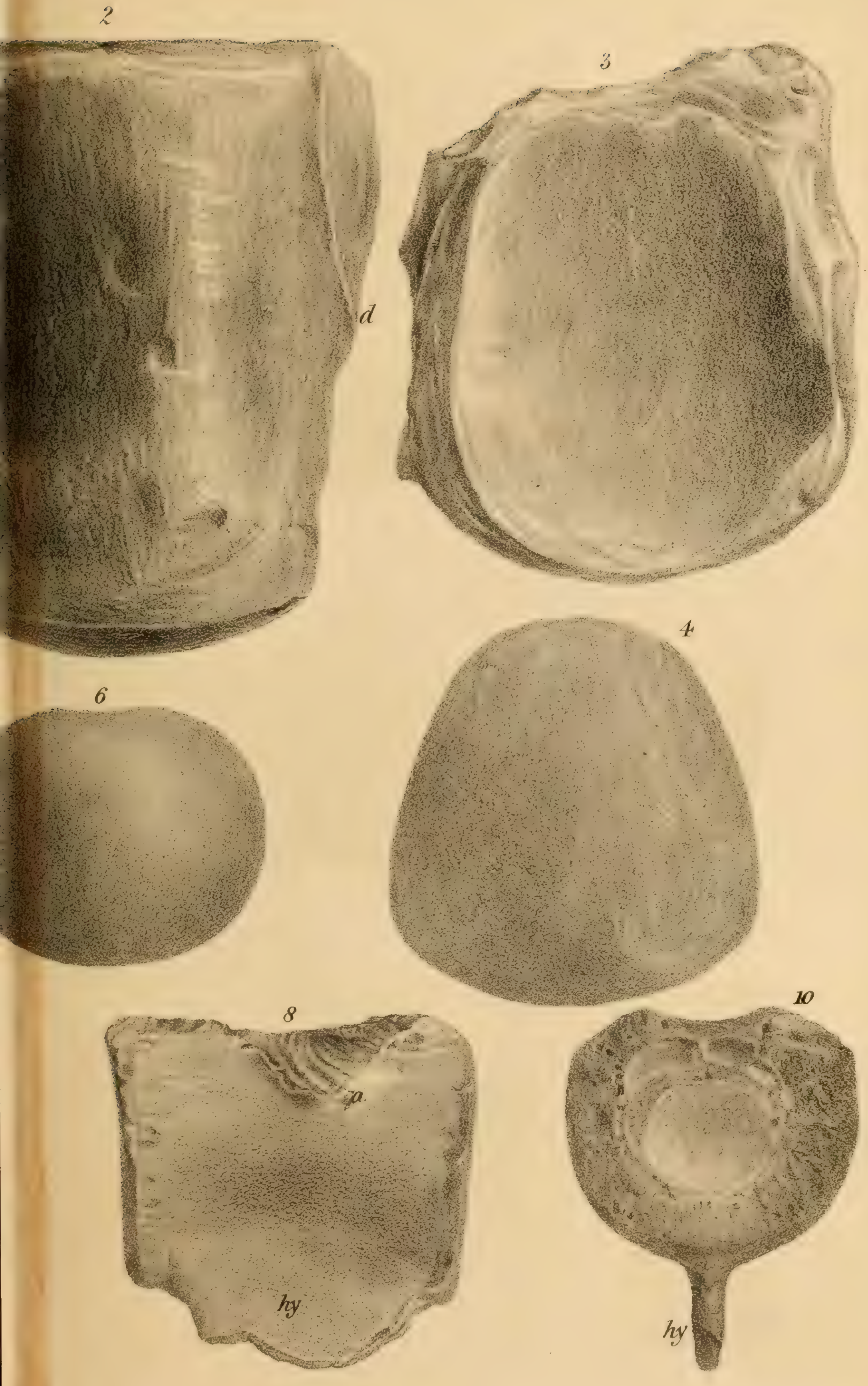
5

9

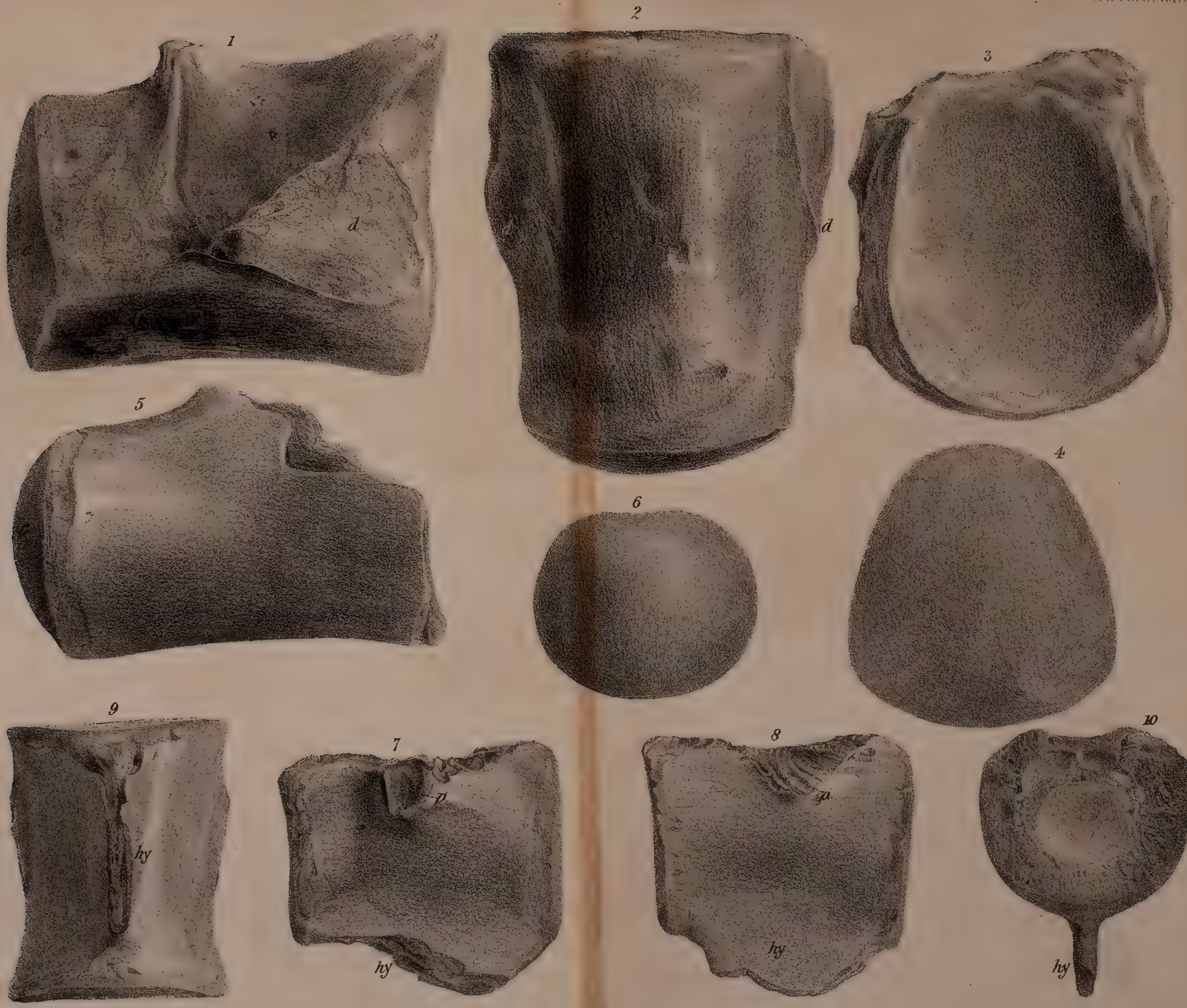
7



J. Erxleben del. et lith.



Day & Son. lith^rs to the Queen.



J. Erxleben, del. et lith.

Day & Son, lithrs to the Queen.

the thoracic region, in which the parapophysis (*p*) has ascended to the upper border of the side of the centrum, whilst the hypapophysis (*h*) still continues to be developed from the lower surface of the centrum. The peculiar and distinctive character of these vertebræ is shown in the large size, and especially the great antero-posterior extent of the hypapophysis. Its base occupies the whole extent of the median line of the inferior surface between the prominent borders of the anterior and posterior articular ends of the centrum; and the length of this large lamelliform hypapophysis seems to have been considerable, since, in the vertebra, figs. 8, 10, in which upwards of half an inch of its base is retained, there is little diminution of thickness at the fractured surface.

The degree of concavity of the two articular extremities of the centrum corresponds with that in the *Teleosauroids*, to which family of amphicælian *Crocodilia* these vertebræ are referable. They indicate, however, a particular genus in that family, of which, from their stratum, it would seem to be the latest representative; and I propose the name *Hyposaurus* for this *genus*, in reference to the characteristic process—the hypapophysis, and suggest that the species, when its characters are more fully worked out, should be called after the distinguished and amiable geologist to whom we are indebted for our knowledge of the existence of such a Teleosauroid in the cretaceous æra.

DESCRIPTION OF THE PLATES.

PLATE X.

Fig. 1. Side view of the third or fourth cervical vertebra of the *Crocodilus basifissus*.
Fig. 2. Under view of the same vertebra.
Fig. 3. Side view of the corresponding vertebra of the *Crocodilus basitruncatus*.
Fig. 4. Under view of the same vertebra.
In all these figures, *c* is the centrum, *hy* the hypapophysis, *p* the parapophysis, *d* the diapophysis, *n* the fractured base of the neural arch.
Fig. 5. Back view of the basioccipital bone of the *Mosasaurus Maximiliani*: *hy*, its hypapophyses.
Fig. 6. The same view of the basioccipital of an Iguana.
Fig. 7. The same view of the basioccipital of a young Alligator.

PLATE XI.

Fig. 1. Side view of a cervical or anterior abdominal vertebra of the *Macrosaurus lævis*.
Fig. 2. Under view of the same vertebra.
Fig. 3. Anterior concave articular surface of the same vertebra.
Fig. 4. Posterior convex articular surface of the same vertebra.
Fig. 5. A smaller vertebra of the same species.
Fig. 6. Posterior convex articular surface of the same vertebra.
Fig. 7. Side view of the centrum of an anterior dorsal vertebra of the *Hyposaurus Rogersii*.
Fig. 8. Side view of a succeeding vertebra of the same species.
Fig. 9. Under view of the vertebra fig. 7.
Fig. 10. Posterior subconcave articular surface (partially mutilated) of the vertebra fig. 8.
In all these figures *d* is the diapophysis, *p* the parapophysis, and *hy* the hypapophysis.
In both Plates the figures are of the natural size.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

April 1st to June 30th, 1849.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

American Journal of Science. Second Series, vol. vii. nos. 20 and 21.

——— Philosophical Society, Proceedings. Vol. v. no. 41.

Athenæum Journal, April to June.

Berwickshire Naturalists' Club, Annual Address, 1848.

Cornwall Polytechnic Society (Royal), Annual Report, 1848.

France, Société Géologique de, Bulletin. Deux. Série, tome iv. f. 79–86; and tome vi. f. 11–18.

Geological Survey of the United Kingdom, Memoirs of the. Figures and Descriptions of Fossils, Decade 1.

Indian Archipelago, Journal of the. Vol. iii. nos. 1–5.

Mining Almanack for 1849.

Munich Academy (Royal), Abhandlungen. Vol. v. part 2; Bulletin, nos. 1–52, 1848.

Muséum d'Histoire naturelle, Archives. Tome iv. liv. 3.

Philosophical Magazine, April to June. *From R. Taylor, Esq., F.G.S.*

Yorkshire, Geological and Polytechnic Society of the West Riding. Reports of the Proceedings, 1847–8.

Zoological Society, Transactions, vol. iii. part 6; Proceedings, nos. 181–189; Annual Report, 1848.

Zurich, Naturforschenden Gesellschaft in, Denkschrift zur Feier des hundertjährigen Stiftungfestes, November 1846; Mittheilungen, Heft 1 & 2; Meteorologische Beobachtungen augestellt auf Veranstaltung, 1837–1848.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Berger, Reinholdus. De Fructibus et Seminibus ex Formatione Lithanthracum.

Buckman, James. An Essay on the former Marine Conditions which separated England and Wales.

Dana, James D. Notes on Upper California.

———. Review of Chambers's Ancient Sea Margins.

Darwin, Charles. Geology, from the Manual of Scientific Inquiry.

Delaunay, M. Conjecture sur la cause de la Chaleur centrale du Globe terrestre.

Deville, Ch. Ste. Claire. Voyage géologique aux Antilles et aux Iles de Ténériffe et de Fogo. Liv. i. & ii.

D'Orbigny, Charles. Classification et principaux Caractères minéralogiques des Roches.

———. Description sommaire des divers Terrains qui constituent l'Ecorce terrestre.

Élie de Beaumont, L. Note sur les Emanations volcaniques et métallifères.

———. Note relative à l'une des causes présumables des Phénomènes erratiques.

Encyclopædia Metropolitana. Part 54, Mineralogy, by H. J. Brooke; and Part 55, Geology, by Prof. J. Phillips. *From Prof. J. Tennant, F.G.S.*

Falconer, Hugh, M.D. and Capt. P. J. Cautley. Fauna Antiqua Sivalensis. Illustrations to parts 7, 8 & 9.

Faraday, M., D.C.L. Experimental Researches in Electricity (22nd Series), 1848.

Favre, Alphonse. Notice sur la Géologie du Tyrol Allemand.

Frodsham, Charles. A few Remarks upon the Aneroid Barometer.

Gibbes, R. W., M.D. Monograph of the Fossil Squalidæ of the United States.

Goeppert, H. R., M.D. Zur Flora des Quadersandsteins in Schlesien.

———. Fossile Hölzer gesammelt während Middendorffs' Sibirischer Reise.

———. Ueber Beobachtungen der in der älteren Kohlenformation zuweilen in aufrechter Stellung vorkommenden Stämme.

———. Ueber pflanzenähnliche Einschlüsse in den Chalcedonen.

———. Bericht über eine in den preussischen Rheinlanden und einem Theile Westphalens unternommenen Reise zum zwecke der Erforschung der fossilen Flora jener Gegenden.

Goeppert, H. R., M.D. Auszug aus der Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Kultur im Jahre 1839, 1843, 1845 und 1847.

Humboldt, Alexander von. Cosmos. A Sketch of a Physical Description of the Universe, 2 vols. *From Dr. G. A. Mantell, V.P.G.S.*

Jobert, A. C. G. Ideas, or Outlines of a New System of Philosophy. Essay the 2nd and last.

Leonhard, Dr. K. C. von, und Dr. H. G. Bronn. Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde, 1840–43. *From Sir Roderick Impey Murchison, V.P.G.S.*

Logan, W. E. Geological Survey of Canada. Report on the north shore of Lake Huron, 1849.

Lubbock, Sir J. W. On the Theory of the Moon. Part 7.

Lyell, Sir Charles. A Second Visit to the United States of North America. 2 vols.

Nattali, M. A. Catalogue of Books for 1849.

Nicol, James. Manual of Mineralogy.

Petermann, Augustus. On the Depression of the Dead Sea, and on the Fall of the Jordan, as compared with that of British Rivers.

Pissis, M. Mémoire sur les Rapports qui existent entre la configuration des Continents et la direction des Chaînes de Montagnes.

THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE FIFTH.

1849.

PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On Altered Tertiary Rocks near CAIRO.

THE following remarkable case of metamorphosis in rocks adjoining the alluvial land of Lower Egypt is well deserving the attention of geologists, from the difficulty of assigning the cause or causes to which the change of structure in so modern a sedimentary deposit can be ascribed. It appears from Russegger's geological map of Egypt, that the nearest igneous rock is seventy miles distant, on the southern flank of the mountain Dschebel Arcidy, on the border of the Gulf of Suez, in the parallel of the town of Benisuef on the Nile.

[L. H.]

[From Russegger's Reisen in Europa, Asien und Afrika, B. i. s. 272–277.]

"North-east from the Mokattam * the coarse limestone beds are covered by a sandstone, consisting of a mixture of fragments of quartz, agate, flint, chalcedony, hornstone and flinty slate, with a pretty uniform grain, and of considerable hardness. It contains a few marine organic remains, and, in my opinion, is an ancient marine diluvium. This sandstone forms in general a plateau, with low flat-topped hillocks, but rises here and there into groups of hills, the height of which however is inferior to that of the Mokattam. It is the prevailing rock throughout the whole Isthmus of Suez, and on the coast it is overlaid by a recent marine formation. This sandstone contains siliceous concretions, and also fragments of fossil wood, which is converted wholly into silica.

"In several places this rock exhibits some remarkable alterations of structure, which, at first sight, one is almost convinced must have been occasioned by volcanic action. The grains of the sandstone appear agglutinated, as if changed into the state of a frit; the mass appears penetrated throughout by pure siliceous matter, which gives it a homogeneous structure, until at last it acquires the aspect of a hornstone passing into an obsidian, with a flat conchoidal fracture and a ringing sound when struck, like phonolite. This altered rock is in parts remarkably beautiful, exhibiting all manner of colours, with a lustre between greasy and vitreous. The included nodules appear

* A hill composed of nummulite limestone and other tertiary sedimentary rocks, near Cairo, rising to a height of 430 feet above the Mediterranean.

little changed, except that at their exterior they appear to melt into the surrounding mass. The rock has a remarkable resemblance to those sandstones which have been long exposed to a very great heat in a blast-furnace or glass-house, so that even the pure quartz and substances related to it have undergone a slight degree of fusion.

"This fritted and half-molten sandstone covers a large area in the desert, and entire hills are composed of it. Moreover, we meet with this appearance not only in the diluvial sandstone district of Lower Egypt, but likewise in the tertiary sandstones of Upper Egypt, in the red sandstone of Mount Sinai, in the tertiary variegated red sandstone of Nubia, and, with the exception of Lower Egypt, frequently in the vicinity of outbursts of unstratified rocks, such as granite, porphyry, trachyte, &c. It is this last circumstance especially which, on viewing this remarkable appearance, suggests the idea of volcanic action; for we conclude, and to a certain extent must necessarily conclude, that heat was the agent in the formation of the above-named crystalline rocks. Nevertheless we come to places where one must have a strong prepossession in favour of igneous action to be able to discover any trace of volcanic agency. When we meet with exactly the same appearances in the widely extended plains of the desert, far distant from the above-named unstratified rocks, without a trace of any elevation, any fissure, or any outburst, we naturally ask, where can the focus of volcanic action have been?

"It seems then that in this case we have to do with two powers, which although essentially different, have in different ways produced the same effects,—have given rise to the same appearances. The one of these, *volcanic action*, caused by the vicinity of crystalline rocks, in connection with their eruption; the other, a separation of the siliceous matter in the sandstone, and an after-precipitation of it in certain places, causing the particles of the sandstone to assume a more or less homogeneous structure,—an action similar to that which gives rise to siliceous concretions. There is however this difference in this last process, that the concretions are constituted of the precipitated material only, and form a simple mineralogical body; whereas the concretions in the case in question present the appearance of the particles of the precipitated matter, not combining with each other only, but mixing up with the unaltered and altered constituents of the rock in which the process has taken place, forming a new body, a newly compounded stone, which becomes more homogeneous the greater the action of the precipitated material, both in amount and in effect.

"Which of these two ways nature chose in each particular case I will not venture to decide, and I therefore undertake only, as often as this appearance presents itself, to describe the circumstances of each locality in detail, leaving to those who are not contented with knowing the facts only, to deduce from them such hypothesis or theory, or by whatever name they choose to call it, as they may feel inclined.

"One of the most remarkable places where this vitrified sandstone may be seen is the Dschebel Achmar (the red mountain) north of the Mokattam, and separated from it by a defile. This hill may be seen to the right of the road from Cairo to Abus-abel, rising in a sharp broken outline to the height of 360 Paris feet above the Mediterranean. In this hill there are some distinct traces of a volcanic eruption: even as seen from a distance it is distinguished by its conical shape, and it is also remarkable by the strong contrast of its brownish-red colour with the pale yellow of the desert. Dschebel Achmar is wholly composed of vitrified sandstone, and forms a distinct group of conical hills. In the midst of these there is a wide crater-like hollow, the bottom of which exhibits great inequalities, and which has openings on the N.W. and S.E. The chief group, which encloses the crater, if it can be so called, has a circumference of nearly 4000 fathoms (*klafter*) = $4\frac{1}{2}$ miles. In the bottom of this crater there are several holes, how deep I know not, which are perhaps rents in the rocks, that played an important part in the eruption, if there ever was one. The walls of these sloping cracks are completely vitrified; and to suppose that to have been produced or even helped by artificial means is out of the question. One of these clefts is still open to a considerable depth, and then ends in broken masses. From Dschebel Achmar many similar conical hills may be seen, but none of them equal to it in extent. It really appears as if the whole ground under the strata of coarse limestone of the Mokattam had been in a state of volcanic activity; that the molten mass had burst through in several places and overflowed at the surface, causing new secondary fusions and metamorphoses of the rocks. For besides the vitrified sandstone on Dschebel Achmar, we see several kinds of stone which have all the appearance of being nothing else than the rocks of the Mokattam, vitrified and half melted. We see there, in short, the sand of the desert, melted and in the state of frit, as well as the diluvial sandstone of the isthmus. We see the sandy iron-shot clay that lies between the siliceous limestone and the superior nummulite limestone, burnt and melted. We see melted and vitrified siliceous limestone, vitrified white earthy limestone, and also melted nummulite limestone, with its included nodules and fossils wholly changed by the fire. We found in the half-melted iron-shot clay some fossil wood, quite similar to that commonly occurring in the Mokattam and its neighbourhood, but entirely converted into hornstone; also a white granular quartz in the state of a frit, probably a melted lower bed of sandstone; and lastly, we found some basalt-like rocks, but without olivine, and consequently their basaltic nature is certainly doubtful; and these rocks appear to rise from a considerable depth, for I never saw them resting on the ground.

"If, taking into account what has just been said, I consider the appearances which the localities present, the finding all the rocks of the Mokattam, but in an altered condition, and not, as it would seem, by the action of fire; if further I consider, not so much the area which is occupied by these remarkable rocks, but their mass, the fissures in the crater-like hollow with vitrified sides, and such like, I cannot, on the one hand, believe that there is nothing more in all this than concretionary formations of the siliceous material; and still less can I believe that it is the effect of formerly-existing thermal springs, now dried up. But, on the other hand, there are wanting many of those criteria of extinct volcanic action which would lead me to lean with confidence to the side of an igneous origin; for with the exception of the few loose fragments of a basaltic rock, I miss every product of extinct or active volcanos; I see no lava, not one of the so-called plutonic rocks. I miss a distinct undoubted crater, all lava-streams, &c.; in short, the agreement with any one of the volcanos I have since seen, either in respect of the nature of the rocks or the structure of the soil; in fine, of the whole *habitus*. Are the appearances to be explained by supposing the rocks to have been altered by hot vapours? by the action of some principle similar to that which in the island of Milo has changed clay into porcelain jasper?

"I believe that I ought to call upon every geological traveller who visits the land of the pyramids not to omit to visit Dschebel Achmar. As far as I know, I am the first who has examined it with reference to science; but I am by no means convinced, and I say so with perfect sincerity, of the soundness of my conclusions; and of this he will be able to judge, who, free from prejudice, will investigate the phænomena on the spot."

Contributions to the Flora of the Brown-Coal Formation. By Prof. Göppert.

[From Arbeiten der Schlesischen Gesellsch. 1847, p. 74.]

In the year 1839 I examined some of the bituminous wood found in the brown-coal formation in various districts of Northern Germany*, and at that time described two species (*Pinites Protolarix* and *Taxites Ayckii*), which, from the width of their distribution, seemed to me peculiarly deserving of attention. More recently, in the work published conjointly with Dr. Berendt in Danzig, on the vegetable remains found in amber, I collected a flora, comprising fifty-four species, which in regard to the genera could not be distinguished from that of the brown-coal; although no brown-coal beds containing amber in its natural position have yet been certainly pointed out. The amber which I formerly thought I had discovered in the brown-coal at Muskau is nothing more than Retinasphalt. I now possess a small stem covered with the bark, on which the resinous exudation appears in drops, and many other fossil coniferæ, among them even Taxineæ, show the same appearance, but none of them, so far as I know, such an abundance of resin as the small stems and the fragments of wood in my collection which produced the amber. These I have figured and described in the work mentioned above, and they have been seen by a great number both of German and foreign naturalists. At present they must be regarded as the only remains which give us any certain knowledge of the existence of at least one tree producing amber, although I have no doubt that there were several.

* See a paper 'On the bituminous and petrified wood recently discovered in the basaltic tufa of the high Seelbachkopfe near Siegen, with remarks on the brown-coal formation generally,' in Karsten and v. Dechen's Archiv, vol. xiv. p. 182 etc.

Dr. Thomas, to whom I am indebted for many interesting contributions to my inquiries, having chemically examined several remains of wood from the brown-coal deposits of the Samland, and found succinic acid in them, considers that these trees must also be added to those producing amber, and that these deposits generally must be regarded as the place in which this substance originates. I would however remark, that this fact alone cannot be considered as sufficient proof, since succinic acid occurs as a product of oxidation of many kinds of wax or fats, in many deposits of brown-coal, and even in the resin of still-existing coniferæ and several other plants, as in wormwood and lettuce. The actual occurrence of amber in the wood or the layers of bark can alone prove decisive, and justify us in regarding a fossil as belonging to a tree producing amber. But even were the original bed containing the amber-tree actually discovered on the coast of Prussia, and that it may be so I have the less reason to doubt, from having never visited the place myself, still the numerous facts collected by my respected coadjutor, proving the wide drifting of the amber by floods in the districts round the Baltic, lose nothing of their value, and I can now only confirm their truth from many observations which I have either made personally in Silesia and the Lausitz, or obtained from others*. In not one of the many brown-coal beds opened in our province has amber ever occurred, but always in the undoubted drift deposits (*in rein aufgeschwemmtem Lande*) above them, generally very near the surface, in sand or loam-pits with many boulders, and, as very lately above the brown-coal bed at Schwiebus, with fragments of friable wood rounded on all the corners like drift-wood, such as I never saw in our brown-coal deposits. The number of localities in both provinces known to me at present amounts to *ninety*. I confine myself in these, as in all similar cases, entirely to observations on which prejudice can have no influence, as I do not consider myself qualified to decide on geognostic and geological questions; but I entreat geologists not to neglect such observations, especially at present, when there seems a disposition unconditionally to recognise our brown-coal deposits as the native place of the amber. I have only interfered with this question so far as, from the existing materials, considered in a purely botanical point of view, I have endeavoured to show, what hitherto had not been done, that there existed at least one amber-bearing tree; and at the same time, from the other enclosed vegetable remains, to construct a picture of the co-existing flora. A solution of the still unsettled problem of the original repository of the amber I leave to geologists. Almost the whole of the specimens of the amber-tree in my collection mentioned above show distinct traces of having been drifted.

Continually occupied with the examination of the bituminous wood found in the brown-coal deposits of Northern Germany and the Rhine, I shall annex to these observations a few of the results obtained.

1. The predominance of Coniferæ seems very remarkable. Among 300 specimens of bituminous wood collected in the Silesian brown-

* Julius Müller in der Allgem. Naturhist. Zeit. von Sachse, vol. i. 2 Heft.

coal deposits alone, only a very few (*nur ein paar*) other kinds of dicotyledonous wood occur. This seems the more remarkable, since in many places leaves of dicotyledonous trees with deciduous foliage have been found in the clays of the brown-coal formation, and yet in the coal-beds the trees on which we may suppose them to have grown are wanting. This might be regarded as indicating a formation from drift-wood, but the following considerations are opposed to this view.

In the brown-coal beds at Blumenthal near Neisse, wood of deciduous trees occurs along with twigs and fruits of a Taxus and Cupressinea; amongst the trees only Taxus and Cupressinea, with no trace of any other kind of dicotyledonous tree. This seems an important fact, as perhaps leading to an explanation of this remarkable phænomenon. I believe that during the process of maceration and decomposition, to which the vegetation of the brown-coal forests was subjected before it was buried between layers of earth and protected from atmospheric influences, the deciduous-leaved trees lost their organic connection sooner than the highly resinous wood of the coniferæ, and hence fell to pieces, whilst the latter were for the most part preserved,—a view, so far as I know, in harmony with the result of experience on the duration of these kinds of wood in similar circumstances. I throw out this however only as a conjecture, which may perhaps be subsequently confirmed by an examination of different brown-coal deposits.

2. The number of species is on the whole very small in comparison with the enormous mass of brown-coal they have contributed to form, from which we may conclude that the coniferæ of the ancient world had a similar gregarious mode of growth with those that now flourish on the earth. To prove this in certain beds, even for single species, I collect as many specimens of different trunks or fragments of bituminous wood as are to be found, and then examine them. From this the predominance of certain species at once appears, and though it may be justly remarked that several fragments of one and the same tree may often occur, still frequent repetition of this somewhat laborious process at last enables us to obtain a result approaching nearly to certainty.

3. The fossil species are remarkably distinct from those of the present coniferous flora of northern Germany; few resemble our *Pinus Abies* and *Picea*, and I have hitherto only found a single species with the structure of *Pinus sylvestris*, or generally of the genus Pinus as limited by Richard and Link; the greater part agree with Cupressinea, if we may judge from the smooth bark of the larger stems, the sharply-defined annual rings, the small number of cells contained in a medullary ray, although there are exceptions to this rule; whilst the predominance even quantitatively of the form of Taxus, of which I can well distinguish at least four species, is remarkable. Among them are species of which the wood, formed of cells with thick walls, is denser and more compact than that of the existing Taxus; but also one species of uncommon lightness and with large cells, similar to the wood of the North American *Taxus montana*, Nutt., or *Torreya taxifolia*, Arnott. My present as well as former researches show as a

whole that a great similarity prevails between the flora of the brown-coal and the flora of the temperate zone of the United States of North America. This will appear more decisively when I am able to bring together all the results bearing on this point.

All the species of Taxus observed in the brown-coal differ remarkably from those now existing in the three or fourfold striation of the sides of the cells running at acute angles, whereas in the latter a single fibre forms an almost horizontal spiral. In many brown-coal deposits in Silesia as well as in Prussian Saxony (Nietleben near Halle, Wörschen, Gramschütz, Rossbach near Weissenfels, Teuditz, Tollwitz near Dürenberg, Voigtstedt near Artern) species of Taxus seem to predominate even quantitatively, and among them the *Taxites Ayckii* formerly described has an uncommonly wide distribution, not only in the localities now named, but also occurs in the Rhenish brown-coal deposits, in Hessenbrück near Laubach in the Wetterau, in Silesia, the Lausitz, at Redlau near Danzig, in the Samland in Prussia, and Ostrolenka in Poland. Further researches will undoubtedly show similar results in relation to other species, as for example the *Pinites Protolarix*.

4. Narrow annual rings, consequently a highly compressed growth, such as in existing coniferæ is only found, according to Martins, in high northern latitudes, and according to my own observations formerly published, on high mountains, is constantly found prevailing in the bituminous trees, and imparts to some of the wood an uncommon density and weight, similar to that of the Guaiac wood. In many species I have counted 15–20 annual rings in the breadth of a line, of course in round stems, as in those pressed flat the influence of the compression must also be taken into account, though in other respects its influence, as for instance on the walls of cells, is less than might be imagined. A stem of a *Pinites Protolarix* from the brown-coal pits near Laasan, with a diameter of 12 inches in breadth and 16 inches in length, showed in this narrow circumference not fewer than 700 annual rings. Yet in the ancient as in the present world, there was a great diversity in the rate of growth even of the same species, for in another nearly cylindrical stem of this tree 16 inches in diameter, only 400 annual rings could be distinguished.

5. I have repeatedly observed on trunks and branches, the broken-off twigs and branches grown over by new layers of wood, and to my great joy in the brown-coal pit of Francisca at Popelwitz near Nimptsch in Silesia, a stump of a conifera perfectly shut in by the more recent layers, which might have served right well for a *Krater* or drinking-cup, for which, as Theophrastus tells us, the ancient Thracians used these stumps of the pine. As the same laws of vegetation prevailed in the ancient and in the existing creation, there is nothing singular in this observation, yet still it seemed to deserve a passing notice. [J. N.]

On Jointed Tentacles or Pinnulæ, composed of Calc-spar, found on the Ambulacral spaces of the Pentremites. By Dr. FRED. ROEMER.

[Leonhard and Bronn's Jahrbuch, 1848, p. 291.]

A FORTUNATE discovery in the beds of the carboniferous limestone on Mount Sano, a hill near the town of Huntsville in Alabama, in North America, has enabled me to add something to our knowledge of the remarkable genus *Pentremites*, in consequence of which its position in the system must be essentially altered.

The Pentremites, as is well known, exhibit on the surface of their spherical or pear-shaped shell five distinctly bounded spaces, which diverging like the rays of a star from the central opening above, pass down the sides of the body and are pierced by longitudinal rows of minute holes or pores. These divisions have been compared with the ambulacral spaces of the Echinides; and in consequence, Say the founder of the genus, Goldfuss and others who have subsequently studied its characters, have considered the Pentremites as a connecting link between the Crinoids and the Echinidæ.

Hundreds and thousands of specimens, which I have either collected myself in the Western States of the Union or seen in the museums there, all show these spaces penetrated by pores, and without any appendage or covering. In the specimen discovered in the above locality in Alabama the case is different, as I shall now more minutely describe.

The specimen is a Pentremite about an inch long, belonging to a species intermediate to *Pentremites florealis* and *P. pyriformis*, Say. Only one side of the body is visible; the remainder is concealed in the rock,—which also contains a fragment of that remarkable coral of the genus *Archimedes*, Lesueur, which, not less than the Pentremites, is characteristic of the lower division of the carboniferous limestone in the Western States. The exposed side shows distinctly—two of the three basal or pelvic joints;—two of Miller's so-called scapulæ, standing on the former and bifurcating so as to receive the supposed ambulacral spaces;—further, one of the five trapezium-like pieces which stand on the obliquely truncated points of two adjoining scapulæ*;—and lastly, two of the five so-called ambulacral spaces.

These spaces exhibit the truly singular peculiarity of the specimen. They are covered with highly delicate appendages or tentacles, composed of minute fragments of calc-spar, and placed close together in two regular longitudinal rows on each space.

The structure of these appendages is similar to that of the tentacles or pinnulæ (as they are more correctly named by Johannes Müller in contradistinction to the membranous feelers or tentacles, which also appear there) on the arms of the Crinoids.

The basis of each of them is formed by a single portion of calc-spar which is obtusely bevelled above; to this succeeds still smaller thin-

* These have not been observed by any one except Dr. Troost, who has contributed so much to our knowledge of the natural history of the Western States. Compare Transactions of the Geol. Soc. of Pennsylvania, vol. i. p. 224 *et seq.*

ner laminæ in two rows alternating with each other, and at length towards the extremity larger laminar pieces in a single row. In the specimen described the last are placed vertical to the plane of the tentacular space (*Fühlerfeld*), whilst the other part of the appendage lies with its broad side on the plane of the space.

The length of the pinnulæ is very considerable in relation to their thickness: some of those originating at the lower extremity of the field can be followed even beyond the point of the interscapulary trapezoidal piece.

The direction of all these appendages is very accurately towards the vertex of the shell; consequently in the middle of the tentacular space they lie thickly compressed on each other, and this seems to have caused that half-turning round of the tentacles, so that the laminar portion of the upper extremity comes to be vertical to the shell.

The number of the pinnulæ in each row of a space (*Feld*) is about fifty, which is also about the number of the holes in a row of the uncovered, so-called, ambulacral space of a Pentremite of nearly the same size.

In the annexed drawings, which my friend Dr. Ewald has had the kindness to prepare, all the circumstances described are represented with remarkable fidelity and care, and render any further description unnecessary.

Fig. *a*.

Fig. *b*.

Fig. *c*.

Fig. *a*. is a view of the specimen of the natural size.

Fig. *b*. a view of a tentacular space with the pinnulæ, magnified two times.

Fig. *c*. a single pinnula, magnified three times.

The most general result regarding the structure of the Pentremite that may be deduced from the consideration of this specimen is:—

"The minute pores which penetrate the ambulacral spaces of the Pentremites in two marginal longitudinal rows are not, as was formerly supposed, intended for the passage of soft membranous feelers, like the holes on the tentacular spaces of the Echinidæ, but they are canals for nourishing appendages composed of portions of calc-spar, and formed in the same manner as the pinnulæ on the arms of Crinoids."

With this the approximation of the Pentremites to the Echinites hitherto generally received falls to the ground, as no longer capable of being maintained*. The Pentremites are genuine Crinoids, which instead of a limited number of compound arms, are provided with numerous, definitely-arranged, simple, undivided appendages, composed of pieces of calc-spar.

They form a peculiar group among the Crinoids, characterized not only by the numerous, simple, arm-like appendages, but also by the five large openings placed round the central vertical opening, and by a peculiar simple disposition of the plates of the cup.

In the absence of true compound arms, the Blastoideæ (the family name already given to them by Say) agree with the Cystideæ of L. von Buch. The scars (*Narben*) which occur near the mouth in some of the latter may have been the points of attachment for similar simple appendages; but many arms could not have been placed there, as has already been distinctly stated in the celebrated monograph of the family.

In conclusion, we must say one word in regard to the physiological purpose of the arm-like appendages now described in the Pentremites. The pinnulæ of the Comatulæ and Pentacrini with which these appendages may be most suitably compared, have, according to Johannes Müller, a twofold purpose. In the first place, they serve to seize and to convey to the mouth the food necessary to the support of the animal; and in the second, the male and female reproductive organs are situated at the base of these pinnulæ.

It is in every respect very probable that the appendages of the Pentremites may have served for the first purpose, and the definite direction which they all assume towards the central opening in the vertex, which undoubtedly corresponds to the mouth, confirms this view. On the other hand, it is impossible that the reproductive organs can have been placed at their basis, if, as seems necessary, we consider the five openings on the top surrounding the central one of the mouth as the ovarial openings.

That these arm-like appendages of the Pentremites should not have been previously observed, does not seem remarkable when their extremely delicate structure is considered, and we must rather ascribe it to some peculiarly favourable conditions during petrifaction that they have been preserved even in a single case.

Though not immediately connected with what precedes, I must

* That the formation of the so-called ambulacral spaces themselves, and the position of the holes upon them, is entirely different from that of the tentacular spaces of the Echinites, can only be indicated in this place. The more complete exposition of the fact must be reserved for a connected work on the genus *Pentremites*, for which I have collected rich materials in North America.

remark that the genus *Pentremites* was also represented in the Silurian division of the palæozoic formations. A species described some years ago by Dr. Troost as *Pentremites Reinwardti*, I have myself found very abundantly in the vicinity of Perryville, in the state of Tennessee, along with *Caryocrinus ornatus*, in strata identical in age with the Niagara group of the New York geologists, and consequently with the Wenlock limestone of England. [J. N.]

The Fossil Flora of PARSCHLUG. By F. UNGER.

[From Steyermärkische Zeitschr., *b*, ix. Jhrg., 1 Heft, in Leon. and Bronn's Jahrb. 1848, p. 505.]

A VERY limited space around Parschlug has already furnished 141 species of fossil plants. This place is situated in the valley of the Wurz, which runs for eight (thirty-seven English) miles from north-east to south-west, and is nowhere above half a mile ($2\frac{1}{4}$ English) broad, and is inclosed by lofty mountains of the slate-formation, whose summits are from four to six thousand feet high. This valley during the tertiary period appears to have been shut up at the lower extremity, and to have formed a lake in which lacustrine beds with shells of freshwater mollusks (Unio), shells of Cypris, wing-cases of Coleoptera, and especially portions of plants, were deposited. The series of tertiary strata is as follows: —

15.	Surface soil.	
14.	Whitish yellow marl-shales	Some fathoms.
13.	Hard marl-shales with the best impressions of plants, and clay-ironstone	5 inches.
12.	Soft grey slate-clay	7 feet.
11.	Blackish brown slate-clay with leaf impressions	Thin.
10.	Pitch-coal and slate-coal	7 feet.
9.	Fuller's earth	Thin.
8.	Black lignite (brown coal)	3 feet.
7.	Marl-slate	6 feet.
6.	Compact marl-slate	Thin.
5.	Slate-clay	9 feet.
4.	Black lignite (brown coal)	2 feet.
3.	Compact marl-slate with shells	8 inches.
2.	Black slaty lignite (brown coal) on slate-clay and sand ...	6 feet.
1.	Fine-grained quartzose sandstone.	

The beds are inclined at 22° to h. $9\frac{1}{2}$ (S. $37\frac{1}{2}$° W.), and are covered by horizontal diluvial beds. The vegetable remains consist of leaves, bud-scales, winged seeds and fruits, pods and other parts of the fruit, branches without leaves, fragments of bark, rarely nuts and stone-fruits, catkins of flowers and seeds. It is the autumnal stripping (*Abfälle*) of a forest vegetation, composed, according to the indications here preserved, almost exclusively of trees and brushwood, with which five plants are associated, which may have lived in marshy places in the woods; but no traces of water-plants have as yet occurred. All the characters lead us to believe that soon after their fall from the trees these remains were collected by an inundation of a stream from a wide-extended river-basin (for so great a variety of trees are never found growing in a limited district), and carried with a gentle inclination into a lake, where they were deposited along with the mud. The number of trees with ever-green leaves, together with those with leathery (*häutigen*) foliage, indicates a climate of 12°—17° C. (54°—63° Fahr.); and as there are no palms among them which suppose an annual temperature of 15° C. (59° F.), we may assume that the climate of Parschlug (which at present is only 9° C. (48½° F.)) was during the tertiary period 12°—15° C. (54°—59° F.), corresponding in Europe to 45°—42° of N. lat., or the shores of the Mediterranean; in North America to 43°—37° N. lat., or southern Virginia. In its special character this fossil flora agrees with that of the southern parts of the United States of North America and of Upper Mexico. In sixty-seven genera (*Sippen*) there are indeed above forty which belong both to the old and new continents, but in the remainder only *Paliurus*, *Zizyphus* and *Celastrus* are confined at present to the old world, whereas on the other hand, *Taxodium*, *Liquidambar*, *Comptonia*, *Achras*, *Prinos*, *Nemopanthes*, *Ceanothus*, *Smilax*, *Robinia* and *Amorpha*, occur exclusively in America. In like manner the number of species which have their nearest allies on the Mediterranean are only twelve, whereas those related to American species are twice as many, and also greatly preponderate in the number of individuals. The author does not think that any species still existing occurs among them, for although some remains cannot be distinguished from the corresponding parts of living plants, yet he believes that as the greater number are certainly distinct, we must draw the same conclusion regarding the few that remain*.

Besides Parschlug, where a tooth of the *Mastodon angustidens* was found in the coal, there are some other localities of tertiary plants, as Aflenz and Turnau (where the miocene *Dorcatherium Naui* has occurred), Winkel, Hauenstein, Judenburg and Leoben, which however have not furnished many well-preserved species, and very few identical with those of Parschlug, a greater number indeed agreeing more nearly with those of other remoter localities† (although if we rightly understand the author, he considers the formations at Winkel, Leoben, &c., as identical with that of Parschlug). Parschlug likewise shows more agreement with distant localities, as Öningen, Bilin, Radoboj and Häring, some of which have produced also insects, fishes, reptiles, and mammalia, and must in like manner be regarded as miocene; and in respect of the plants, insects and reptiles, possess, according to the researches of Al. Braun, Osw. Heer, and Herm. v. Meyer, a closer relationship to North America, Japan, and the Mediterranean coun-

* Since it is beyond all doubt that the tertiary strata contain species of mollusks and mammalia which still occur living, so that the proportion of recent shells in different deposits is found = 0·20 — 0·50 — 0·80 — 0·95, and R. Owen estimates that of the mammalia in England at 0·50, it seems to us, as we have often stated, juster and more unprejudiced to allow those things to remain united which we cannot distinguish, especially as the opposite conduct leads to results to which no end can be assigned. Why should we, by violent separations, produce forced exceptions to the universal laws of nature?—*Edit. L. & B.'s Jahr.*

† The difference does not however seem of much importance, and in consequence of the small number of species known from these places, perhaps only accidental.

tries of Europe, than to the present fauna and flora of the districts themselves. It seems therefore that even during the miocene tertiary period itself, various successive floras have flourished in these countries. The author is of the opinion that the miocene fauna and flora had a uniform character over the whole earth; that this character has continued to exist in those regions whose temperature and local peculiarities have remained unchanged; but that where, in consequence of alterations in the relievo of the earth's surface, the temperature and other conditions have also been modified, there the species have not emigrated, but gradually (as species) become extinct, whilst other species of a different type have taken their place. Where, however, the temperature has remained uniform, there the successive species have retained the original character, and in this way the agreement of this fragment of the European tertiary flora with that now existing in North America, on the shores of the Mediterranean, and in Japan, may be explained. The author intends to describe the new species in detail in his 'Genera et Species Plantarum Fossilium,' but in this place gives only the names*. Several are already described by Unger (*Chloris protogæa*), Alex. Braun and Brongniart. [J. N.]

Palæontological Notes. By HERMANN V. MEYER.

[From Leonhard and Bronn's Jahrbuch, 1848, p. 465.]

HÖLZERWIED near Bussenhausen, in the Canton Zurich, must now be added to the localities in Switzerland in which the diluvial Löss contains remains only of the *Elephas primigenius*, as Herr A. Escher von der Linth has sent me some teeth of this animal of a calcined aspect from that place. More importance attaches to the occurrence of this elephant in the diluvial slate-coal, which much resembles brown-coal, at Dürnten, a league from Rapperswyl, where a large molar tooth has been found of a brown colour like walnut wood, and thus very similar to teeth from the tertiary brown-coals. This coal deposit represents the oldest diluvial filling-up of the valleys in the Swiss Alps, and contains plants which Heer was not able to distinguish from those now living in moist places in Switzerland. Near Utznach, this slate-coal furnished the tooth of a large ruminant resembling the deer. The occurrence of *Elephas* in this situation reminds me of a Mammoth skeleton dug out at Troïtskoë near Moskau, and described by Rouillier. The upright position in a marsh, in which the animal was found, shows distinctly that it had been buried in the mud when venturing too far on the soft ground in search of food. The formation at Moskau also consists of a fine laminated mass resembling brown-coal, containing fishes, infusoria and plants of species still living in the neighbourhood. I would also draw attention to an observation recorded in my 'Palæontologica,' p. 540, according to which the *Elephas* occurred with remains of the ox, stag, fishes, shells and plants, in a turf-like diluvial bed at Wittigendorf

* The list will be found in Leonhard and Bronn's 'Jahrbuch,' but it has not seemed necessary to reprint it in this place.

near Sprottau. All these places are only the natural abodes of the ancient elephant, where it found its food, consisting of species of plants, which were not distinct from those that still flourish in these localities. Such facts refute the groundless hypothesis, that the remains of elephants were transported by great floods from distant regions to the places where they are now found; or that the species was only enabled to exist in them by the influence of external causes or great changes in climate. They also testify to the truth of a view which I have long adopted, that there is some internal cause of this phænomenon, through which, even in historical times, the extinction and geographical distribution of species have been limited.

Goldfuss in his work on the *Archegosaurus* describes the skull of an animal, from the stone-coal formation of Heimskirchen near Kaiserslautern, which he names *Sclerocephalus*, as that of a fish. It seems to me to have more resemblance to that of the Labyrinthodonts than even the *Archegosaurus*, and consequently may as well as this genus be added to the Saurians.

Professor E. Schmid of Jena has recently entrusted to me his whole collection of fossil vertebrate animals from the muschelkalk of that district. To it was added two new species of Ammonites from the celestine strata in the lower muschelkalk at Wogau; one of them is a very beautiful species which I have named *A.* (*Ceratites*) *Wogauensis*. It is nearest the *A.* (*Ceratites*) *enodis*, Quenst., but is smaller, and the back is not arched but acute, thus giving a different character to the sides; it is perfectly smooth, and even the sutures do not agree with those of the species compared with it.

The remains of saurians in this collection formed a very acceptable addition to my 'Monograph of the Saurians of the Muschelkalk.' Previously I only knew from the vicinity of Jena those remains which Count Münster had received from Professor Schmid; and it is of great importance that I now have the use of Schmid's own collection. The muschelkalk saurians of Jena were mostly of small dimensions; but one rib bespeaks a large animal. The collection contains the humeri, always the most important bone, of eight smaller species, belonging to more than one genus; and the large rib indicates a ninth species. Formerly I knew no humerus from the muschelkalk in which the foramen for the passage of the ulnar artery was wanting; but this is the case in one of the Jena bones, a circumstance hardly accidental, as the bone otherwise indicates a peculiar species. A humeral bone in the collection of Count Münster also shows the existence of another species, so that there were at least ten saurians in the muschelkalk of Jena; and among these humeri there is scarcely one that agrees with the bones from Upper Silesia or other localities in this formation. The coracoid bones in Schmid's collection belong to six species, two others are found in that of Count Münster, and this bone in the large species is still wanting; so that the coracoid bones from Jena also point to the existence of nine species, most of them distinct from those of other districts. These collections contain the scapulæ of four small species, the femoral bones of three species, and the pelvic bones of at least four species; all, as well as the small vertebræ, showing no complete agreement with the bones from Upper Silesia or other countries. The teeth resemble those of the Nothosaurus. Labyrinthodonts as yet are entirely wanting. Besides these there has been found : in the bone-beds of the muschelkalk of Wogau the humerus of two species, but not distinct from those of Jena; in the Wellenkalk (lower muschelkalk) of Lobedaburg a tooth of a small species, formed like that of the Nothosaurus; in the bone-breccia of the muschelkalk of Keilhau near Rudolstadt, vertebræ of a very small species; in the terebratula-limestone of Zwetzen, a bone of the pelvis ; in the highest beds of the muschelkalk at Mertendorf, three leagues from Jena, a humerus; and in the keuper-limestone of Vieckberg near Apolda, a large, nothosaurus-like tooth.

The fishes from this district, with those from Querfurth and from Upper Silesia, will be described by me in one of the early numbers of the 'Palæontographica,' the plates being already lithographed. Besides scales and an unimportant fragment of the jaw of a small fish with cylindrical teeth, the proper muschelkalk of Jena has only furnished the *Saurichthys tenuirostris*, of which Agassiz (Pois. Foss. ii. b, p. 88) incorrectly states that it only occurs in the muschelkalk of Bavaria, where it is entirely unknown. It is confined to Jena, and occasionally occurs also at Querfurth, from which the specimen was derived which Büttner long ago figured (Rudera testis diluvii, 1710). The glauconite muschelkalk of Mattstädt near Apolda contains teeth of *Saurichthys Mougeoti*. More important is the terebratula-limestone of Zwetzen, containing teeth of *Placodus*, which, besides *Placodus gigas*, seem to have belonged also to another species. The most interesting specimen from Zwetzen is a jaw with several teeth of a new genus of fish also of a large size, which from the dome or cupola-like form of the top of the teeth I have named *Tholodus*, and this species *Tholodus Schmidi*. It is best placed near *Acrodus*, though the teeth are wholly distinct.

In the 'Athenæum' for June 5, 1847, Sir R. Murchison has published a letter of Agassiz from America, in which he expresses his astonishment at the analogy which exists between the types of life in the temperate regions of North America, and those in the molasse of Öningen. He believes consequently that these deposits were formed in a climate that was not tropical, and in this comparison he also introduces Japan. These are exactly the same views that were already published in my work on 'The Fossil Mammalia, Birds and Reptiles, from the Molasse Marls of Öningen,' which work Agassiz knew before his journey to America. In that work I have not only pointed out the close relation which the tertiary Öningen, without renouncing its European character, still bore to the present North America and Japan ; and also came to the conclusion that the tertiary creatures of Öningen required for their existence a climate not at all warmer than that which now prevails in the region of Öningen, so that the assumption of a tropical climate in which the animals of the molasse have lived, is anything but well founded.

In Tayler's museum at Haarlem, which I visited in August 1847, I saw the beautiful remains of the Mastodon found at Öningen, which belong to the *Mastodon angustidens*. In this collection there are also some species of vertebrata not hitherto known to occur in that place, and the first specimen which I saw in the rich collection of Professor van Breda was a new rodent from Öningen, to which I have given the name of *Sciurus Bredai*. In Tayler's museum I saw also the Anguisaurus from the lithographic slates of Solenhofen, assuredly a most remarkable creature and well deserving a thorough description, which however would require more time than I can command. It seems related to the Pleurosaurus, of which I have the middle portion of the skeleton before me, and perhaps the two genera may come to be united.

Whilst residing on the coast of the North Sea in Holland and Belgium, I thought myself transported to the very workshop where the marine molasse and the shell-sandstone of the molasse were forming before my eyes. The dunes are an analogous formation; the sand of the dunes is the molasse sand of historical times ; the similarity is so remarkable that it only requires consolidation, in order to represent the molasse sandstone with its contents, which would consist of living instead of extinct species. The sand of the dunes rarely envelopes mollusks in a living state ; it is chiefly the shells of dead animals, and these for the most part fractured, broken into fragments or rubbed by the incessant beating of the waves. The beach, seen during the ebb, may be compared to a great extent of exposed strata, on which remains of organisms appear in various places. Even the flame-like distribution of colours and other markings on the divisional surfaces of rocks may be partly explained by the deposit of foam from the waves. The manner in which the waves during the ebb of the retiring sea sport with the fine sand on the beach is very interesting. They give it a wave-like, variously furrowed arrangement, resembling the sculptured markings on the skull of the crocodile. Similar appearances, and no less regular, occur on the surfaces of many rocks containing petrifactions. The sea-shore may also convince us that many phænomena in the fossiliferous rocks have their cause in the alternation of the seasons,—a phænomenon which must be carried further back in the history of the earth than our theorists imagine. When it is considered for example that the immense profusion of fish on the shores of the Netherlands, in summer declines to absolute poverty, many of the fish then seeking other littoral regions, we may conceive that the variation in the numbers of petrifactions which the strata of one and the same formation present, the alternation of highly fossiliferous beds with others in which fossils are rare or entirely wanting, that the interruptions in the occurrence of species by beds in which they do not appear, as well as the diversity in fossils which is observed when in wide-spread formations the same stratum is followed to distant points, may in part be explained by the alternation of seasons. On the strand, newly exposed by the retiring sea, at the season of my visiting it, I rarely found a fish ; it was chiefly mollusks, sea-stars, among them often those with four rays, prawns, and among plants fucoids, that were left behind. In a sand-hill I found the shell of a crab full of the fine sand, and in the best way to become a petrifaction. Even the more frequent occurrence of cetacea in certain parts of the molasse formation is explained by the fact that at present there are particular parts of the sea-shore where cetacea are very frequently stranded; Ostend is such a locality. There whale-like animals are often thrown on shore; among others the monster which after going the tour of Europe as a curiosity, is now found at St. Petersburg.

[J. N.]

Results of an Examination of the Coal Beds on the Rhine. By Professor Göppert.

[From Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterländische Kultur im Jahre 1847, p. 68.]

It might well be supposed that the peculiar structure of the stone-coal observed in the Silesian mines would also appear in other ancient coal deposits. This view was fully confirmed when in the autumn of 1846 I had an opportunity of examining the coal strata in the district of Saarbrück, near Aix la Chapelle, some of those at Liege, and in Westphalia. I everywhere found, exactly as in Silesia, though not in such perfection as in the Nikolai mines in Upper Silesia, that the coal contained plants visible with the naked eye, Stigmariæ, Lepidodendra (especially *Lepidofloyos laricinus*), and Sigillariæ; and in the pit at Norheim near Kreuznach, for the first time even a fern (*Cyatheites arborescens*, mihi), together with so many Calamites belonging to the *Calamites decoratus*, that I thought myself almost entitled to term it a Calamite-coal.

These facts give that completeness to the circle of our observations which was much to be desired: *representatives of all the families of plants observed in the coal formation have now been found in the coal itself.* From Norheim I proceeded towards St. Wendel, visiting in the vicinity, the so-called Zettow mines at Mätzweiler and Urexweiler, and then the Mareschweiler pits and the carboniferous sandstone and limestone quarries of the district between St. Wendel and Ottweiler. The flora of the limestone quarries, together with the limestone itself, exhibits a remarkable similarity to the Silesian and Bohemian deposits which appear in the red sandstone between Wünschelburg in Silesia and Braunau in Bohemia. The coal of these various mines was pretty uniform in character. It contained a vast quantity of minute fragments of the fibrous coal (*Araucarites* mihi) running through the seams in every direction, and much pyrites, so that it usually appears very loose, and after a few months even crumbles down.

From Ottweiler I went to Neuenkirchen, the vicinity of which occupied me for a long time;—the Königsgrube, the red ironstone (hæmatite) beds of the Fuchsgrube, the vast quantities of clay ironstone collected at the foundries, in particular the Lebach ore containing fishes, and also, though the fact was at one time doubted, plants;—the exceedingly interesting Wellesweiler mine with its upright stems, in which the distinct character of the coal in each of the twelve seams appeared in a most convincing manner (the first seam, for instance, was throughout rich in Sigillariæ and Lepidodendra, especially the *Lepidofloyos laricinus*; the Martin's bed in Stigmariæ);—the small Querscheid mines with the Dechen bed, in the coal from which Sigillariæ predominate to a degree not seen in any other pit in the whole Rhenish mining district, and strongly recalling the Leopold mine near Ornontowitz in Upper Silesia. From this I proceeded to Saarbrück, where the Director of Mines Sello pointed out to me the general features of the coal district, and where in several collections I had an opportunity of obtaining more precise information regarding the occurrence of the fossil plants. I then returned to several of the other mines, in particular the colossal Gerhard mines, which every year furnish 800,000 tons of coal, and in which the Beust seam must be designated a true Stigmaria coal, containing this plant in immense and almost incredible abundance;—the Leopold pits, in which in a distance of 60 fathoms I observed fifteen upright stems, chiefly Sigillariæ, so that in this place a whole subterranean forest seems to lie buried. The Lehbach, the Crown Prince Friedrich Wilhelm, and the Hostenbach mines are remarkable for the great abundance of fibrous coal, which forms whole stems almost as in some mines in Upper Silesia near Chelm, and Myslowitz and near Krakau.

After completing the examination of the Saarbrück district, my attention was directed to the coal-basin round Aix la Chapelle, and particularly that on the Inde near Eschweiler and Stolberg, where I spent several days studying the very rich collections of Director Gräser. This collection has a peculiar interest, as proceeding entirely from one locality, from the very extensive works of the Centrum mine. It contains perhaps fifty new species; amongst them fifteen new ferns of the genus *Sphenopteris* alone, several with that kind of fruit, which ten years ago I foretold would be found, though then scarcely credited; and twelve species of Sigillaria.

A very remarkable circumstance in this coal-deposit is the occurrence of Mytulites, over an extent of several hundred fathoms. On inquiring about the existence of plants in the coal, I was shown a piece of coal with Sigillaria, as the only instance known during the last thirty years. Yet I succeeded here, just as in all other places, where I was met with doubts of the possibility of finding such remains. After I had shown the way in which the planes of stratification, especially those that are dull, must be brought under the eye and examined by light falling on them in various directions, it turned out here as in other places: *Stigmaria ficoides* was frequently observed as the prevailing plant, and Lepidodendra and Sigillariæ also appeared in sufficient abundance.

The coal in all the pits on the Worm appeared to me very peculiar. The structure of the coal, visible with the naked eye, tends to disappear in a very uniform manner in all directions. Thus, just in proportion as the Sigillariæ, Stigmariæ and Lepidodendra appear more rarely on the shining, often anthracitic-looking coal, so also the remains of Coniferæ decrease; whilst the so-called fibrous coal, or the

Araucarites carbonarius, is in a remarkable degree more rarely met with here than in any other coal with which I am acquainted. The short time left me was occupied with an excursion to Belgium, where at Liege I examined the coal-mines situated in the town itself (houillères de Bellevue à St. Laurent), where I found exactly similar conditions, beautiful Lepidodendra, as in the Wellesweiler mine.

On my journey home I visited some mines in Westphalia, near Essen, under the friendly guidance of Herr Heintzmann, Councillor of Mines ; all of which showed in the coal, along with multitudes of Stigmariæ, also Sigillariæ and Lepidodendra in more or less abundance.

When we now reflect, that in every carboniferous deposit which I have had an opportunity of examining, I have found the coal, not as has hitherto been universally assumed, and as Elie de Beaumont has recently maintained in his Lectures on Geology, a more or less uniform mass, showing no trace of vegetation, but that I have distinctly recognized, even with the unaided eye, the plants that have contributed to its formation ;—it becomes more than probable that the same thing would be found everywhere, if these conditions and the way and manner in which I make my observations were only attended to. Differences will no doubt always appear, since the more or less perfect preservation of the structure depends, among other conditions, very much on the degree of decomposition to which the vegetables had already attained, before they were protected from any further waste or decay, by being buried between layers of earth and stone, which cut off all access of the air. The vegetables, for example, which are found buried in the coal-basin on the Worm, had made further progress towards decay than usual, and hence the rarity of specimens in which the structure is well-preserved.

[J. N.]

On the Relations of the Gypsum at Lüneburg, Segeberg, *and* Lübtheen. By C. J. B. Karsten.

[From Monatsbericht der Akademie der Wissensch. zu Berlin, 1848, p. 130.]

The masses of gypsum at the localities just mentioned are anhydrite, which has been partially converted into gypsum in its original situation. The plutonic formation of the anhydrite is proved by its relation to the stratified rocks, which, in consequence of the elevation of the anhydrite, have also been brought nearer to the surface of the earth. It is also confirmed by the character of the matter with which the fissures in the gypsum are filled. This matter shows in all the three localities the same relations and the same chemical composition. It consists of a crystalline, sometimes compact, sometimes granular, sometimes slaty, bituminous mixture of finely pulverized silicate of alumina, of carbonate of lime and carbonate of magnesia, in very different proportions. These combinations of the carbonates are very distinct from the composition of the dolomite from which they may have originally been produced. The muschelkalk, which at Lüneburg is raised to the surface in highly inclined strata, contains the carbonate of magnesia, not mixed with the carbonate of lime, but in the condition of a true dolomite. The change of the muschelkalk into dolomite is always the more complete the nearer the limestone approaches to the fissure through which the anhydrite has been elevated. The higher strata contain only a small proportion of dolomite, which has not essentially altered their character, which in the vicinity of the fissure was entirely destroyed.

The peculiar nature of the matter filling the fissures in the masses of gypsum at Segeberg and Lübtheen leads to the conclusion that the anhydrite on its elevation must also have broken through beds of limestone, and partially changed them into dolomite, although these strata have not been forced up to the surface, as has actually occurred at Lüneburg. From the disposition of the beds, and from the nature of the matter in these fissures, it further appears that the mass of gypsum now exposed must have reached the surface after the tertiary formations were deposited. On the other hand, the mechanical disturbances which the beds of the inferior rocks have undergone, and the chemical alterations of the limestone strata which come more immediately into contact with the fissure of elevation, probably belong to a very much earlier period than that of the elevation of the anhydrite, which, as the nature of the matter filling the fissures shows, has taken place slowly and probably with interruptions.

[J. N.]

Mud of the Nile.

The following analysis of the mud of the Nile, by M. Lassaigne (Journ. de Pharm. t. v. p. 468), is more recent and complete than that given by Lieut. Newbold from Regnault, in the last number of the Quarterly Journal of the Society*.

Silica	42·50
Alumina	24·25
Magnesia	1·05
Peroxide of iron	13·65
Carbonate of lime	3·85
Carbonate of magnesia	1·20
Humic acid	2·80
Water	10·70
	100·00

[J. N.]

* Vol. iv. p. 341.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Description of the ORTHACANTHUS DECHENII. By Dr. GOLDFUSS.

[From Beiträge zur vorweltlichen Fauna des Steinkohlengebirges. Bonn, 1847.]

THE skeleton figured* was found in a slab of reddish-coloured, slaty limestone, from a bed in the carboniferous sandstone of Ruppersdorf in Bohemia, and presented by its discoverer, Herr v. Dechen, Director of Mines, to the museum of our university. It lies on the belly with the left side a little turned up, so that the right side appears shortened. The tail is broken off behind the ventral fin, and the length thus far is fifteen inches Rhenish. The slab over the whole outline of the animal and for an inch beyond has a red colour, so that the form of the body is shown, as it were, by a shaded outline. The head, the vertebral column, the pectoral and pelvic arches are covered with vitreous, rounded quadrangular, granular scales (*Körnerschuppen*), pushed over each other. The head has a semicircular outline, which seems also to correspond to the large opening of the mouth, since on the right side numerous remains of broken teeth are seen all round. Behind the probable termination of the lower jaw the head suddenly contracts about a fourth. On the anterior portion behind the obtuse snout, two conical cavities are visible, which appear to open out forwards, and hence may be considered to be nostrils. On the other hand, no trace remains of the cavities for the eyes. A straight spine is rooted in the neck, and is 4 inches 7 lines long, and 3 lines broad at the root. It has no articulation at the base, is smooth on the anterior surface, though slightly cracked, and on the posterior side is enclosed in the stone. The vertebral column shows indistinct spinous processes, whence it may be deduced that it was imperfectly ossified. From it, as far down as the pelvis, numerous, short, straight ribs proceed, which are inclined backwards, and at the thin end are often bent in various directions, and seem to consist of a single series of granules. The scapular arch on each side is formed by a bone 5 lines broad, which is curved inwards, directed backwards, and has a knee-shaped angle on the posterior third of its outer margin. This margin is covered thus far with fin-rays which are formed of two alternating series of osseous granules (*Knock-*

* In tab. 5. fig. 9–11 of the above work.

enkernen). The anterior rays are very short and thin, the succeeding ones increase in length and thickness. Immediately before the knee-shaped angle there arises a carpal ray, distinctly articulated, turned backwards, and 3 inches 8 lines long. On its outer side it has seventeen thick, strong rays, much divided externally, and, as a remarkable peculiarity, also on the inner side a smaller number of weaker rays divided in a similar manner towards their point.

The pectoral fins had consequently a great extent and an anomalous (*abweichende*) structure.

The pelvic arch is less distinctly preserved. A broad, short bone proceeds obliquely forwards from the spinal column, and attached to it is the knee-shaped tarsal ray turned backwards, which with its numerous fin-rays, attached on the exterior side, and likewise much divided towards the point, forms a large fin. Whether the bundle of fibres (seen in the figure) extending from the vertebral column to the knee-shaped angle indicates a bone, and whether this belongs to the right or left ventral fin, cannot be ascertained. Remains of the former, however, are apparently indicated between the vertebral column and the carpal ray.

Close behind the pelvis, opposite the ventral fin, are situated the remains of a dorsal fin composed of numerous rays. The body being broken off at this point, it is uncertain whether there was also a second dorsal fin.

It is thus evident that this skeleton belongs to a cartilaginous fish, with a semi-ossified vertebral column, of the order of Selachii,—a fish which from the breadth of its head and pectoral fins, and the small thickness of its body, resembled the living genus *Squatina*. But as it is probable that the opening of the mouth corresponded to the circumference of the head, and as the carpal ray of the pectoral fin is furnished with fin-rays on its inner side also; its alliances can only be sought for among extinct genera, of which, so far from any completely preserved skeleton having as yet been found, in general the teeth and the cervical spine form the only basis of comparison. The numerous fragments of small teeth, lying along the right-hand margin of the head, render it probable that there were several rows of them. The anterior teeth are larger than those placed farther back, so that the form of some of them can still be recognized*. When magnified, it is seen that from each root three conical points arise, a large one in the middle, with a smaller one on each side. They are slightly compressed from within outwards, so that the interior side appears flatly convex, the outer side almost flat. Both sides are longitudinally furrowed and covered with a shining enamel. In fig. 10 *a* †, several broken teeth lie above each other, of which the one in front seems to have four points ; in fig. *b* the inner convexity is shown ; in fig. *c* the more flat external side. Similar teeth characterise the genus Hybodus (Agass. *l.c.* p. 178. tab. 22. *a*. 24), but its cervical spine is very different from that of the present

* See fig. 10 of original.

† Tab. 5 of the original Memoir.

genus. This is situated at the extremity of the head, and no trace appears behind it of the rays of a dorsal fin, of which it might have formed the commencement. The root which was buried in the flesh is not renewed (*verjüngt sich nicht*), but the whole spine gradually increases in thickness from the point to the basis, is quite straight, cylindrical and smooth on the anterior surface, whereas the spines of the Hybodus are compressed, curved backwards, striated on the root and furrowed on the lateral faces. In order to observe the characters of the posterior surface of the spine which was hid in the stone, a portion of it was dug out and an impression taken of the uninjured furrow in which it lay. This showed an elevated central line, with minute points at alternate intervals on each side of it, indicating small spines. These are not placed close to the central line, but at some distance from it on the margins*, whereas in all the known Hybodus' spines, they approximate so closely towards the upper extremity as to form only a single row. There is also no indication of a second spine at the commencement of a posterior dorsal fin, as seems to have been the case in the Hybodus. On the other hand, the spine of this fish has the most perfect similarity to a large spine from the coal formation of Manchester, which Agassiz (iii. tab. 45. fig. 7–9) has distinguished generically under the name of *Orthacanthus cylindricus*. It must therefore be conjoined with the genus *Orthacanthus*, but forms a distinct species of scarcely half the size, characterized by a spine of one-third the thickness and by the distance of the smaller teeth from the middle line.

The discovery of this fish not only enriches the fauna of the coal formation with a new species, but completes our knowledge of the genus Orthacanthus, of which the following are the characters :—

Mouth large, corresponding to the circumference of the head, with several rows of small, numerous, three-pointed, slightly compressed, longitudinally furrowed teeth.

Instead of the first *dorsal fin*, a single, straight, flattened, cylindrical, subulate (*platter, drehrunder pfriemenformiger*) *spine*, which has on the posterior side, at a little distance to the right and left of a raised middle line, a row of fine spines.

The *second dorsal fin*, opposite the ventral fin, without a spine.

Pectoral fins lateral, large, with a long, articulated carpal ray directed backwards, and furnished with fin-rays on its inner and outer sides.

Ventral fins moderately large, with a similar tarsal ray, which, however, has fin-rays only on the outer side.—[J.N.]

---

2. *Memoir on the Test of Trilobites and on some accidental Distortions of its Form ; with Notes on some Species from* Brittany. By M. Marie Rouault.

[Bull. Soc. Géol. France, 2nd series, vol. vi. p. 67.]

The information in this paper may be considered supplementary to the author's former communication on the "Silurian Fossils of Brit-

* See fig. 11. pl. 5. of the original.

tany," an abstract of which appeared in vol. iv. part 2, p. 35 of the Quarterly Journal of the Geological Society.

The comparative amount of calcareous matter in the test of Trilobites, and the shells of Mollusks, may certainly be determined, where the sulphuret of iron has been abundant, as at Angers and Poligné, by the amount of this mineral replacing it, since at certain spots, such as Couyère, where there has been a paucity of the sulphuret, the lime is found in corresponding quantity, or if the test or shell was corneous, it has been replaced by sulphate of barytes.

Among the very few genera which appear to have had a considerable quantity of calcareous matter in their test:—

Calymene and *Phacops* offer either the original calcareous test, in which case these fossils are very difficult to disengage from the matrix; or the sulphuret of iron.

Ogygia and *Illænus* break out with ease from a block of stone, and show a varnished or lustrous surface: these do not present any sulphuret of iron (except when the mineral has been overabundant), but *Ogygia* and *Nileus** often have sulphate of barytes replacing them.

A new *Orthis*, of the '*arcuato-striatæ*' group, figured under the name *O. Berthoisii*, Rouault, appears to have had shelly matter only at the beaks, since these have not undergone distortion, are difficult to disengage from the stone, and show either carbonate of lime or iron pyrites; the rest of the shell has been pressed into every possible form, is easily disengaged from the rock, and presents no pyrites. The surface of the slate immediately round the shell is generally smooth and lustrous for some little distance, which the author thinks may be due to the animal matter pressed out of the shell: this surface is generally covered by sulphate of barytes.

Some of the Trilobites of the clay-slate, preserved in the museum of the "Jardin des Plantes," are next examined critically.

The fine species of which Brongniart figured a portion as *Ogygia Desmaresti* is here reproduced under the name of *O. Brongniarti*, Rouault, and figured of full size. It is distinguished from all described species by marked characters of breadth and proportions of the parts; and from *O. Edwardsi*, a new species also figured here, by some differences of proportion more minute, and less easily recognisable. The following four species are characterised by the relative proportions of length and breadth in the head:—

	Length.	Breadth.
O. Brongniarti	1	$3\frac{1}{2}$
O. Edwardsi	1	$2\frac{1}{2}$
O. Buchii	1	2
O. Guettardi	1	$1\frac{1}{4}$

The author finds that in this genus—in proportion as the form of the species is rounder and less elliptical—the length of the three portions, head, thorax and abdomen, become more nearly equal; and by pursuing this clue, he is enabled to restore with great probability of correctness the entire animal, and has done so in his figure. The proportions borne by the head and abdomen to the length of the

* Of the author; it is more probably *Illænus*.—[J.W.S.]

thorax being nearly uniform throughout a genus, assist him very much in the restoration from fragments. He finds that *Ogygia* has the body nearly equally divided into three—the middle of the length being between the 4th and 5th segment; while in *Calymene*, *Homalonotus* and *Paradoxides*, the thorax occupies more than half the entire length, the centre being at the 6th segment; in *Illænus* it is between the 5th and 6th. In *Asaphus* and *Nileus* it is between the 4th and 5th; in *Trinucleus* at or above the 1st.

Again, in *Ogygia* the greatest width of the oval body is in the centre, or between the 4th and 5th segment.

By all these observations of the species he is guided to the same result, and therefore believes that the restoration he has given is not only correct in the present instance, but may form the basis of future restorations where fragments only exist; and even where slaty distortions may have altered the original form entirely, the relative proportions will still remain intact.

Abbreviating a little, *O. Brongniarti* is thus described:—

"Slightly oval; the width rather greater. Head crescent-shaped, $3\frac{1}{2}$ times as wide as long. Glabella wide, short, only $\frac{3}{4}$ths the length of the buckler, with two shallow furrows radiating inwards from the upper angle of the eye, one obliquely upwards, the other horizontal. Cheeks flat, triangular, not separated from the glabella. Eye large, horny, with 1000 or 1200 very fine lenses at least. Palpebra* continuous with the glabella. Facial suture parallel (within) to the front margin for some distance, then sharply turning round backwards to the eye, and thence outwards to the very end of the cheek before it curves inwards again to cut the posterior margin.

"Thorax wide; 8 segments, oblique and curved back at the ends; pleuræ once and a half the width of the axis, with diagonal furrows.

"Tail (as restored) wider than semicircular, with a broad conical axis, and a margin only moderately wide."

The characters of *O. Edwardsi*, Rouault, are given:—

"Oval, less elongate than *O. Buchii*. Head semicircular, $2\frac{1}{2}$ times as wide as long; margin and posterior spines much-dilated, and covered with fine striæ; glabella longer than broad, without furrows, convex in front, the convexity continued, but narrower, to the faint neck-furrow; cheeks small, flat.

"Eyes and facial suture nearly as in *O. Brongniarti*, the suture less parallel to the edge in front. Thorax one-third wider than long; 8 joints, each with a gently curved diagonal furrow, and obliquely pointed and curved back at their ends. Tail with wide lateral lobes, the axis of 18 joints (with a backward notch in each), lateral lobes 8-ribbed; border concentrically striate."

He endeavours to show that *Ogygia* had the thorax-joints soldered, and not therefore capable of bending or of slipping under each other, although they were not so firmly united as to resist the lateral dis-

* A useful term for the upper lunate plate which covers the eye in most Trilobites.

placement which the movements in the slaty rocks have given rise to, and which movements he considers to have been sharp and violent shocks, which have broken the testaceous species; while such as had only a corneous covering (most Trilobites) were bent and distorted, elongated, shortened, or laterally squeezed, according to the position of the fossil, and direction of the shock.

He describes and figures these displacements in *Illænus giganteus*, Burm., from Angers; which he calls *I. Desmaresti*, and enters into an argument to show, that as Guettard's figures consist only of this species and *Calymene*, and as Brongniart refers them to his genera *Ogygia* and *Calymene*, he must have intended by his *O. Desmaresti* some of the specimens of the *Illænus*. Brongniart's description, too, contains references to the entire form; he says, " une fois et demie plus longue que large ; " which he could not have drawn from his own figured specimen, but which would agree well with Guettard's figures of *Illænus* under his eye. The author would therefore take away from Brongniart's species the diagnosis, and the figure by which it is illustrated (and which he admits to be a good figure of the *Ogygia*), and transfer the name, and so much of the description as will agree with it, to Guettard's *Illænus*, under the above name; giving to the *Ogygia* the new name *O. Brongniarti*.

Some additional notes are given on *Trinucleus*, first with reference to the propriety of Burmeister's division of Trilobites into those which have, and those which are deprived of the power of rolling up, as he believes that in this genus both divisions may be found; *T. granulatus* having the thorax-joints all soldered, while in *T. Pongerardi* the rolling is evident, and even twice upon itself—a condition more complete than in any other Trilobite. He mentions also that Green in 1832 showed that *T. tesselatus* could bend. He also goes over the history of the genus, and points out that Wahlenberg, Green and Corda describe the fringe without understanding its true structure, the nearest approach to a true description of it being found in the "Silurian System," where the name "*Tretaspis*," or perforated shell, is spoken of as appropriate for it. Beyrich, in 1846, had called the points 'alveoli,' and Barrande 'points.' He then refers to his own previously published account of its true nature as a hollow double crust, perforated by cylinders of shell, previously given in the "Bulletin," and proposes *T. Pongerardi* as the type of the genus.

A new species of *Calymene*, *C. Arago*, allied to *C. Blumenbachii*, but the tail with a many-jointed axis and smooth sides, is described and figured.—[J.W.S.]

On the Natron Lakes *in the Plain of the* Araxes. By Prof. H. Abich.

[From Bull. de l'Acad. de St. Pétersbourg, vol. v. p. 117.]

One of the least important of these lakes occurs about two wersts from the Armenian village Tasch-burun (*Stone-nose*) at the extremity of the extensive lava-mass, which in one of the most recent periods of volcanic activity in this district, has burst forth from a line of distinctly marked eruption-cones of considerable size at the north-west foot of the Greater Ararat, which seem as it were to push the declivities of the mountain forward into the plain. The extent of the lake is such, that the water-fowl frequenting it are, when in the middle, beyond gun-shot from any side. It contains a weak solution of common salt along with that mixture of Glauber-salt and carbonate of soda, which effloresces from the marly clays, that form the soil of the plain, wherever artificial irrigation has not been introduced, and a more or less vigorous vegetation of Gramineæ, heaths and soda-plants, been established.

In the warmest season of the year the water of the shallow lake retires three or four feet from its usual banks; on which a crust of salt a few feet broad and about half an inch thick is then deposited. It forms an irregular crystalline mass of porous cubes of common salt, the lamellæ and spaces between which are filled with the saline mixture just mentioned. It has in general a pale rose-red colour.

The water taken from the lake in the end of October contained in 100 parts 93·34 water and 6·66 solid anhydrous salt. Analysis showed the latter to consist of—

Sulphate of soda ($\dot{Na}\,\dddot{S}$)	10·36
Carbonate of soda ($\dot{Na}\,\ddot{C}$)	14·71
Chloride of sodium ($Na\,Cl^2$)	74·61

Hence 100 parts of the fluid contain only 2·63 per cent. $\dot{Na}\,\dddot{S} + 10\,\dot{H}$ and 1·78 per cent. $\dot{Na}\,\ddot{C} + 10\,\dot{H}$.

The composition of the salt-crust deposited in the warm season I found to be—

Carbonate of soda ($\dot{Na}\,\ddot{C}$)	22·91
Sulphate of soda ($\dot{Na}\,\dddot{S}$)	16·05
Chloride of sodium ($Na\,Cl^2$)	51·49
Water	9·88
Magnesia	traces.

By dissolving and recrystallizing I obtained natron mixed with Glauber-salt, which by repeated crystallization formed fine crystals.

Other lakes, very remarkable both for their geological relations and the salt they contain, lie to the south-east of the Little Ararat. On this side, and exactly in the direction of the longer axis of the system of Ararat, the Little Ararat has at one time opened about half-way up in a fissure and spread out over its gentle declivities towards the plain of the Araxes, that gigantic flood of dolerite, which pushes far down into the basin of Nachitschevan. Its principal branch follows a valley that opens in a south-eastern direction, on the right side of the Araxes, between a rocky chain of hills named Güsgündag (i. e. *Hill of the Sun's eye*, because it lies to the south), and a group of mountains which surround in a large semicircle the Little Ararat on the south and south-west, until it disappears entirely below the colossal lava-covering of the Carnijarach, the greatest of all the secondary eruption-cones of the Ararat system.

In this rather extensive valley, the bottom of which is only partially filled with the immense streams of lava, which have issued from the Little Ararat and the beautiful secondary eruption-cone of the Dujirdag on its lower declivities, a number of small lakes occur, in a white clayey formation, which rests immediately on the horizontal surface of the lava currents, which appear partially depressed in a singular manner ; whilst the borders of the streams are formed by a continuous series of wildly torn-up, long-extended swellings, similar in form and freshness of aspect to those I had seen on the large lava streams at the foot of Ætna.

One of these lakes, remarkable for the red colour of its waters, rendered more intense by contrast with the white ground enclosing it, had attracted my attention in a high degree when on the top of the Little Ararat. It lies on the left side of the valley, which there expands like an amphitheatre close under the steep, terraced precipices of the highest point of the Güsgündagrotte, which consists of various members of the old red sandstone, of dolomites and metamorphic slates of the transition formation, enclosing limestone with spirifer and productus—violently dislocated and heaved up by the red quartziferous porphyry which appears in great extent and in very interesting geological relations in the interior of the valley. In July 1845, I visited this lake, which is from one to two wersts in circuit. In crossing the white clayey soil, covered with a luxuriant vegetation of reeds and reed-like grasses, a strong alkaline odour, like that felt on entering a soap-boiler's workshop, was perceived. A broad zone of this snow-white soil, so soft that the feet sunk in it, formed the margin of the lake, and was covered with an accumulation of irregular lump-like incrustations of a very compact salt, of a white colour inclining to red, and with a foliated fracture. These saline crusts lay all around the white shore of the lake, chiefly floating in the water ; some fragments broken off floated about like ice-shoals on the deep red surface of the lake, which had quite the aspect of water almost on the point of congealing.

On examining the bottom of the flat lake-basin, so far as the difficult access to the shore would allow us to do with long Cossack spears tied together, I found it covered with a similar saline crust, which was quite continuous, and appeared to increase with the distance from the shore in such a manner as left no doubt that a layer of salt several inches thick extends over the whole bed of the lake.

These crusts have a high specific gravity and a very remarkable structure. They consist of a very compact, intimately connected aggregate of diverging (scopiform) bundles of crystals, like some varieties of radiating zeolite, whose dull, rounded extremities form the roughly mammillated surface of the crust. On the cross fracture the thick rind shows distinctly a whole series of such thin crystalline layers, firmly interwoven with each other. The fractured surfaces of this interesting salt show a strong pearly lustre, whilst its colour is exactly that of the carbonate of manganese-protoxide. The curious colouring-matter of the saturated solution which fills the lake, has concentrated itself in a dark-red coating on the horizontal divisions, and also on the under surface of the crust where it adheres to the clay bottom.

The salt mentioned above as floating on the surface of the water is only distinguished from that just described by less compactness in the union of the layers which are scarcely a line in thickness, and being separated from each other by small horizontal spaces, have a more laminar aspect. It is also nearly pure white, with a pale rose-red tinge.

The salt from the bottom of the lake had the following composition :—

Sulphate of soda ($\dot{Na}\ \dddot{S}$)	74·44
Carbonate of soda ($\dot{Na}\,\ddot{C}$)	18·42
Chloride of sodium ($Na\ Cl^2$)	1·92
Water	1·18
Manganese and magnesia	traces
	98·96

This salt ignited in the platina capsule retained its crystalline character and pearly lustre to the point of fusion, but assumed the colour of chloride of silver. It requires a continuous and strong ignition over the spirit-lamp to cause it to fuse.

The salt from the surface of the lake had this composition :—

Sulphate of soda	80·56
Carbonate of soda	16·09
Chloride of sodium	1·62
Water	0·55
Magnesia and Manganese	traces
	98·82

The almost entire absence of water of crystallization, as well as the physical peculiarities of these salts, are remarkable facts, and show that the sulphate and carbonate of soda in the anhydrous condition can, in favourable circumstances, combine in a double salt. The combination is not subject to deliquescence, and it would appear has no tendency to attract moisture, for masses of it placed for a long time in damp situations yield no more water than those previously exposed to a strong heat. The affinity of the two salts, conducing to the formation of an anhydrous double-combination, must be stronger in the given conditions than that of water to either ; for in no place could any other crystallizations be discovered in the fluid. Hence this salt forms in reality a new mineral species, most nearly allied to the Thenardite, and which might not inappropriately be named Makite, as the lake is situated in the territory of the Chan of Maku.

The water of the lake itself has entirely the colour of a concentrated solution of sulphate of manganese-protoxide*. In 100 parts

* The peculiar colouring principle is not known to me at present. I have examined it for Bromine, but without finding any trace of this substance. I would conjecture that it is some vegetable matter.

it contains 30·63 of a mixture of salts in the following proportions:—

Sulphate of soda	18·18
Carbonate of soda	12·08
Chloride of sodium	69·73

Traces of magnesia and a little manganese.

On my retutn to my quarters between the Great and Little Ararat, part of a bottle containing the solution became filled with beautiful crystals of Glauber-salt, which only partially again dissolved in the higher temperature of the Araxes plain.

In the immediate vicinity of these red lakes a number of small pools occur on the same level, distinguished by the absence of all salt-crusts and by the wine-yellow colour of their alkaline waters. These small lakes are true reservoirs of carbonate of soda, and thus undoubtedly the most interesting phænomenon of this singular locality.

This alkaline solution contained in 100 parts 34·70 parts of a salt with the following composition:—

Carbonate of soda	68·90
Sulphate of soda	15·55
Chloride of sodium	15·50

In the bottle containing a quantity of this solution, a tabular crystalline mass of carbonate of soda, occupying nearly the whole volume of the fluid, formed in the same circumstances as in the saturated solution of Glauber-salt mentioned above.

Two or three wersts from these lakes, in the prolongation of the valley, where it expands into the plain of the Araxes, two other lakes of considerable size occur. The larger, with an area of five or six square wersts, extends even beyond the valley, the widest part lying in the plain. These lakes much resemble that of Tasch-burun, but in a solution of equal strength the amount of Glauber-salt and carbonate of soda is greater than in the latter.

The existence of these lakes as perennial receptacles of water depends evidently on the Karassu-springs, which issuing from below the lava, form small reedy marshes, and, uniting their waters in broad, shallow hollows, expose an extensive surface to rapid evaporation. The lake of Tasch-burun, which has no outlet, probably originate in the same cause, acting at the bottom of the basin. There can be no doubt, that within the district occupied by these lakes, an immense quantity of Glauber-salt and soda in a solid form as an anhydrous salt, could be collected in a short time and at a comparatively small expense. J. N.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

INDEX PALÆONTOLOGICUS, *or Review of all known Fossil Organisms, prepared with the Co-operation of* Prof. H. R. GÖPPERT *and* H. v. MEYER, *by* Dr. H. G. BRONN (*oder Uebersicht der bis jezt bekannten fossilen Organismen, unter Mitwirkung der* Herren Prof. H. R. GÖPPERT *und* H. v. MEYER *bearbeitet, von* Dr. H. G. BRONN).

THIS work forms the third volume of 'The History of Nature' by Professor Bronn, the well-known author of the 'Lethæa geognostica' and other works on fossil geology. It is divided into two parts, of which one, under the title of "Nomenclator palæontologicus," gives a list of all known names of fossils in alphabetical order. The other part, entitled "Enumerator palæontologicus," contains the species classed in systematic order, with indications of the formations in which they occur, thus forming a "history of the appearance of the individual organic beings on the surface of the globe." The preparation of such a work, as the author remarks, is subject to many difficulties, especially in the determination and comparison of the organic remains described by different persons in different places, and in the synchronizing and grouping of the various geological deposits in which they occur. The very partial and limited investigation of the different formations of the earth's crust compared to their entire extent, is also a great obstacle to rendering such a work perfect.

The second part of the work, or the systematic arrangement, occupies a volume of 726 pages. Each genus is classed in its proper place under the great natural-historical divisions of the animal and vegetable kingdoms. The specific names follow, but seldom systematically arranged, being more generally classed according to the order of the formations in which they occur, beginning with the more ancient. The following may be considered as the general plan of the work. Each page is divided into eight columns, of which the first contains the names of the families, genera and species, distinguished by difference of type, the higher divisions being repeated at the top of each page. The second column marks the region of the globe in which the species occurs, the five quarters being designated by letters, and the different zones in them by numbers attached. The six remaining columns are appropriated to the various formations, of which he adopts the following periods and subdivisions :—

I. Carboniferous Period	*a.* Lower Silurian.
	b. Upper Silurian.
	c. Devonian.
	d. Mountain limestone.
	e. Coal formation.
	f. Lower New Red Sandstone (*Todtliegende*).
	g. Magnesian limestone (Zechstein).
II. Trias or Salt Period.	*h.* St. Cassian beds.
	i. Bunter or Variegated sandstone.
	k. Muschelkalk.
	l. Keuper, or Upper New Red Sandstone.
III. Oolitic Period	*m.* Lias.
	n. Lower Jurassic.
	o. Upper Jurassic.
	p. Wealden.
IV. Cretaceous Period .	*q.* Neocomian.
	r. Greensand.
	f. Chalk.
V. Tertiary or Molasse Period.	*s.* Nummulite formation.
	t. Lower Tertiary.
	u. Middle Tertiary.
	v. (Molasse.)
	w. Upper Tertiary.
	x. Diluvial.
VI. Recent Period	*y.* Alluvial.
	z. Living.

Some of these divisions do not represent formations chronologically distinct, but are introduced only provisionally from uncertainty as to the true position of the beds included in them. Others again should probably be further divided, though the want of precision in the nomenclature and divisions of various authors renders this at present impossible. Thus the St. Cassian beds, *h*, are kept separate until it is determined whether they form a distinct chronological formation between the Zechstein and Muschelkalk, and hence probably better following *i*, or are merely a peculiar facies of the Muschelkalk. In the oolitic series no further subdivision between the lias and the Kimmeridge clay could be effected ; and though it was at first attempted to place a limit between the Oxford clay and the coral rag, this had subsequently to be given up from the multitude of common species. The Wealden is kept separate, some geologists regarding it as only the lacustrine aspect of the Neocomian. In the latter, *q*, the lower greensand of Dr. Fitton is included, but his greensand from Blackdown is united with the greensand *r*. This formation, however, presents many difficulties, so that a true and certain arrangement is scarcely possible. The Nummulite strata are also kept distinct, though the author has no doubt of their true position in the eocene tertiaries. The Molasse, *v*, is placed between the middle and upper tertiaries, its vertebrata corresponding more to the lower, its shells to the higher position.

The following table, which we have drawn up from these lists, contains an approximation to the number of known fossil species in each of the great divisions of the vegetable and animal kingdoms. Many of these are, however, duplicates, which on a thorough revision of the different families would require to be suppressed. Prof. Bronn thinks that in the invertebrate classes the known species are perhaps a fifth fewer than the names in his list.

VEGETABILIA.			
Plantæ cellulares		773	
Plantæ vasculares.			
Monocotyledones		1138	
Dicotyledones		725	
Organa plantarum, &c.		34	
Plantarum summa		——	2670
ANIMALIA.			
Phytozoa.			
Pseudozoa		2	
Amorphozoa		462	
Polygastrica		672	
Polypi.			
Polythalamia	893		
Bryozoa	810		
Anthozoa	825		
	——	2528	
Entozoa		0	
Acalephæ		43	
Echinodermata		1189	
Incertæ classis		5	
		——	4901
Malacozoa.			
Gymnacephala		1	
Brachiopoda	952		
Rudistæ	194		
	——	1146	
Pelecypoda.			
Monomya	1066		
Dimya	3650		
	——	4716	
Pteropoda		41	
Heteropoda		85	
Protopoda		120	
Gasteropoda		6110	
Cephalopoda		1452	
		——	13,671

Entomozoa.		
Vermes	288	
Crustacea	894	
Myriapoda	17	
Arachnoidea	131	
Hexapoda	1551	
		2881
Spondylozoa.		
Pisces	1318	
Reptilia	384	
Aves	148	
Mammalia	705	
		2555
Animalium summa		24,008

The total number of fossil species enumerated in this portion of the treatise therefore amounts to 26,678. In the continuation of the work, the author intends to present the general geological and zoological conclusions derived from this view of the periods at which the various races of organic beings first appeared on the globe. [J. N.]

Notes on Trilobites. By M. Barrande.

[From Haidinger's Berichte von Freunden der Natur, in Wien, vol. iv. p. 353.]

Whilst investigating the Bohemian trilobites, M. Barrande has come to the conclusion that no good classification of this family has yet been proposed. The division according to the peculiarities of the eyes, as wrought out by Goldfuss, Quenstedt and others, though based on an important character, is yet too artificial, and has too little regard to the diversity of other organs. Burmeister has selected the capability of rolling themselves up, as the basis of his highest divisions; but M. Barrande by careful search has succeeded in finding individuals of all species of trilobites, even those said not to possess this power, rolled up, and consequently this distinction fails. The classification in Corda's work on the Bohemian trilobites is founded on a character of small importance in regard to the entire organization of the animal, namely on the peculiarity of the caudal plate (*Pygidium*) as either entire or divided on the margin. By this classification, species of one and the same genus are placed in two distinct sections of the family; as for example, *Phacops stellifer* is distinguished by no character, except the divisions of the tail, from the other species of *Phacops* in which it is entire on the margin. M. Barrande thinks that a good classification, on which M. L. von Buch is said to be at present engaged, will only be possible when a greater number of species are known; and recommends special research to be made for them in localities where they abound.

The largest Bohemian species known to him is the *Paradoxides Linnei,* which attained a foot in length. One of the largest species is the *Asaphus nobilis,* which is also remarkable for the sculpturing of its shell.

An interesting peculiarity of many species of *Odontopleura,* particularly *O. Buchii* and *Keyserlingii,* is that some individuals are distinctly narrower than the others, with which they perfectly agree in all other respects. M. Barrande is inclined to refer this distinction to difference in sex, the narrower specimens being males, the broader females.

The same genus, *Odontopleura*, shows the care necessary in forming new species; almost every individual has a different number of spines on the tail, so that this forms no ground for distinguishing species. Even the nature of the stone in which they are imbedded produces remarkable differences: thus in the slates all the projecting ridges, &c. are pressed flat; in the quartzites, on the contrary, they preserve the same prominence as during the lifetime of the animal.

The compound eyes are in many specimens singularly well preserved. In the eye of a *Brontes palifer* M. Barrande counted nearly 30,000 lenses. [J. N.]

Observations on the Relation between the Mineral Character of the different Formations and their Vegetable Productions. By M. J. Durocher.

[Comptes Rendus, tom. xxvii. p. 506.]

In the course of the many years that I have been engaged in examining the west of France, I have observed numerous facts regarding the influence of the mineral nature of the different formations on the development of plants, of which the following are a few:—

In an agricultural point of view, the formations composing the subsoil of Brittany and the neighbouring districts may be divided, without regarding their geological age, into five classes: 1. granite and crystalline schists (of granitic elements); 2. clayslates and greywackes; 3. quartzite or sandstone, and quartzose schists; 4. tertiary deposits of an argillaceous-gravelly or pebbly nature; 5. calcareous formations. In another respect three great *agronomique* divisions may be formed: 1. cultivated ground and meadows; 2. the forests; and 3. the landes. During my geological studies I have determined the manner in which the landes and forests are distributed over the surface of these various formations. I have remarked that in Brittany and the surrounding countries they are generally confined to two kinds of formations—to the argillaceous-pebbly tertiary deposits, and more especially to the quartzite and quartzose schists. The latter variety of soil, though comparatively it does not occupy a very large extent of surface, still in many departments presents a greater extent of landes and forests than all the other formations conjoined. Landes and forests are also occasionally observed on granite, principally in Morbihan; but they are less frequently seen on the clayslate and greywacke, and very rarely on the calcareous formations.

The peninsula of Brittany presents four zones well-characterized by their geognostic and agricultural characters: a littoral zone, comprising the two coasts north and south, formed chiefly of granite and crystalline schists; secondly, a central zone composed of clayslates and greywackes, sprinkled with a few tertiary deposits; and lastly, the two zones that separate this central band from the coasts, consisting of quartzose rocks, intermixed with schists and some granite masses.

The littoral region is the most fruitful in grain and the most densely peopled, both from its fertility and on account of its maritime commerce and fisheries; then follows the central zone, possessing the largest extent of meadows, and yielding the greatest amount of dairy produce; the two intermediate zones, formed chiefly of quartzose rocks, are inferior in population and in fertility; they are the region of landes and forests, in which all the iron furnaces are grouped together.

It is principally in the eastern part of Brittany that a large extent of landes is found on the argillaceous-gravelly and pebbly tertiary deposits. South of the Loire they all occur on these deposits, that country containing no quartzose rocks; and, I may add, most of the forests of Normandy and Maine cover either the tertiary or quartzite formations. That much wood and landes occur on the tertiary deposits arises in general from the very argillaceous nature of these formations, which are too compact, and difficultly traversed by water, or even wholly impermeable. Many of the soils that cover the quartzites show the same influence, being also very argillaceous; though there are some with no argillaceous beds, when frequently the soil, composed almost entirely of siliceous detritus, is too poor, too dry, and thus with the contrary defect to that just now mentioned. This occasionally occurs on the top of hills formed of granite. The landes observed on the quartzose or granitic formations are constantly on high ground; whilst those covering the tertiary deposits are frequently in low situations.

In the west of France the kind of cultivation and the species of plants growing naturally vary from one formation to another. The most striking differences are caused by the sandy or clayey nature of the soil, by the presence of calcareous matter either existing naturally or introduced artificially, and finally by the complex influence of the vicinity of the sea. The schistose formations and the argillaceous tertiary deposits show the greatest extent of pasture-land and those beautiful meadows which charm the eye by their perpetual verdure, thanks to the humidity of the soil; but they are less adapted for fattening horned cattle than the argillo-calcareous soils, where the pasture is more rapidly restored, and which produce a greater variety of plants, especially dicotyledons.

The culture of buckwheat extends universally over every part of western France that is composed of ancient rocks, and consequently presents granitic, argillaceous or siliceous soils. Much less buckwheat is produced, and the cultivation of wheat and other plants, regarded as exhausting to the soil, is extended in the regions where the activity of vegetation can be promoted by the use of lime, as chalk, marl, shell or other calcareous sands, and thus in the maritime zone or near the limestone formations. When quitting Brittany, we enter the plains or plateaux of Normandy, in which the secondary limestones crop out, the cultivation of the buckwheat is seen at once to cease, and the aspect of the country undergoes a complete change. The undulating surface of Brittany is divided into an infinite number of minute fields, separated by ditches and hedges so covered with trees that the country seems to the eye like an immense forest. On the other hand, the secondary limestones form very level plateaux, with extremely little wood; and the trees too are of a different kind; the oak and chestnut, which abound in the fields in the ancient formations, being replaced by the elm. A similar change may be observed in the small limestone basins which occur in Brittany and on parts of the coast. In the same manner as the elm, the maple (*Acer campestre*) and the walnut are more developed on the calcareous soil; the birch, the willow, the oak, and the chestnut thrive better on the argillaceous and siliceous formations. The maritime pine is cultivated with success on the same soils, even in the most interior localities; the beech appears to prefer the granitic soils. The furze (*Ulex europæus*) and broom (*Sarothamnus scoparius*) grow spontaneously, or are cultivated on the older formations, but not on the limestone soils. The colza (colewort) and tobacco flourish in some parts of the littoral region, and the lucerne also succeeds there. In like manner, as on the calcareous soils in the interior, the peat-mosses in the west occur principally in its low lands.

Among the plants growing spontaneously, few can be cited as exclusively characteristic of the schists, the sandstones, or the granites, though many are found on one soil rather than on another. The vegetation of the argillaceous or siliceous tertiary deposits also offers few peculiarities when compared with that of the primary or transition formations. The most striking contrast is between the flora of the calcareous soils and those soils which do not contain lime in notable quantity; but these differences are becoming less sensible, as calcareous substances are more generally applied to improve the soil. A certain number of plants are found both in the maritime region and on the few, small, calcareous deposits occurring in Brittany, but rarely or almost never on other formations: among these are *Linum angustifolium, Silene inflata, S. gallica, S. otites, S. conica, Reseda lutea, Asperula cynanchia, Ononis repens, Anthyllis vulneraria, Poterium sanguisorba, Eryngium campestre, Scabiosa arvensis, Anchusa italica, Linaria minor, L. supina, Salvia verbenaca, Erigeron acre, Thesium humifusum, Chlora perfoliata, Iris fœtidissima,* &c. Certain plants which differ from the former in appearing not to suit the maritime region, grow exclusively on calcareous soils, or are more frequent there than in other places. Such are the *Orchis pyramidalis, O. hircina, Ophrys apifera, Op. aranifera, Lepidium campestre, Thlaspi perfoliatum, Diplotaxis muralis, Dianthus carthusianorum, Lithospermum officinale, Helianthemum vulgare, Astragalus glycyphyllos, Medicago marginata, M. Gerardi, Hippocrepis comosa, Scabiosa columbaria, Stachys germanica, S. annua, Galeopsis ladanum, Calamintha acinos, Melampyrum cristatum, Cichorium inthybus, Centaurea scabiosa,* and many other species. In general the soils covering the tertiary or jurassic limestones appeared to present a greater number of characteristic plants than the soils lying on the palæozoic limestones or on the marbles, undoubtedly because the latter being less friable have yielded less detritus to the vegetable soil.

The influence of the limestone formations shows itself even on animal life. It manifests itself in the development of freshwater and terrestrial shells. So also the crabs abound in many of the rivulets n the districts containing limestone rocks, whilst it is rare to find them in other formations where the running water appears to be incapable of furnishing these crustaceans with an amount of calcareous matter sufficient for the formation of their integument. Analogous considerations may perhaps contribute to explain the absence or rarity of testaceous animals in certain geological formations. [J. N.]

On a new Pyrenean Type parallel to the Chalk. By M. Leymerie.

[Comptes Rendus, tom. xxviii. p. 738–740.]

This formation has been particularly studied near Monléon and Gensac, between the Hautes-Pyrénées and Haute-Garonne, where the fossils are abundant and easily collected, but extends over the whole breadth of the latter department. In these localities it usually occupies the sides of hills, the summits of which consist of the tertiary formations. It is composed of yellowish and grey marls and marly limestones, resting on a white limestone with very few fossils, and is of moderate thickness. The strata, badly characterized, in general dip irregularly towards the north. In regard to its geological position, it is placed between two systems ; the lower composed of limestones and black slates, with conical orbitolites and caprotinæ (*calcaire à Dicérates,* Dufrénoy) ; the upper the *terrain à nummulites* or *épicrétacé.*

Its fossils have been carefully studied. In forty-two well-marked species, twenty-five are new ; the remaining seventeen belong to almost all the chalk-beds from the *craie chloritée* to the upper Maëstricht chalk. The chief species of the lower chalk are, *Ostrea lateralis,* Nilsson ; *Terebratula alata,* Lamk. ; *Ammonites Lewesiensis,* Sow. ; *Baculites anceps,* Lamk. Those indicating the common white chalk are, *Ananchytes ovatus* (var.), Lamk. ; *Pecten striatocostatus,* Goldf. ; *Spondylus Dutempleanus,* d'Orb. ; *Ostreav esicularis,* Lamk. ; *O. Larva,* Lamk. ; *Terebratula alata,* Lamk. Lastly, a very marked analogy with the chalk of Maëstricht is indicated by the following fossils :—*Hemipneustes radiatus,* Agass. ; *Thecidea radiata,* Def. ; *Natica rugosa,* Han. ; *Pecten striatocostatus, Ostrea vesicularis* and *O. Larva.* These fossils are not disposed in groups according to their supposed antiquity, but occur mixed together at all vertical heights. The ammonites and baculites, indeed, are found only in the lower beds, but along with fossils of the white and even of the Maëstricht chalk.

A remarkable palæontological paradox is the presence, as common and characteristic fossils in the lower part of the marly system, of the *Terebratula Venei,* Leym. and the *Ostrea lateralis,* Nils., species which occupy a no less important place in the department of the Aude, in the middle of a fauna essentially tertiary.

A prodigious quantity of discoidal orbitolites found in several places, characterise this formation as a Mediterranean type ; but not even a single nummulite has been as yet discovered in it, that fossil being confined exclusively to the superior system. [J. N.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Some considerations on Palæontological Statics, *drawn up from the 'History of Nature' (Geschichte der Natur), or Index Palæontologicus.* By Professor H. G. Bronn.

(From Leonhard and Bronn's 'Neues Jahrbuch, Jahrgang 1849,' p. 123.)

Four years ago Professor Göppert published a report in the 'Jahrbuch' (1845, pp. 415–418), on the present state of our knowledge of fossil plants. This was an extract from his contribution to the Index Palæontologicus of our 'History of Nature,' in which, however, some additions have subsequently been embodied, to which we have regard in what follows. The zoological portion of this treatise was completed two years ago, and the printing (extending to 130 sheets) is also finished; so that we are now able to give a general review of the whole, in the four following tables, which, however, are not so detailed as in the above place, and also require some further illustration. We will therefore endeavour to extract a few of the most essential results from out the sea of figures.

In the Enumerator palæontologicus, which forms the second part of the Index, we have enumerated the genera (*Sippen*) and species (*Arten*) of fossil bodies, according to the geological periods and formations in which they occur, under five larger or more extensive, and in twenty-four smaller or more limited heads, of which the first are marked with I—V. and the second with *a—x*. These signs are more fully stated in the table below, and in the following pages will often be used for the sake of brevity to designate the different formations.

I. Carboniferous Period.							II. Trias Period.				III. Oolite Period.				IV. Cretaceous Per.			V. Tertiary Period.						I—V.	
Lower Silurian.	Upper Silurian.	Devonian.	Mountain Limestone.	Coal-formation.	Lower New Red Sandstone.	Zechstein.	St. Cassian beds.	Variegated Sandstone.	Muschelkalk.	Keuper.	Lias.	Oolite.	Kimmeridge Clay.	Wealden.	Neocomien.	Greensand.	Chalk.	Nummulite formation.	Calcaire grossier.	Middle Tertiary.	Molasse.	Upper Tertiary.	Diluvial.	All fossil species together.	Living.
a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	ſ	s	t	u	v	w	x	y	z

There is still some uncertainty about the right arrangement of several rock formations. A very considerable number of species are enumerated by Phillips as common both to the Devonian and Carboniferous formations, being quoted from the one in his 'Geology of Yorkshire,' from the other in his 'Palæozoic Fossils.' The St. Cassian beds are placed, according to the former state of our knowledge, under the head *h*, and in II. or the Trias period, on the boundary of I. or the Carboniferous; whereas according to the most recent geological investigations they come above the Muschelkalk or *k*; and the only undecided question is, whether they should be conjoined to this as its higher division with a peculiar aspect (*Facies*)—as a coral-reef variety—or must be regarded as the oldest member of the Lias formation, since they contain two or three lias ammonites, whereas the other petrefactions rather favour the Muschelkalk. The red ammonite-marbles are joined to the lias, although now they appear, at least in part, rather to fall under the oolite series *n*; whilst the ammonite-marbles with *Terebratula diphya* are included as Neocomien under *q*; it being still undecided whether the *Terebratula diphya* may not be divided into two species of distinct age. —In regard to the Oolite, in very many cases, it was not possible, from the existing data, to determine with sufficient certainty the member of the formation in which this or that organic remain occurred; and hence almost the entire oolite series, from the lias to the Kimmeridge clay, had to be comprised under one head marked *n*, although in many cases where it was possible, the subdivisions of this formation are more particularly distinguished in the Enumerator (as n^1, n^2, &c.).—Some English fossils, which are included under the Greensand [Gault] *r*, should perhaps be added to the Neocomien, as in England geologists have only recently begun to distinguish these two formations. On the other hand, it is probable that some Glauconie beds *f'*, with their organic remains, especially from Germany, have been conjoined with the Greensand (Gault), the two formations having hitherto been often confused; the latter also probably contains a number of species common to it with the Chalk *f*, which in reality do not occur in both. Some time ago it became customary to distinguish from the other deposits a peculiar nummulite formation, which had immediately to be again divided into two or three formations of distinct ages, of which two are placed between the white Chalk and the Calcaire grossier (Grobkalk), so that the one shall belong to the cretaceous, the other to the tertiary period. Besides, there is in the Etang de Berre another nummulite formation with hippurites, which consequently should be classed in the lower part of the white chalk. Our enumeration was produced whilst these views were in process of formation, and the result of this has been, that whilst the Glarus slates, which are conjoined with one nummulite deposit, are placed under *r* (probably however too low?), the tertiary nummulite rocks in the Paris Calcaire grossier, and at Monte Bolca, as well as in the Val Ronca, remain united with the Calcaire grossier formation under *t* (and τ), whilst only a few small nummulite deposits, whose age was not certainly determined at that time, are inserted between *f* and *t* in a peculiar column *s*. The head *v* is designed for the Molasse, and contains the fossil remains from certain rocks, of which it is uncertain whether they should be reckoned to the middle or upper tertiary strata: whenever this question is decided, the contents of this head will fall to be divided between the two adjoining divisions. In like manner, if only formations of distinct age were classed under separate heads, the head *x*, for freshwater diluvial formations, should vanish and be conjoined with *w*, as in reality several species of mammalia are common to both. We would thus, on the whole, obtain only 21 to 22 instead of 24 formations.

But irrespective of these difficulties, the complete enumeration of fossil bodies has another class of hindrances to contend with. The stratum in which many species, and hence even genera, occur, is unknown; and whether we omit them altogether, or class them in all possible formations, or in one period and formation selected arbitrarily, still the truth must suffer. A large number of organic remains appear under two or three synonyms, which for want of accurate comparison cannot be conjoined, and hence must be numbered two or three times over, although they occur only once. This happens especially in the polyparia and mollusca, the synonyms of which have not yet been sifted and arranged in any monographical work; whereas the polygastrica and foraminifera by Ehrenberg and D'Orbigny, the crustacea by Behrendt, Burmeister, and others, the echinoderms and fishes by Agassiz in special monographs, the plants and the three higher classes of the vertebrata by Göppert and H. v. Meyer for the 'History of Nature' itself—have all been so carefully wrought out, that in these parts but few synonyms now appear among the true species. But among the polyparia and conchyliæ the species depending on mere synonyms may amount to 0·10 to 0·20. We have also, with few exceptions, made it a rule, where fossils appear under unsuitable specific or generic names, still in this catalogue to form no new names, but to leave this to future monographs, and were consequently compelled to quote many species under unappropriate genera, as has been occasionally pointed out in the Enumerator itself;—there are likewise a number of genera wholly or partly synonymous, which for the same reason we must allow to remain, although this also, in the majority of cases, is indicated in the Enumerator: such species consequently could not always be counted in the proper place and under the right family; and the number of the genera has thus also turned out rather too large, although in the summing-up attention was for the most part paid to these circumstances. If in this manner a greater number of fossil species and genera appear than were really before us, yet on the other hand the deduction to be made on this account is more than compensated by the new discoveries made during the last two years since the completion of our work, though these indeed extend over the whole system, and do not exactly fall in those orders in which they were wanted to supply these defects. Many insects and species of birds are only noticed under the proper families and orders, since their genera were not determined, and consequently they could only be assumed as divided among those that were determined; but a great part of the species of insects from the amber, noted in this manner by the Breslau entomologists, probably agree with those of which Behrendt has given a list, and thus the number of amber insects seems larger than it really is. A great part of the genera of plants and fish are founded merely on leaves, stalks, and fruits, or on scales, teeth, and fin-spines, so that one species may appear not only in three genera, but also under three to six specific names. Many plants especially are enumerated under peculiar names, although their fossil remains cannot be distinguished from certain living genera, and hence must be united with them (Pinites, Pinus—Acerites, Acer, &c.); and the fossil ferns particularly are divided into genera from the form of their leaves, which, were the fructification of all of them known, might perhaps fall under those genera which have been established for the existing ferns. The views of the different palæontologists who have been engaged on these remains, and several of whom will not admit of any species common to the living and extinct creation, or to different periods or even formations, have had great influence on the nomenclature, which has again affected the following collected results.

Finally, were even the whole of these difficulties attaching to the preparation of such a work overcome, a third class of them would still remain, preventing us from instituting a just comparison between the former organic world and that which now exists. They depend on this, that we do not know even the actual creation accurately enough, that we know still less accurately all that portion of former creations which lies buried in the bosom of the earth, and lastly, that the part which is here buried represents but very imperfectly the whole which once existed. Many soft naked animals are altogether unfit for becoming fossilized, as the greater number of infusoria (soft polygastrica, as the rotatoria), the entozoa, the acalephæ, naked annelids, tunicatæ, and other molluscs, even some scaleless, cartilaginous fishes. In other animals a whole series of favourable conditions must be combined in order to their preservation in the strata of the earth, so as to be recognizable in after-times. Remains of land-animals and land-plants can only reach the water by accident so as to become imbedded in the strata deposited from it; even when arrived there, except in very rare cases, we could never expect the soft cellular tissue of plants and animals, but merely, in favourable circumstances, of the former the woody fibres of the vascular plants, of the latter the horny parts—more readily the earthy portions of the skeleton, as bones, spines, teeth, scales, shells, polypidom, bucklers,—to be preserved either immediately and continuously,—or at least so long that they should form an enduring impression, whether sufficient or insufficient for identifying them. Calcareous strata are peculiarly favourable for the preservation in a determinable condition of calcareous and siliceous remains; siliceous strata for that of woody bodies; clays for vegetable substances in general, and the horny (chitine) portions of the animal kingdom; whilst in sand and sandstone strata almost no calcareous, in limestone almost no vegetable remains can be preserved. In order, therefore, that these remains should come down to us in a recognizable condition, it is not only necessary that they should reach the water and sink to the bottom of it whilst it was forming a deposit, but this deposit must also be of that nature which is adapted for the preservation of that peculiar kind of organic remain; it must exclude the action of the air as well as of mechanical forces with sufficient rapidity before these remains are decomposed or destroyed; it must consolidate with sufficient quickness, or increase so slowly in weight as not to crush them into a wholly undeterminable condition. The inhabitants of the sea with characteristic, hard, earthy parts are much more favourably situated. They occur always in the same element from which the strata are deposited, and consequently are at all times in a position to be enclosed in them. Let any one consider an existing continent and ask himself how many of its organic beings could probably be recognized from their remains which might be preserved in the recent stratified formations of this continent, as for instance in lakes, in river deposits, on the sea-coasts, or below mountain slips: not a thousandth part of the species would be again distinguishable. Let us imagine this continent sinking one portion after another, step by step, below the sea, which along one part of the new coast soon spreads out new strata over it, whilst on the shore all the organisms sunk along with it lie open and uncovered, exposed to destruction from the water and the ravages of its inhabitants. How small the probability after a thousand years, supposing it possible to turn over all these beds, that the remains found in them would enable us to form an image of the former fauna and flora of this portion of the globe! But how little do we really know of the strata of the earth! How large is that part of the rock-formations of Europe, the interior of which is unknown, compared with the strata which have been examined at their outcrop! And how much smaller is the portion of the earth's surface examined in a similar manner in other quarters of the globe! Finally, should we attempt to institute a comparison between the distinguishable fossil beings and the present creation, what is the present creation? Does it consist of 100,000 or 200,000 species of animals, of 70,000 or 150,000 species of plants? and how many genera does it contain? What is a species? and what indeed is a genus? Cuvier twenty-five years ago believed the surface of the earth so well explored, that there was but little hope of many new species of large animals being discovered. Now certainly the number of very large species has not been great; but the highest class of animals, the mammalia, has since 1829 increased from 800 to 2000 species. The birds have never been completely described. The work on the species of fish is also still unfinished. Count Dejean has about 30,000 species of Coleoptera alone in his collection, ten times as many as are known in the whole class of the Diptera; and yet Wurtemberg, which has been carefully explored in regard to both classes by Roser, furnishes at least full as many Diptera as Coleoptera. We have assumed the number of genera of living insects quite arbitrarily at 4000; perhaps we ought to assume 5000, 6000, 7000 or more; the extent of a genus is almost entirely arbitrary. And how shall we distinguish genera of organisms, whose remains, occurring too only as rarities, are so imperfect, so crushed, so small, so unlike those parts on which existing genera depend, as is the case in regard to insects? How shall we distinguish genera from such unimportant external parts as the shells of the Asiphonobranchiæ among the molluscs, a group, of which the soft inhabitants even in the existing world are for the most part not examined, but only distributed by chance among the established genera of shells? How shall we recognise fossil genera from the leaves and wood of plants, when we are not able to determine even existing genera from their leaves and wood?

It thus indeed seems too early to institute a comparison between the present and former creations; these difficulties must first be set aside, these doubts solved, these deficiencies filled up! But will they ever all be so? Will even a considerable portion of them soon be so? We are not bound to wait for this, but only, when instituting this comparison, to keep in remembrance, that all the imperfections just mentioned attach to this comparison. It is necessary for us to remember that when we express the results of this comparison in mathematically precise terms, these yet are only inexact, approximate values, according to the present momentary condition of our knowledge,—that those results which are deduced only from single small numbers, are of much inferior value to those which depend on the combination of higher numbers,—that the image (*Bild*) here given depends on the sum of the previous considerations, and that new observations may in the course of years very considerably modify it, even although many of the results it contains must already be regarded as firmly established for ever.

[In explanation of the following tables we must premise that the columns with the headings a g, m p, g f and s x, contain those sums arising from the addition of the columns between these two letters (a g = a b c d e f g), which sums naturally are too large, since many species, genera, &c. occur more than once in them, and on this account immediately after, under I, II, III, IV, V, the true sum of the genera and species is given. This also happens in the last column but one of Table II. with the lines a—x and I—V, of which the latter is again too large, and the true sum is therefore given in the last column*.]

---

* As stated above, Professor Bronn, in preparing his summary, has occasionally made allowance for errors in the lists, and the number of species in these Tables consequently varies slightly from that given in the Journal, p. 33, above, which was drawn up from the work itself. The *Plantæ cellulares* are there also erroneously stated at 773 instead of 193, the number of names in the list.—J. N.

	V. Tertiary Period.					I—V.	
	t	u	v	w	x	All the species together.	Living. z
I.	136	319	110	48	4	2055	69,403
Cellular	4	34	19	4	...	188	9100
Vascula	132	285	91	44	4	1867	60,303
Mono	132	31	12	3	...	1139	10,629
Dicot	108	254	79	41	4	728	49,674
Mo	28	122	38	23	4	358	3246
Co	..	13	14	1	...	28	23,900
Ch	74	68	27	9	...	175	22,528
Du	6	51	...	8	...	167	...
II.	383	476	502	412	278	4895	4818
Pseudoz	1	...	...	...	...	2	50
Amorph	12	6	47	9	30	461	250
Polygas	1	...	369	29	223	672	500
Polypi	269	390	77	365	21	2528	1810
Fora	97	184	65	220	10	893	1000
Bryo	79	129	4	51	3	810	380
Anth	93	77	8	94	8	825	430
Entozo	..	...	...	...	...	...	1500
Acalep	9	7	...	2	...	43	210
Echino	91	73	9	61	4	1189	498
Stell	6	3	2	5	...	416	286
Echi	84	70	7	56	4	770	146
Fistu	1	...	...	...	...	3	66
II	25	2725	783	1609	642	13,885	11,482
Tunica	1	...	...	...	...	1	71
Brachi	13	6	...	23	4	1146	48
Pelecy	05	783	164	556	189	4836	2413
Pterop	2	8	...	2	8	41	62
Hetero	..	...	...	...	...	23	85
Protop	32	24	1	34	8	120	64
Gaster	54	1892	218	984	439	6110	8673
(C	70	1540	152	853	300	5281	5520)
Cephal	18	12	...	4	...	1546	128
I\	85	251	1381	91	9	2885	67,360
Verme	49	27	1	22	5	292	770
Crusta	36	46	14	67	3	894	791
Cirri	6	23	1	39	2	87	107
Ent	14	13	2	23	1	563	143
Mal	16	10	11	5	...	244	541
Myria	.	...	14	1	...	17	200
Arachn	.	4	132	...	...	131	600
Hexap	.	174	1220	1	1	1551	65,000
V	57	279	311	110	488	2701	18,085
Pisces	56	90	54	54	5	1461	8000
Lep	.	...	...	...	...	...	11
Ela	76	56	24	34	...	550	221
Gan	19	...	5	4	...	572	30
Tel	71	34	25	16	5	339	7738
Reptil	33	59	74	8	24	384	1055
Bat	.	35	15	4	12	65	175
Oph	4	3	8	2	2	14	300
Sau	8	8	13	...	4	206	460
Che	21	13	38	2	6	99	120
Aves.	1	25	5	...	101	148	7000
Mamm	7	105	178	52	358	708	2030
AN	0	3721	2977	2222	1417	24,366	101,745
AN	6	4040	3087	2270	1421	26,421	171,148

	I. Carboniferous Period.							II. Trias Period.				III. Oolite Period.				IV. Cretaceous P.			V. Tertiary Period.						I—V.	Living.
	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	f	s	t	u	v	w	x	All the species together.	z
I. PLANTÆ	...	...	55	2	879	52	29	...	31	5	62	71	152	2	16	...	77	7	10	136	319	110	48	4	2055	69,403
Cellulares	...	...	6	...	13	1	14	...	...	1	1	9	46	...	1	...	22	5	9	4	34	19	4	...	188	9100
Vasculares	...	...	49	2	866	51	15	...	31	4	61	62	106	2	15	...	45	2	1	132	285	91	44	4	1867	60,303
Monocotyledones	...	...	49	2	772	49	13	...	22	1	45	32	57	...	9	...	14	...	...	132	31	12	3	...	1139	10,629
Dicotyledones	...	...	...	...	94	...	2	...	9	3	16	30	49	2	...	...	31	2	1	108	254	79	41	4	728	49,674
Monochlamydeæ	...	...	...	...	21	...	2	...	9	1	16	30	42	2	6	...	14	...	...	28	122	38	23	4	358	3246
Corolliflorae	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	13	14	1	...	28	23,900
Choristopetalæ	...	...	...	...	2	...	...	...	...	...	...	...	1	...	...	...	3	...	...	74	68	27	9	...	175	22,528
Dubiæ	...	...	...	...	71	2	...	...	...	2	...	...	6	...	...	...	14	1	1	6	51	...	8	...	167	...
II. PHYTOZOA	36	223	228	263	1	...	17	128	1	19	2	29	579	16	2	149	270	1162	35	383	476	502	412	278	4895	4818
Pseudozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	1	...	...	...	...	2	50
Amorphozoa	1	13	9	...	...	...	...	44	1	2	1	...	81	...	...	18	50	108	...	12	6	47	9	30	461	250
Polygastrica	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	19	...	1	...	369	29	223	672	500
Polypi	29	145	137	156	...	...	16	35	...	3	...	3	221	9	...	54	112	673	3	269	390	77	365	21	2528	1810
Foraminifera	...	...	...	9	...	...	...	...	...	...	...	...	28	...	...	14	10	254	2	97	184	65	220	10	893	1000
Bryozoa	12	61	56	64	...	...	13	9	...	1	...	...	26	1	...	27	42	323	...	79	129	4	51	3	810	380
Anthozoa	17	84	81	83	...	...	3	26	...	2	...	3	167	8	...	13	60	96	1	93	77	8	94	8	825	430
Entozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1500
Acalephæ	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	9	7	...	2	...	43	210
Echinodermata	6	65	82	106	1	..	1	49	...	14	1	26	276	7	(2)	77	108	289	13	91	73	9	61	4	1189	498
Stelleridæ	6	65	82	106	1	...	1	9	...	13	1	17	92	1	(1)	4	6	36	...	6	3	2	5	...	416	286
Echinidæ	...	...	...	...	...	...	...	40	...	1	...	9	182	6	(1)	73	102	253	13	84	70	7	56	4	770	146
Fistulidæ	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	1	...	...	...	...	3	66
III. MALACOZOA	260	416	979	809	143	7	94	603	38	109	26	533	1455	242	102	751	566	1500	39	2125	2725	783	1609	642	13,885	11,482
Tunicata	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	71
Brachiopoda et Rudistæ	151	148	131	199	4	...	35	43	1	10	2	24	80	3	1	61	26	227	1	13	6	...	23	4	1146	48
Pelecypoda	25	69	287	186	70	7	44	129	30	71	10	212	786	173	77	336	279	697	25	705	783	164	556	189	4836	2413
Pteropoda	1	10	13	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	8	...	2	8	41	62
Heteropoda	10	24	28	35	7	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	23	85
Protopoda	...	...	4	3	1	...	...	4	...	2	...	2	8	...	...	8	8	13	...	32	24	1	34	8	120	64
Gasteropoda	38	71	246	248	16	...	14	341	6	26	14	81	300	53	24	135	125	415	12	1354	1892	218	984	439	6110	8673
(Ctenobranchia	34	68	230	222	15	...	13	335	5	21	9	79	275	52	23	130	122	395	12	1170	1540	152	853	300	5281	5520)
Cephalopoda	35	94	270	137	44	...	1	86	1	18	0	214	281	13	...	211	127	146	1	18	12	...	4	...	1546	128
IV. ENTOMOZOA	218	264	94	43	18	...	4	6	3	12	1	50	256	7	69	35	28	114	11	85	251	1381	91	9	2885	67,360
Vermes	4	7	8	10	...	...	1	6	...	4	1	9	58	6	...	19	16	61	6	49	27	1	22	5	292	770
Crustacea	214	257	86	30	10	...	3	...	3	8	...	10	152	1	12	16	10	53	5	36	46	14	67	3	894	791
Cirripedes	...	...	1	...	...	...	...	...	...	...	...	...	4	...	...	4	3	20	...	6	23	1	39	2	87	107
Entomostraca	214	257	85	30	9	...	2	...	1	3	...	1	16	...	11	7	...	20	...	14	13	2	23	1	563	143
Malacostraca	...	...	...	...	...	...	1	...	2	4	...	9	132	1	1	5	7	13	5	16	10	11	5	...	244	541
Myriapoda	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	14	1	...	17	200
Arachnidæ	...	...	...	...	2	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	4	132	...	...	131	600
Hexapoda	...	..	...	3	6	...	...	...	...	...	...	31	43	...	57	...	2	...	...	...	174	1220	1	1	1551	65,000
V. SPONDYLOZOA	...	7	110	65	80	17	49	4	12	50	77	172	278	42	60	10	70	161	2	367	279	311	110	488	2701	18,085
Pisces	...	7	110	65	78	11	42	4	5	37	58	130	222	27	43	10	68	152	2	266	90	54	54	5	1461	8000
Leptocardii, Cyclostomi et Dipnoi	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	11
Elasmobranchi	...	7	38	63	27	...	11	2	1	23	40	26	49	12	23	5	18	80	...	76	56	24	34	...	550	221
Ganoidei	...	...	72	2	51	11	31	2	4	14	18	104	172	15	19	5	7	28	2	19	...	5	4	...	572	30
Teleostei	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	43	44	...	171	34	25	16	5	339	7738
Reptilia	...	...	...	...	2	6	7	...	7	13	18	41	53	15	17	...	5	9	...	33	59	74	8	24	384	1055
Batrachii	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	35	15	4	12	65	175
Ophidii	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	3	8	2	2	14	300
Saurii	...	...	...	...	2	6	7	...	7	13	17	40	48	10	12	...	5	9	...	8	8	13	...	4	206	460
Chelonii	...	...	...	...	...	...	...	...	...	...	1	1	5	5	5	...	...	...	...	21	13	38	2	6	99	120
Aves	...	...	...	...	...	?	...	...	...	...	...	...	...	...	...	...	2	...	...	11	25	5	...	101	148	7000
Mammalia	...	...	...	...	...	?	...	...	...	...	1	1	3	...	...	...	...	...	...	57	105	178	52	358	708	2030
ANIMALIA	514	910	1411	1180	242	24	164	741	54	190	106	784	2568	307	233	945	934	2937	87	2960	3721	2977	2222	1417	24,366	101,745
ANIMALIA et VEGETABILIA	514	910	1466	1182	1121	76	193	741	85	195	168	855	2720	309	249	945	1011	2944	97	3096	4040	3087	2270	1421	26,421	171,148

	riod.	V. Tertiary Period.								I—V.		
	True sum. IV.	s	t	u	v	w	x	Together. s-x	True sum. V.	Formations. a-x	Periods. I-V.	True sum.
I. PLANTÆ ..	36	8	30	115	53	31	...	237	189	592	463	350
Cellulares	12	4	2	16	6	4	...	32	21	82	61	38
Vasculares	24	4	28	99	47	27	...	205	168	510	402	312
Monocotyledones	9	3	9	16	6	2	...	36	27	270	203	152
Dicotyledones	15	1	19	83	41	25	...	169	141	240	199	160
Monochlamydea	9	...	7	36	17	16	...	76	57	133	102	70
Corollifloræ	1	...	...	8	7	...	...	15	13	16	14	14
Choristopetalæ	3	...	11	31	14	6	...	62	57	67	62	59
Dubiæ	2	1	1	8	3	3	...	16	14	24	21	17
II. PHYTOZOA	199	13	115	134	115	117	53	547	307	1283	811	524
Pseudozoa	1	...	1	...	...	...	...	1	1	2	2	2
Amorphozoa	26	...	9	5	10	3	4	31	17	106	71	42
Polygastrica...........	7	...	...	2	63	14	32	111	80	119	88	84
Polypi	105	3	79	110	37	81	16	326	164	740	437	251
Foraminifera	38	2	24	45	29	43	8	151	76	230	126	81
Bryozoa	44	...	28	37	4	16	3	88	56	253	165	97
Anthozoa...........	27	1	27	28	4	22	5	87	41	257	146	73
Entozoa	...	...	...	...	...	...	...	...	...	...	...	...
Acalephæ	1	3	1	...	...	1	...	5	3	6	4	3
Echinodermata	59	7	25	17	5	18	1	73	42	310	209	142
Stelleridæ	15	...	3	2	1	5	...	11	6	143	103	77
Echinidæ...........	44	7	21	15	4	13	1	61	35	164	103	62
Fistulidæ	...	...	1	...	...	...	...	1	1	3	3	3
III. MALACOZ	181	25	199	218	93	209	146	890	301	2059	865	473
Tunicata	...	...	1	...	...	...	...	1	1	1	1	1
Brachiopoda	16	1	3	2	...	3	1	10	5	116	52	29
Pelecypoda	83	13	77	85	41	85	54	355	113	905	362	174
Pteropoda	...	...	1	5	...	6	...	12	6	21	11	10
Heteropoda	1	...	...	...	...	...	...	...	...	11	5	4
Protopoda	3	...	3	4	1	3	3	14	4	31	11	5
Gasteropoda	62	9	111	116	51	111	88	486	166	801	362	202
(Ctenobranchia	54	9	88	89	35	84	62	367	123	689	295	175)
Cephalopoda	16	2	3	6	...	1	...	12	6	127	61	48
IV. ENTOMOZ	32	3	21	134	431	19	6	614	516	981	783	686
Vermes	8	2	4	5	1	5	3	20	6	66	38	21
Crustacea..............	24	1	17	17	15	13	2	65	42	269	184	165
Cirripedes	4	...	2	8	1	6	1	18	10	26	16	13
Entomostraca	2	...	2	1	1	1	1	6	2	131	73	70
Malacostraca	18	1	13	8	13	6	...	41	30	112	95	82
Myriapoda	...	...	...	...	6	...	...	6	6	8	8	7
Arachnidæ	...	...	...	4	50	...	...	54	53	57	56	55
Hexapoda	...	...	...	108	359	1	1	469	409	581	497	438
V. SPONDYLO	83	...	178	117	151	29	152	627	459	1092	801	731
Pisces	69	...	126	35	31	17	1	210	160	560	412	355
Leptocardii, Cyclos	...	...	...	...	...	...	...	...	...	...	...	...
Elasmobranchii ...	26	...	20	15	12	10	...	57	32	216	142	110
Ganoidei	8	...	10	3	2	1	...	16	12	167	117	96
Teleostei	35	...	96	17	17	6	1	137	116	177	153	149
Reptilia	12	...	12	20	22	4	10	68	43	177	127	116
Batrachii	...	...	...	7	9	1	3	20	14	20	14	14
Ophidii...............	...	...	3	1	4	...	1	9	7	9	7	8
Saurii	11	...	4	6	2	3	2	17	10	113	85	79
Chelonii	1	...	5	6	7	...	4	22	12	35	21	16
Aves	2	...	10	11	4	...	33	58	55	60	57	56
Mammalia	...	...	30	51	94	8	108	291	201	295	205	204
ANIMALIA	495	41	513	603	790	374	357	2678	1583	5415	3260	2414
ANIMALIA et VE	531	49	543	718	843	405	357	2915	1772	6007	3723	2764

	I. Carboniferous Period.									II. Trias Period.					
	a	b	c	d	e	f	g	Together. a-g	True sum. I.	h	i	k	l	Together. h-l	True sum. II.
I. PLANTÆ	...	...	21	2	121	15	17	176	124	...	15	4	26	45	39
Cellulares	...	...	2	...	8	1	2	13	8	...	...	1	1	2	2
Vasculares	...	...	19	2	113	14	15	163	116	...	15	3	25	43	37
Monocotyledones	...	...	19	2	101	13	12	147	101	...	10	1	19	30	27
Dicotyledones	...	...	...	...	12	1	3	16	15	...	5	2	6	13	10
Monochlamydeæ	...	...	...	...	10	...	2	12	12	...	5	1	6	12	9
Corolliflorae	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Choristopetalæ	...	...	...	...	...	1	...	1	1	...	...	...	...	...	...
Dubiæ	...	...	...	...	1	...	1	3	2	...	...	1	...	1	1
II. PHYTOZOA	20	88	68	59	1	1	6	243	146	24	1	12	2	39	34
Pseudozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Amorphozoa	1	8	5	...	...	...	...	14	11	6	1	2	1	10	7
Polygastrica	...	...	...	1	...	...	...	1	1	...	...	...	...	...	...
Polypi	13	47	45	39	...	...	6	150	82	14	...	3	...	17	16
Foraminifera	...	...	...	7	...	...	...	7	7	...	...	...	...	...	...
Bryozoa	6	24	22	11	...	...	4	67	38	6	...	1	...	7	7
Anthozoa	7	23	23	21	...	...	2	76	37	8	...	2	...	10	9
Entozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Acalephæ	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Echinodermata	6	33	18	19	1	(1)	...	78	52	4	...	7	1	12	11
Stelleridæ	6	33	18	19	1	(1)	...	78	52	3	...	6	1	10	9
Echinidæ	...	...	...	...	...	...	...	...	...	1	...	1	...	2	2
Fistulidæ	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
III. MALACOZOA	44	62	94	90	35	4	33	362	149	63	20	44	14	141	77
Tunicata	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Brachiopoda	11	13	13	12	5	...	7	61	18	6	1	3	1	11	7
Pelecypoda	5	18	35	33	13	4	18	126	51	24	13	23	7	67	30
Pteropoda	1	4	3	1	...	...	...	9	5	...	...	...	...	...	...
Heteropoda	1	1	3	3	1	...	...	9	3	1	...	...	...	1	1
Protopoda	1	1	1	1	1	...	...	5	1	1	...	1	...	2	1
Gasteropoda	18	16	30	31	11	...	7	113	54	25	5	13	5	48	32
(Ctenobranchia	17	15	27	28	10	...	6	103	50	24	4	10	4	42	27
Cephalopoda	7	9	9	9	4	...	1	39	17	6	1	4	1	12	6
IV. ENTOMOZOA	37	41	31	21	10	...	2	142	86	1	3	5	1	10	9
Vermes	3	6	4	5	...	...	...	18	14	1	...	2	1	4	3
Crustacea	34	35	27	13	5	...	2	116	64	...	3	3	...	6	6
Cirripedes	...	...	1	...	...	...	...	1	1	...	...	...	...	...	...
Entomostraca	34	35	26	13	5	...	1	114	62	...	1	1	...	2	2
Malacostraca	...	...	...	...	...	...	1	1	1	...	2	2	...	4	4
Myriapoda	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Arachnidæ	...	...	...	...	2	...	...	2	2	...	...	...	...	...	...
Hexapoda	...	...	...	3	3	...	...	6	6	...	...	...	...	...	...
V. SPONDYLOZOA	...	5	47	21	37	4	19	133	103	3	10	19	20	52	37
Pisces	...	5	47	21	35	1	15	124	94	3	3	12	10	28	18
Leptocardii, Cyclostomi et Dipnoi	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Elasmobranchii	...	5	20	19	17	...	7	68	52	1	1	5	5	12	7
Ganoidei	...	...	27	2	18	1	8	56	42	2	2	7	5	16	11
Teleostei	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reptilia	...	...	...	...	2	3	4	9	9	...	7	7	9	23	18
Batrachii	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ophidii	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Saurii	...	...	...	...	2	3	4	9	9	...	7	7	9	23	18
Chelonii	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Aves	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mammalia	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1
ANIMALIA	101	196	240	191	83	9	60	880	484	91	34	80	37	242	157
ANIMALIA et VEGETABILIA	101	196	261	193	204	24	77	1056	608	91	49	84	63	287	196

	III. Oolite Period.						IV. Cretaceous Period.					V. Tertiary Period.								I—V.		
	m	n	o	p	Together. m-p	True sum. III.	q	r	f	Together. q-f	True sum. IV.	s	t	u	v	w	x	Together. s-x	True sum. V.	Formations. a-x	Periods. I-V.	True sum.
I. PLANTÆ	30	54	1	12	97	75	...	32	5	37	36	8	30	115	53	31	...	237	189	592	463	350
Cellulares	5	15	...	2	22	18	...	9	4	13	12	4	2	16	6	4	...	32	21	82	61	38
Vasculares	25	39	1	10	75	57	...	23	1	24	24	4	28	99	47	27	...	205	168	510	402	312
Monocotyledones	18	25	...	5	48	39	...	9	...	9	9	3	9	16	6	2	...	36	27	270	203	152
Dicotyledones	7	14	1	5	27	18	...	14	1	15	15	1	19	83	41	25	...	169	141	240	199	160
Monochlamydeæ	7	11	1	5	24	15	...	9	...	9	9	...	7	36	17	16	...	76	57	133	102	70
Corolliflorae	...	...	...	...	...	...	...	...	1	1	1	...	...	8	7	...	...	15	13	16	14	14
Choristopetalæ	...	1	...	...	1	1	...	3	...	3	3	...	11	31	14	6	...	62	57	67	62	59
Dubiæ	...	2	...	...	2	2	...	2	...	2	2	1	1	8	3	3	...	16	14	24	21	17
II. PHYTOZOA	14	122	8	...	144	125	63	83	184	310	199	13	115	134	115	117	53	547	307	1283	811	524
Pseudozoa	...	...	...	...	...	...	...	...	1	1	1	...	1	...	...	...	...	1	1	2	2	2
Amorphozoa	...	10	...	...	10	10	6	12	23	41	26	...	9	5	10	3	4	31	17	106	71	42
Polygastrica	...	...	...	...	...	...	...	...	7	7	7	...	...	2	63	14	32	111	80	119	88	84
Polypi	4	68	5	...	77	70	28	42	100	170	105	3	79	110	37	81	16	326	164	740	437	251
Foraminifera	...	14	1	...	15	14	8	8	41	57	38	2	24	45	29	43	8	151	76	230	126	81
Bryozoa	...	24	1	...	25	24	13	16	37	66	44	...	28	37	4	16	3	88	56	253	165	97
Anthozoa	4	30	3	...	37	32	7	18	22	47	27	1	27	28	4	22	5	87	41	257	146	73
Entozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Acalephæ	...	...	...	...	...	...	...	...	1	1	1	3	1	...	...	1	...	5	3	6	4	3
Echinodermata	10	44	3	...	57	45	29	29	52	90	59	7	25	17	5	18	1	73	42	310	209	142
Stelleridæ	7	19	1	...	27	21	3	2	12	17	15	...	3	2	1	5	...	11	6	143	103	77
Echinidæ	3	23	2	...	28	22	26	27	40	73	44	7	21	15	4	13	1	61	35	164	103	62
Fistulidæ	...	2	...	...	2	2	...	...	...	...	...	...	1	...	...	...	...	1	1	3	3	3
III. MALACOZOA	78	132	66	27	303	157	116	101	146	363	181	25	199	218	93	209	146	890	301	2059	865	473
Tunicata	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	1	1	1	1
Brachiopoda	3	5	2	...	10	6	8	3	13	24	16	1	3	2	...	3	1	10	5	116	52	29
Pelecypoda	45	74	43	13	175	85	61	53	68	182	83	13	77	85	41	85	54	355	113	905	362	174
Pteropoda	...	...	...	...	...	...	...	...	...	...	...	...	1	5	...	6	...	12	6	21	11	10
Heteropoda	...	...	...	...	...	...	...	1	...	1	1	...	...	...	...	...	...	...	...	11	5	4
Protopoda	1	2	...	...	3	2	2	2	3	7	3	...	3	4	1	3	3	14	4	31	11	5
Gasteropoda	18	38	16	14	86	48	31	31	52	114	62	9	111	116	51	111	88	486	166	801	362	202
(Ctenobranchia	17	33	15	11	76	41	28	29	44	101	54	9	88	89	35	84	62	367	123	689	295	175)
Cephalopoda	11	13	5	...	29	16	14	11	10	35	16	2	3	6	...	1	...	12	6	127	61	48
IV. ENTOMOZOA	32	88	2	41	173	140	10	8	24	42	32	3	21	134	431	19	6	614	516	981	783	686
Vermes	2	7	1	...	10	7	3	3	8	14	8	2	4	5	1	5	3	20	6	66	38	21
Crustacea	5	45	1	3	54	48	7	5	16	28	24	1	17	17	15	13	2	65	42	269	184	165
Cirripedes	...	1	...	...	1	1	1	1	4	6	4	...	2	8	1	6	1	18	10	26	16	13
Entomostraca	1	4	...	2	7	5	1	...	1	2	2	...	2	1	1	1	1	6	2	131	73	70
Malacostraca	4	40	1	1	46	42	5	4	11	20	18	1	13	8	13	6	...	41	30	112	95	82
Myriapoda	...	2	...	...	2	2	...	...	...	...	...	...	...	...	6	...	...	6	6	8	8	7
Arachnidæ	...	1	...	...	1	1	...	...	...	...	...	...	...	4	50	...	...	54	53	57	56	55
Hexapoda	25	33	...	38	106	82	...	...	...	...	...	...	...	108	359	1	1	469	409	581	497	438
V. SPONDYLOZOA	41	83	22	23	169	119	4	44	63	111	83	...	178	117	151	29	152	627	459	1092	801	731
Pisces	33	52	11	9	105	71	3	37	53	93	69	...	126	35	31	17	1	210	160	560	412	355
Leptocardii, Cyclostomi et Dipnoi	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Elasmobranchii	12	17	5	4	38	25	1	16	24	41	26	...	20	15	12	10	...	57	32	216	142	110
Ganoidei	21	34	6	4	65	44	2	4	8	14	8	...	10	3	2	1	...	16	12	167	117	96
Teleostei	...	1	...	1	2	2	...	17	21	38	35	...	96	17	17	6	1	137	116	177	153	149
Reptilia	7	29	11	14	61	45	1	7	8	16	12	...	12	20	22	4	10	68	43	177	127	116
Batrachii	...	...	...	...	...	...	...	...	...	...	...	...	...	7	9	1	3	20	14	20	14	14
Ophidii	...	...	...	...	...	...	...	...	...	...	...	...	3	1	4	...	1	9	7	9	7	8
Saurii	7	25	7	11	50	37	1	6	7	14	11	...	4	6	2	3	2	17	10	113	85	79
Chelonii	...	4	4	3	11	8	...	1	1	2	1	...	5	6	7	...	4	22	12	35	21	16
Aves	...	...	...	...	...	...	...	...	2	2	2	...	10	11	4	...	33	58	55	60	57	56
Mammalia	1	2	...	...	3	3	...	...	...	...	...	...	30	51	94	8	108	291	201	295	205	204
ANIMALIA	165	425	98	91	789	541	193	236	417	826	495	41	513	603	790	374	357	2678	1583	5415	3260	2414
ANIMALIA et VEGETABILIA	195	479	99	103	886	616	193	268	422	863	531	49	543	718	843	405	357	2915	1772	6007	3723	2764

iod.	V. Tertiary Period.			I—V. Period.			VI. Existing Period.	
	Total.	Living.		Total.	Living.		Sum of all the living species.	Proportion of fossil to it.
ta.		Absolute.	Quota.		Absolute.	Quota.		
)	189	60	0·32	350	60	0·17	6529	0·009
)	21	4	0·19	38	4	0·10	718	0·005
)	168	56	0·33	312	56	0·18	5811	0·010
)	27	5	0·19	152	1	0·03	1172	0·004
)	141	51	0·36	160	51	0·33	4639	0·001
)	57	17	0·30	70	17	0·24	300	0·057
)	13	6	0·46	14	6	0·43	2280	0·003
)	57	28	0·49	59	28	0·48	2059	0·013
)	14	0	0	17	0	0	...	...
58	307	215	0·70	524	242	0·48	652	0·37
00	1	1	1·00	2	2	1·00	13	0·15
35	17	12	0·76	42	15	0·32	15	1·00
57	80	68	0·85	84	69	0·82	168	0·41
73	164	113	0·68	251	138	0·55	245	0·56
82	67	55	0·82	81	59	0·73	77	0·75
55	56	27	0·48	97	33	0·34	75	0·44
89	41	31	0·76	73	46	0·63	93	0·50
.	...	...	...	...	...	...	60	0·00
0	3	0	0	3	0	0	75	0·00
34	42	21	0·50	142	28	0·20	76	0·37
40	6	5	0·83	77	8	0·10	36	0·22
32	35	16	0·46	62	18	0·29	29	0·62
.	1	0	0	3	2	0·67	11	0·18
70	301	274	0·91	473	302	0·64	515	0·59
.	(1	1	1·00	1	1	1·00)	13	0·08
31	5	5	1·00	29	5	0·07	5	1·00
83	113	104	0·92	174	114	0·65	128	0·89
.	1	1	1·00	2	2	1·00	2	1·00
.	...	...	...	4	0	0	9	0·00
67	4	4	1·00	5	4	0·80	5	0·80
81	166	151	0·91	202	167	0·83	221	0·76
78	123	111	0·90	127	126	0·80	138	0·91)
06	6	3	0·50	48	5	0·10	21	0·24
63	516	449	0·87	686	484	0·76	5036	0·09
50	6	5	0·83	21	10	0·48	180	0·06
67	42	34	0·81	165	53	0·32	302	0·55
75	10	10	1·00	13	12	0·92	40	0·30
00	2	2	1·00	70	6	0·09	66	0·09
61	30	22	0·73	82	35	0·43	196	0·18
..	6	6	1·00	7	7	1·00	40	0·17
..	53	39	0·74	55	39	0·71	212	0·18
..	409	365	0·89	438	375	0·85	(4000	0·09)
23	459	257	0·56	731	263	0·36	1311	0·20
25	160	83	0·52	355	87	0·25	496	0·18
..	...	...	...	...	...	...	6	0·00
46	32	19	0·60	110	22	0·20	66	0·33
0	12	1	0·08	96	1	0·01	4	0·25
14	116	63	0·54	149	64	0·43	420	0·15
17	43	30	0·70	116	32	0·28	315	0·10
..	14	7	0·50	14	7	0·50	85	0·08
..	7	6	0·86	7	6	0·86	105	0·06
09	10	8	0·80	79	9	0·11	100	0·09
00	12	9	0·75	16	10	0·62	25	0·40
..	55	48	0·88	56	48	0·86	350	0·14
..	201	96	0·48	204	96	0·47	250	0·38
54	1403	962	0·61	2414	1291	0·54	8232	0·157
50	1592	1022	0·64	2764	1351	0·49	14761	0·090

	I. Carboniferous Period.			II. Trias Period.			III. Oolite Period.			IV. Cretaceous Period.			V. Tertiary Period.			I—V. Period.			VI. Existing Period.	
	Total.	Living.		Total.	Living.		Total.	Living.		Total.	Living.		Total.	Living.		Total.	Living.		Sum of all the living species.	Proportion of fossil to it.
		Absolute.	Quota.		Absolute.	Quota.		Absolute.	Quota.		Absolute.	Quota.		Absolute.	Quota.		Absolute.	Quota.		
I. PLANTÆ	124	0	0	39	0	0	75	0	0	36	0	0	189	60	0·32	350	60	0·17	6529	0·009
Cellulares	8	0	0	2	0	0	18	0	0	12	0	0	21	4	0·19	38	4	0·10	718	0·005
Vasculares	116	0	0	37	0	0	57	0	0	24	0	0	168	56	0·33	312	56	0·18	5811	0·010
Monocotyledoneæ	101	0	0	27	0	0	39	0	0	9	0	0	27	5	0·19	152	1	0·03	1172	0·004
Dicotyledoneæ	15	0	0	10	0	0	18	0	0	15	0	0	141	51	0·36	160	51	0·33	4639	0·001
Monochlamydeæ	12	0	0	9	0	0	15	0	0	9	0	0	57	17	0·30	70	17	0·24	300	0·057
Corollifloræ	...	...	...	...	...	...	...	...	...	1	0	0	13	6	0·46	14	6	0·43	2280	0·003
Choristopetalæ	1	0	0	...	...	...	1	0	0	3	0	0	57	28	0·49	59	28	0·48	2059	0·013
Dubiæ	2	0	0	1	0	0	2	0	0	2	0	0	14	0	0	17	0	0	...	...
II. PHYTOZOA	146	37	0·25	34	17	0·50	125	69	0·55	199	111	0·58	307	215	0·70	524	242	0·48	652	0·37
Pseudozoa	...	...	...	...	...	...	...	...	...	1	1	1·00	1	1	1·00	2	2	1·00	13	0·15
Amorphozoa	11	3	0·27	7	4	0·59	10	6	0·60	26	9	0·35	17	12	0·76	42	15	0·32	15	1·00
Polygastrica	(1	1	1·00)	...	...	...	...	...	...	7	4	0·57	80	68	0·85	84	69	0·82	168	0·41
Polypi	82	30	0·38	16	8	0·50	70	49	0·70	105	77	0·73	164	113	0·68	251	138	0·55	245	0·56
Foraminifera	7	4	0·57	...	...	...	15	15	1·00	38	31	0·82	67	55	0·82	81	59	0·73	77	0·75
Bryozoa	38	11	0·30	7	2	0·28	24	11	0·46	40	22	0·55	56	27	0·48	97	33	0·34	75	0·44
Anthozoa	37	15	0·40	9	6	0·67	32	23	0·72	27	24	0·89	41	31	0·76	73	46	0·63	93	0·50
Entozoa	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	60	0·00
Acalephæ	...	...	...	...	...	...	...	...	...	1	0	0	3	0	0	3	0	0	75	0·00
Echinodermata	52	3	0·06	11	5	0·45	45	14	0·31	59	20	0·34	42	21	0·50	142	28	0·20	76	0·37
Stelleridæ	52	3	0·06	9	3	0·33	21	5	0·24	15	6	0·40	6	5	0·83	77	8	0·10	36	0·22
Echinidæ	...	...	...	(2	2	1·00)	22	7	0·34	44	14	0·32	35	16	0·46	62	18	0·29	29	0·62
Fistulidæ	...	...	...	...	...	...	(2	2	1·00)	...	...	...	1	0	0	3	2	0·67	11	0·18
III. MALACOZOA	149	71	0·47	77	58	0·71	157	116	0·74	181	127	0·70	301	274	0·91	473	302	0·64	515	0·59
Tunicata	...	...	...	...	...	...	...	...	...	...	...	...	(1	1	1·00	1	1	1·00)	13	0·08
Brachiopoda	18	4	0·22	7	4	0·57	6	5	0·83	16	5	0·31	5	5	1·00	29	5	0·07	5	1·00
Pelecypoda	51	36	0·70	30	23	0·77	85	67	0·79	83	69	0·83	113	104	0·92	174	114	0·65	128	0·89
Pteropoda	5	1	0·20	...	...	...	...	...	...	...	...	...	1	1	1·00	2	2	1·00	. 2	1·00
Heteropoda	3	0	0	1	0	0	...	...	...	...	...	...	...	...	...	4	0	0	9	0·00
Protopoda	1	1	1·00	1	1	1·00	2	2	1·00	3	2	0·67	4	4	1·00	5	4	0·80	5	0·80
Gasteropoda	54	28	0·52	32	29	0·91	48	38	0·80	62	50	0·81	166	151	0·91	202	167	0·83	221	0·76
(Ctenobranchia	50	25	0·52	27	24	0·89	41	31	0·76	54	42	0·78	123	111	0·90	127	126	0·80	138	0·91)
Cephalopoda	17	1	0·06	6	1	0·17	16	4	0·25	16	1	0·06	6	3	0·50	48	5	0·10	21	0·24
IV. ENTOMOZOA	86	11	0·13	9	8	0·10	140	73	0·52	32	20	0·63	516	449	0·87	686	484	0·76	5036	0·09
Vermes	14	6	0·43	3	3	1·00	7	5	0·71	8	4	0·50	6	5	0·83	21	10	0·48	180	0·06
Crustacea	64	5	0·08	6	5	0·83	48	11	0·23	24	16	0·67	42	34	0·81	165	53	0·32	302	0·55
Cirripedes	1	0	0	...	...	...	1	1	1·00	4	3	0·75	10	10	1·00	13	12	0·92	40	0·30
Entomostraca	62	5	0·08	2	2	1·00	5	5	1·00	2	2	1·00	2	2	1·00	70	6	0·09	66	0·09
Malacostraca	1	0	0	4	3	0·75	42	5	0·12	8	11	0·61	30	22	0·73	82	35	0·43	196	0·18
Myriapoda	...	...	...	...	...	...	2	2	1·00	...	...	...	6	6	1·00	7	7	1·00	40	0·17
Arachnidæ	2	0	0	...	...	...	1	0	0	...	...	...	53	39	0·74	55	39	0·71	212	0·18
Hexapoda	6	0	0	...	...	...	82	55	0·67	...	...	...	409	365	0·89	438	375	0·85	(4000	0·09)
V. SPONDYLOZOA	103	0	0	37	0	0	119	9	0·08	83	19	0·23	459	257	0·56	731	263	0·36	1311	0·20
Pisces	94	0	0	18	0	0	71	3	0·04	69	17	0·25	160	83	0·52	355	87	0·25	496	0·18
Leptocardi, Cyclostomi et Dipnoi	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	0·00
Elasmobranchii	52	0	0	7	0	0	25	3	0·12	26	12	0·46	32	19	0·60	110	22	0·20	66	0·33
Ganoidei	42	0	0	11	0	0	44	0	0	8	0	0	12	1	0·08	96	1	0·01	4	0·25
Teleostei	...	...	...	...	...	...	2	0	0	35	5	0·14	116	63	0·54	149	64	0·43	420	0·15
Reptilia	9	0	0	18	0	0	45	6	0·13	12	2	0·17	43	30	0·70	116	32	0·28	315	0·10
Batrachii	...	...	...	...	...	...	...	...	...	...	...	...	14	7	0·50	14	7	0·50	85	0·08
Ophidii	...	...	...	...	...	...	...	...	...	...	...	...	7	6	0·86	7	6	0·86	105	0·06
Saurii	9	0	0	18	0	0	37	1	0·03	11	1	0·09	10	8	0·80	79	9	0·11	100	0·09
Chelonii	...	...	...	...	...	...	8	5	0·62	1	1	1·00	12	9	0·75	16	10	0·62	25	0·40
Aves	...	...	...	...	...	...	...	...	...	2	0	...	55	48	0·88	56	48	0·86	350	0·14
Mammalia	...	...	...	1	0	0	3	0	? 0	...	...	...	201	96	0·48	204	96	0·47	250	0·38
ANIMALIA	484	99	0·20	157	93	0·59	541	258	0·48	495	267	0·54	1403	962	0·61	2414	1291	0·54	8232	0·157
ANIMALIA et VEGETABILIA	608	99	0·14	196	93	0·47	616	258	0·42	531	267	0·50	1592	1022	0·64	2764	1351	0·49	14761	0·090

[To face p. 44.

	ther.	V. Tertiary Period.							All the V. Periods.		
								Together.	Sum of	Sum of	True sum.
	-f	s	t	u	v	w	x	s-x	a-x	I-V.	
I. PLANTÆ.											
Number of genera.........	37	8	30	115	53	31	0	237	592	463	350
Number of species	84	10	136	319	110	48	0	623	...	...	2055
Proportion .... = 1 :	·33	1·25	4·53	2·77	2·07	1·55	0	2·63	3·47	4·44	5·87
II. PHYTOZOA.											
Number of genera.........	10	13	115	134	115	117	53	547	1283	811	524
Number of species	81	35	383	476	502	412	278	2086	...	...	4895
Proportion .... = 1 :	·10	2·69	3·33	3·55	4·36	3·52	5·05	8·14	3·81	6·04	9·34
III. MALACOZOA.											
Number of genera.........	63	25	199	218	93	209	146	890	2059	865	473
Number of species	17	39	2125	2725	783	1609	642	7281	...	...	13885
Proportion .... = 1 :	·75	1·56	10·7	12·5	8·45	7·70	4·40	8·18	6·74	16·1	29·3
IV. ENTOMOZOA.											
Number of genera.........	42	3	21	134	431	19	6	614	981	783	686
Number of species	77	11	85	251	1381	91	9	1828	...	...	2885
Proportion .... = 1 :	·21	3·67	4·05	1·87	3·20	4·79	1·50	2·98	2·96	3·68	4·20
V. SPONDYLOZOA.											
Number of genera.........	11	1	178	117	151	29	152	627	1092	801	731
Number of species	31	2	367	279	311	110	488	1557	...	...	2701
Proportion .... = 1 :	·08	2·00	2·06	2·40	2·06	3·79	3·21	3·27	2·47	3·37	3·70
VI. ANIMALIA.											
Number of genera.........	26	41	513	603	790	374	357	2678	5415	3260	2414
Number of species	16	87	2960	3721	2977	2222	1417	13384	...	...	24366
Proportion .... = 1 :	·3	2·12	5·77	6·17	3·77	5·94	3·97	5·00	4·50	7·47	10·1
VII. ANIMALIA et VEGETABILIA.											
Number of genera.........	63	49	543	718	843	405	357	2915	6007	3723	2764
Number of species	00	97	3096	4040	3087	2270	1417	14007	...	...	26421
Proportion .... = 1 :	68	1·98	5·65	5·63	3·66	5·60	3·69	4·80	4·40	7·00	959
Proportion of separate Classes of Animals.											
Amorphozoa ...... = 1 :	..	...	1·33	1·20	4·70	3·00	7·50	...	4·35	6·50	11·0
Polypi.............. = 1 :	..	1	3·41	3·55	2·08	4·51	1·31	...	3·24	5·78	10·1
Echinodermata ... = 1 :	..	1·86	3·64	4·88	1·80	3·39	4·00	...	8·26	11·5	15·4
Brachiopoda ...... = 1 :	..	1·00	4·33	3·00	...	7·67	(4·00)	...	9·88	22·0	39·5
Pelecypoda......... = 1 :	..	1·92	9·16	9·21	4·00	6·54	3·50	...	5·34	13·3	27·7
Gasteropoda ...... = 1 :	..	1·33	12·0	16·3	4·27	8·86	4·99	...	7·61	16·9	30·2
Cephalopoda ...... = 1 :	..	1·00	6·00	2·00	...	4·00	...	...	12·1	25·4	32·2
Crustacea .... = 1 :	..	...	2·12	2·71	1·00	5·15	1·50	...	3·32	4·90	5·36
Pisces .... = 1 :	..	...	2·11	2·57	1·74	3·18	(5·00)	...	4·82	6·56	7·61
Reptilia .... = 1 :	..	...	2·75	2·95	3·37	2·00	2·40	...	2·17	3·02	3·31
Mammalia .... = 1 :	..	...	1·90	2·00	1·89	6·50	3·32	...	2·65	3·69	3·75

IV. *Review of the Numerical Proportion between the Genera and Species.*

	I. Carboniferous Period.								II. Trias Period.					III. Oolite Period.					IV. Cretaceous Period.				V. Tertiary Period.							All the V. Periods.		
	a	b	c	d	e	f	g	Together. a-g	h	i	k	l	Together. h-l	m	n	o	p	Together. m-p	q	r	ſ	Together. q-ſ	s	t	u	v	w	x	Together. s-x	Sum of a-x	Sum of I-V.	True sum.
I. PLANTÆ.																																
Number of genera.........	0	0	21	2	121	15	17	176	0	15	4	26	45	30	54	1	12	97	0	32	5	37	8	30	115	53	31	0	237	592	463	350
Number of species	0	0	55	2	879	52	29	1017	0	31	5	62	98	71	152	2	16	241	0	77	7	84	10	136	319	110	48	0	623	...	...	2055
Proportion .... = 1 :	0	0	2·62	1·00	7·24	3·46	1·70	5·78	0	2·06	1·25	2·38	2·18	2·37	2·82	2·00	1·33	2·48	0	2·41	1·40	2·33	1·25	4·53	2·77	2·07	1·55	0	2·63	3·47	4·44	5·87
II. PHYTOZOA.																																
Number of genera.........	20	88	68	59	1	1	6	243	24	1	12	2	39	14	122	8	2	144	63	83	184	310	13	115	134	115	117	53	547	1283	811	524
Number of species	36	223	228	263	1	1	17	769	128	1	19	2	150	29	579	16	2	626	149	270	1162	1581	35	383	476	502	412	278	2086	...	...	4895
Proportion .... = 1 :	1·80	2·54	3·35	4·46	1·00	1·00	2·83	3·12	5·33	1·00	1·56	1·00	3·85	2·07	4·74	2·00	1·00	4·34	2·36	3·25	6·31	5·10	2·69	3·33	3·55	4·36	3·52	5·05	8·14	3·81	6·04	9·34
III. MALACOZOA.																																
Number of genera.........	44	62	94	90	35	4	33	362	63	20	44	14	141	78	132	66	27	303	116	101	146	363	25	199	218	93	209	146	890	2059	865	473
Number of species	260	416	979	809	143	7	94	2708	603	38	109	26	776	533	1455	242	102	2332	751	566	1500	2817	39	2125	2725	783	1609	642	7281	...	...	13885
Proportion .... = 1 :	5·91	6·71	10·4	8·99	4·09	1·75	2·85	7·48	9·58	1·90	2·48	1·86	5·50	6·83	11·0	3·66	3·78	7·70	6·47	5·60	10·2	7·75	1·56	10·7	12·5	8·45	7·70	4·40	8·18	6·74	16·1	29·3
IV. ENTOMOZOA.																																
Number of genera.........	37	41	31	21	10	0	2	142	1	3	5	1	10	32	88	2	41	173	16	8	24	42	3	21	134	431	19	6	614	981	783	686
Number of species	218	264	94	43	18	0	4	641	6	3	12	1	22	50	256	7	69	382	35	28	114	177	11	85	251	1381	91	9	1828	...	...	2885
Proportion .... = 1 :	5·90	6·44	3·03	2·05	1·80	0	2·00	4·51	6·00	1·00	2·40	1·00	2·20	1·57	2·91	3·50	1·68	2·21	3·50	3·50	4·75	4·21	3·67	4·05	1·87	3·20	4·79	1·50	2·98	2·96	3·68	4·20
V. SPONDYLOZOA.																																
Number of genera.........	0	5	47	21	37	4	19	133	3	10	19	20	52	41	83	22	23	169	4	44	63	111	1	178	117	151	29	152	627	1092	801	731
Number of species	0	7	110	65	80	7	49	328	4	12	50	77	143	172	278	42	60	552	10	70	161	231	2	367	279	311	110	488	1557	...	...	2701
Proportion .... = 1 :	0	1·40	2·34	3·10	2·17	4·25	2·58	2·47	1·33	1·20	2·63	3·85	2·75	4·20	3·35	1·91	2·61	3·27	2·50	1·59	2·55	2·08	2·00	2·06	2·40	2·06	3·79	3·21	3·27	2·47	3·37	3·70
VI. ANIMALIA.																																
Number of genera.........	101	196	240	191	83	9	60	880	91	34	80	37	242	165	425	98	91	789	193	236	417	826	41	513	603	790	374	357	2678	5415	3260	2414
Number of species	514	910	1311	1180	242	24	164	4445	741	54	190	106	1091	784	2568	307	233	3892	945	934	2937	4816	87	2960	3721	2977	2222	1417	13384	...	...	24366
Proportion .... = 1 :	5·09	4·64	5·88	6·18	2·92	2·66	2·73	5·05	8·14	1·59	2·38	2·87	4·51	4·75	6·04	3·14	2·56	4·02	4·90	3·95	7·04	11·3	2·12	5·77	6·17	3·77	5·94	3·97	5·00	4·50	7·47	10·1
VII. ANIMALIA et VEGETABILIA.																																
Number of genera.........	101	196	261	193	204	24	77	1056	91	34	80	63	287	195	479	99	103	886	193	268	422	863	49	543	718	843	405	357	2915	6007	3723	2764
Number of species	514	910	1466	1182	1121	76	193	5462	741	85	195	168	1189	855	2720	309	249	4133	945	1011	2944	4900	97	3096	4040	3087	2270	1417	14007	...	...	26421
Proportion .... = 1 :	5·07	4·65	5·26	6·12	5·50	3·17	2·51	5·18	8·14	2·50	2·44	2·67	4·14	4·38	5·68	3·12	2·42	4·66	4·90	3·77	6·98	5·68	1·98	5·65	5·63	3·66	5·60	3·69	4·80	4·40	7·00	959
Proportion of separate Classes of Animals.																																
Amorphozoa ...... = 1 :	1·00	1·51	1·80	...	...	...	1·64	...	7·33	1	1	1	...	...	1·80	...	...	...	3·00	4·17	7·83	...	...	1·33	1·20	4·70	3·00	7·50	...	4·35	6·50	11·0
Polypi.............. = 1 :	2·23	3·08	3·04	4·00	...	...	2·67	...	2·50	...	1	...	...	1	3·25	1·80	...	...	1·93	2·67	6·73	...	1	3·41	3·55	2·08	4·51	1·31	...	3·24	5·78	10·1
Echinodermata ... = 1 :	1·00	1·97	4·55	5·58	1	...	1	...	12·2	...	2·00	1	...	2·60	6·27	2·33	...	...	2·65	3·72	5·56	...	1·86	3·64	4·88	1·80	3·39	4·00	...	8·26	11·5	15·4
Brachiopoda ...... = 1 :	13·7	11·4	10·1	16·6	...	...	5·00	...	7·17	1·00	3·33	2·00	...	8·00	16·0	1·50	...	...	7·62	8·67	17·4	...	1·00	4·33	3·00	...	7·67	(4·00)	...	9·88	22·0	39·5
Pelecypoda......... = 1 :	5·00	3·83	8·20	5·13	5·38	1·75	2·44	...	5·37	2·30	3·09	1·43	...	4·71	10·6	4·02	5·92	...	5·51	5·26	10·2	...	1·92	9·16	9·21	4·00	6·54	3·50	...	5·34	13·3	27·7
Gasteropoda ...... = 1 :	2·11	4·32	8·20	8·00	1·46	...	2·00	...	13·6	2·00	2·00	2·80	...	4·50	7·90	3·31	1·71	...	4·36	4·03	7·98	...	1·33	12·0	16·3	4·27	8·86	4·99	...	7·61	16·9	30·2
Cephalopoda ...... = 1 :	5·00	10·4	30·0	15·2	10·0	...	1·00	...	14·3	1·00	4·50	...	...	19·5	21·6	2·60	...	...	15·1	11·5	14·6	...	1·00	6·00	2·00	...	4·00	...	...	12·1	25·4	32·2
Crustacea .... = 1 :	6·30	7·35	3·18	2·31	2·00	...	1·50	...	...	1·00	2·67	...	...	2	3·38	1·00	4·00	...	2·28	2·00	3·31	...	...	2·12	2·71	1·00	5·15	1·50	...	3·32	4·90	5·36
Pisces .... = 1 :	...	1·40	2·34	3·10	2·13	(11·0)	2·80	...	1·33	1·66	3·08	5·80	...	3·94	4·27	2·45	4·78	...	3·33	1·83	2·87	...	...	2·11	2·57	1·74	3·18	(5·00)	...	4·82	6·56	7·61
Reptilia .... = 1 :	...	...	...	...	1·00	2·00	1·75	...	...	1·00	1·86	2·00	...	5·86	1·83	1·36	1·21	...	(1·00	1·00)	1·00	...	...	2·75	2·95	3·37	2·00	2·40	...	2·17	3·02	3·31
Mammalia .... = 1 :	...	...	...	...	...	...	...	...	...	...	...	1·00	...	1·00	1·50	...	...	...	...	...	...	...	...	1·90	2·00	1·89	6·50	3·32	...	2·65	3·69	3·75

I. *Duration of Species.*

There can be no doubt that fossil species pass from one formation into another, from one period into the next, and in rare cases even into a third period, if we indeed allow the present creation to rank as a VI. period, even although half the instances of such transitions may depend on erroneous determinations. No further proof of this need be required, than that the most experienced zoologists and botanists, and even the most decided opponents of this view, Agassiz and D'Orbigny, after examining the original specimens adduced in proof, have themselves unconditionally admitted it. For instances of the occurrence of identical species in two neighbouring formations, we will here, to avoid prolixity, refer to the original text, where they are more fully detailed, and confine ourselves to some of the more important proofs. Almost every one knows certain forms of *Terebratula biplicata* from the oolite and the chalk, which cannot be distinguished from each other in any constant manner. Edward Forbes declares expressly that he has found the *Terebratula caput-serpentis* of the white chalk, of the upper tertiary strata, and the present seas; and the *Echinocyamus pusillus* in the eocene, miocene, pliocene strata and living, entirely identical. Ehrenberg mentions—even after the exclusion of all the tertiary strata erroneously joined to the chalk—a still very considerable number of infusoria and foraminifera as occurring in the chalk, in the tertiary formations and living; and D'Orbigny, in agreement with this, declares* that he cannot distinguish the *Dentalina communis* and *Rotalina umbilicata* of the Paris white chalk, either from the tertiary or from the living species of the Mediterranean, and in regard to the latter especially, that after the most minute comparison he cannot find any distinction. He himself quotes five cephalopods (*Ammonites latidorsatus, A. Mayoranus, A. inflatus, Hamites armatus, Turrilites Bergeri*) and three foraminifera (*Dentalina sulcata, Marginulina compressa, Cristellaria rotula*) in the greensand (gault) and in the chalk (in *r* and *f*). Agassiz himself cites *Lamma elegans* in *t, u, v, w*, *Odontaspis contortidens* in *u, v, w*, and *Cytherea* (*Lucina*) *leonina* in *u, v*. That a great number of tertiary species pass into the present creation, is not only admitted by all palæontologists with two or three exceptions, but has also been specially proved by us in our review of Agassiz' memoir "Sur les espèces reputées identiques†," and among other things by showing partly that the specific distinctions which Agassiz adduced between specimens of certain species from the two positions, and partly that the identity of geological position which he assumed for the genuine *Cyprina Islandica* in Sicily as quaternary instead of tertiary, did not exist. There are tertiary and more recent strata where the number of species that continue into the living creation amounts to 0·04—0·20—0·50—0·60—0·70—0·80—0·90—0·95—0·99—1·00, with-

* Mémoires de la Société Géologique, iv. 13, 32.

† Jahrbuch, 1846, p. 250, *seq.*

out any possibility of finding any determinate limit between them. R. Owen has recognized in the English (newer-pliocene) tertiary strata in 40 species of mammalia, 30 (=0·75) as still living. In this respect, however, there appears an essential distinction, since only the tertiary passes thus gradually into the existing period, whereas between all the earlier periods some limit has hitherto been found where the number of transition species is very small, and forms only an inconsiderable proportion (=0·01—0·03), a circumstance which might readily lead to the view, that a community of species, at least between different periods, was to be wholly denied.—These species have both begun to exist at different times within the periods, and have existed for different times; epochs of the synchronous origin and synchronous perishing of an entire creation have never once occurred.—The length of the duration of a species is very unequal; it can, as we have seen, extend into three or two periods, continue for 8—5—3—2—1 formations, nay even only for a portion of a formation, for one or two of its subordinate beds. This leads us to inquire into the mean duration of a species. According to the numbers in the Enumerator, with the exclusion of species still living, there pass

of 2055 plants......	12 or 0·006	}	species into other formations,
of 24,366 animals	3322 or 0·134		
of 26,421 organisms ..	3334 or 0·124		

a proportion that for the plants is too small, as in it the carboniferous plants in the lias of the Tarentaise have not been twice enumerated, whilst in general it must be considered, that many species only appear in two or more formations in consequence of erroneous determinations,—that these cases are chiefly confined to the Amorphozoa, Phytozoa, Anthozoa, and Conchyliæ, with the Trilobites $(a+b)$, since the other classes have been more thoroughly elaborated, and especially among the mammalia the occurrence in two formations, chronologically distinct, almost never happens; that, if the heads v and x, in agreement with a former observation, were cancelled as synchronous with other formations, the most numerous instances of transitions would disappear; whereas some species overleap one or more formations, and hence very probably, at least in general, must also be introduced into the intermediate members: relations, with due regard to which the average duration of the species for individual groups may be calculated. From this it may, on the whole, be deduced that each species has had an average duration of less than 1·12 formation, to which must also be added the very essential consideration, that the occurrence in one period is not an occurrence during this whole period, but rather, according to observations, for the details of which space is wanting in our work, must be assumed as much shorter on the average. Murchison and De Verneuil have also established the view, to which we had long attained, that those species, which possess the greatest geological duration, are also those which have a wide geographical distribution.

II. *Duration of the Genera.*

There are natural genera (*Sippen*), which, even although they contain several species, are limited to a single formation, whilst others pass through several formations, several periods, all periods, and even enter into the existing creation. Thus we find numbered

		in different Periods.	Formations.	Period.	Form.
Plants the	350 genera	463,	592 times = 1 :	1·32 :	1·69
Animals	2501 „	3347,	5415 times = 1 :	1·34 :	2·17
Together	2851 „	3810,	6007 times = 1 :	1·34 :	2·11

Among 100 genera therefore 34 pass into another period, and 100 genera of plants occur 169 times, 100 of animals 217 times, and 100 of both together 211 times in different formations (hence 69, 117, 111 times in a second or other formation). This proportion will, however, become smaller by the elision of the formations ?*k*, *v* and *x*, and be increased when we take into account that many genera occur in two formations or periods between which they are wanting in 1—2 others, but yet probably have existed and hence must be reckoned or supposed to exist,—excepting however those cases where genera are unnaturally composed of heterogeneous species, so that the older species cannot remain united in one genus with the more recent. It is usual to suppose (with Forbes) each genus, during its geological continuance, increasing in species to a point in time of greatest development, and from that again decreasing to its gradual extinction, where indeed this point in time of maximum development does not fall in the earliest silurian or the existing period. Nevertheless though this form of development occurs in some large genera (very small genera furnish no measure or have no form), it is not the usual one; we rather find that in general, between the pretty rapid or occasionally sudden increase or decrease of species, their number in the separate formations or periods remains rather constant. The lower families of plants and animals—which on the whole in this and other conditions of their occurrence bear a closer relation to each other, than the lower to the higher families of plants or the lower to the higher families of animals—contain the genera of longest duration; thus whilst several genera of marine algæ among the cellular plants, and the marine polyps, annelids and especially mollusca among invertebrate animals, continue through the whole series of formations and even into the present creation, the genera of vascular plants, of the other entomozoa, and the whole vertebrata are limited to shorter periods, so that almost all continue only for a few periods, or mostly for one period, and those of the birds and mammalia at the most belong only to one period and almost always to one formation, so far as they do not pass into the present creation. In a geologically limited class or order of organisms all the genera must also necessarily be so (Mammalia, Choristopetalæ); in a geologically extensive one on the contrary, either (almost) all the genera may have the same duration (Monomya), or it may be composed of more limited and more extended subgroups (Brachiopods of the Genuina and Rudistæ), or again consist entirely of limited subdivisions with limited genera (Pteropods).

III. *Number of the Species.*

We have enumerated 2055 species of plants, 24,366 of animals, together 26,421 fossil species, which, as already mentioned, after excluding the synonymous species, may perhaps be reduced about 0·10, in some classes even 0·20. The fossil plants make also 0·08 of the fossil animals; and the proportion of the fossil species to the living is, in round numbers, in the

	Fossil.	Living.	Fossil & living.	
Plants	= 2050 :	70,000 :	72,050 =	3 : 100 : 103
Animals	= 24,000 :	100,000 :	124,000 =	24 : 100 : 124
Both	= 26,250 :	170,000 :	196,050 =	15 : 100 : 115

Whilst therefore the number of species of living animals is not much greater than that of living plants (100 : 70), that of fossil animals surpasses the fossil plants in a much higher ratio (= 100 : 9). But assuredly a proportion between plants and animals so widely different from the present has never formerly existed, since the two kingdoms generally,—in individual families, genera and even species,—exercise so great a reciprocal influence on each other, that a great increase or multiplication of the one kingdom is not possible without that of the other. It is quite certain that formerly, not only relatively many more plants, but also many more insects, birds, soft mollusca, &c., even more land reptiles and mammalia have existed, compared with the conchyliæ, than the strata now show us, since these are not all so well adapted for the reception and preservation of every class of beings as for that of the conchyliæ. We have therefore proposed the question to ourselves, whether,—presupposing the present proportion of the separate divisions of the organic kingdoms to each other to have prevailed so long as these divisions can be proved to have existed—it is not possible from the number of still living species to estimate that of all that have existed, whilst we calculate from the number of preserved species in the easily preserved classes of animals, the number of species that once existed in the difficultly preservable classes, orders, &c. of animals and plants, from the number of parasites the number of the species on which they lived and the reverse, on the supposition of a similar numerical proportion to the present, from the time of the certain appearance of each of these groups to that of its disappearance from the earth's surface, or to the commencement of the present period? For this purpose we must first come to a more precise decision regarding the number of existing formations in a palæontological point of view, and then endeavour to furnish the proof, that the earth was actually at each time as fully and variously peopled as at present by those classes, orders and families at least, which were then in existence. In regard to formations as reciprocal palæontological equivalents, we think it necessary to assume for our present purpose, perhaps, the following fifteen:

a?,	b,	c,	de,	fg,	ikl,	m,	n,	op,	q,	r,	f,	t,	uvwx
Lower Silurian F.	Upper Silurian F.	Devonian F.	Carboniferous F.	Zechstein F.	Trias F.	Lias F.	Oolite F. (double).	Kimmeridge F. Wealden F.	Neocomien F.	Greensand F.	Chalk F.	Calcaire grossier F.	Molasse F.

Although now, as we have seen, among 100 fossil species there may be 12 passing from one formation into another, although further another large part of the fossil species may have continued during the whole time of such a formation, yet nevertheless a much more considerable number, as we already indicated, have been limited merely to $\frac{3}{4}$, $\frac{2}{3}$, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ part of their corresponding formation, so that even within one and the same formation a large part of the species or organisms has been several times changed; and it is assuredly not too high, if we assume, that in each of the fifteen formations just adopted (*a* perhaps excepted, for which however *n* furnishes more than a sufficient compensation) the species have changed at least once, so that if some lived throughout the whole period of a formation, others admitted of a two- to threefold change. This change too has not taken place synchronously for all, or even for the greater part of them, but gradually, in like manner as the individuals of a species are born, some early and others late, and perish, the one after a short, the other after a long life; but, nevertheless, the mean duration of a generation may be determined, as, for instance, in the human race, at thirty-three years. Thus we may also assume the mean duration, or the mean 'life of a species' (although we repeat it, only on the supposition that each species once existing completely filled up at least one of these first formation-times have we found this mean duration $=1\cdot12$ formation) $=\frac{1}{2}$ the time of a formation when these are limited to the above fifteen; we would therefore, without recognising so many universal synchronous renewals of the entire flora and fauna, assume the whole time of the formation of the earth's crust as $=30$ changes of species, or thirty times the duration or 'life of a species.' Turning now to the investigation of the other question, whether the earth during each of these 'lives of a species' was as richly peopled with species as at present,—at least in respect to those classes, orders, and families which already existed,—we cannot hope to obtain an answer by comparing the entire former flora or fauna with the present, or by comparing the whole number of species of fossil reptiles, fishes or mammalia with those now existing, but only when we compare the fossil flora or fauna of some locality, peculiarly favourably situated for the more perfect preservation of their remains, and these collected, not out of a long series of strata, but at most from a succession of strata corresponding to the 'life of a species,' with the present flora or fauna of the same place, and from several such local and temporary results draw conclusions regarding every point of the earth's surface and all the shortest intervals of time of one 'life of a species.' For this purpose we will review various formations.

a–e. For these, the oldest formations, it may suffice to refer to our Enumerator in respect of the Plantæ vasculares monocotyledoneæ, some groups of Anthozoa, the Brachiopods, the Cephalopods, the Trilobites, the Ganoids, and to remark that the numerous species of most of these divisions have been made known from a small number of localities during a period of scarcely ten years' search, in order to produce the conviction that the earth in that period of time was not poorer in species of the orders of plants and animals just named than at present.

h. The St. Cassian formation may belong to the II., or to *m* in the III. period, but anyhow its series of strata bespeaks a limited locality, a time of formation not longer than one of our 'lives of a species,' and furnishes us with a sea fauna of more than 700 species of invertebrate animals and sponges, corals, echinoderms and molluscs, which is more than we are now able to collect from any similarly limited space in the bottom of the sea.

m. Whilst before the Lias we could not bring together a dozen winged insects, this yields us in England not less than four species of Libellulinæ of three different genera, on the surface of one or two layers of a marine deposit, in a district so limited that in the same place at present, and that too on the land (where the Libellulæ live), it would perhaps be difficult to collect with all diligence as many living species. The larvæ of these animals in the water subsist on other larvæ ; in their winged condition they are continually catching other flying insects for food, which there can be no doubt must have formerly existed along with them, even although we should not now find them. In like manner the number of ganoid fishes belonging to the Lepidoid and Sauroid families which may be found collected in a single point in many localities in England is very considerable ; for the quarries of lias-shale at Lyme Regis alone have furnished 8 genera with 22 species of Elasmobranchii, and 18 genera with 49 species of ganoids (which in the whole existing creation are represented by only 4 genera and 27–30 species).

n^1. In the forest-marble of Calvados in the communes of Ranville, Luc, Lebisey, and Langrune, Michelin himself has found 67 species of polyparia and spongiariæ, whilst Ehrenberg, on the coast of the Red Sea, where one-third of all the known coral animals live, could not collect above 120 species, and perhaps the whole Mediterranean would not yield 67 species.

n^5. In like manner, Goldfuss has described from the Upper Jura of Streitberg 45, of Giengen 17, of Nattheim 8, of Thurnau 7 species of spongiariæ and polyparia, without mentioning those also occurring in these localities, but which had been already described in other places. For in the whole Hartmann enumerates 80 species of polyps from Wurtemberg alone, Goldfuss and Münster 40 species of scyphia from Franconia and Swabia, and Münster has left to the Baireuth collection 130 species of polyparia, with 67 scyphia from Franconia. All these remains are derived from the coral limestone, a rock-section, which corresponds neither to the whole of n^5 nor yet to a complete 'life of a species,' nor yet can have formed the only kind of rock of this time, since the following deposit nearly coincides with it.

n^5. One of the most important fossil localities is the Solenhofen deposit, because it, though well-characterized in regard to its position, is yet so peculiar in its organic remains, that it must be regarded in its whole extent and thickness (Solenhofen, Kehlheim, Pappenheim, Aichstedt) as merely a local facies of another rock-formation, and as the produce of less than one 'life of a species' (n^5), during which, except the gradual filling-up of the sea-bottom, scarcely any geological change has taken place. This locality furnishes besides many conchyliæ, which also occur in n^5 in other localities:

	Genera.	Species.
Marine Algæ	8	29
Sepiæ	4	32
Hexapod insects, including 10 Libellulinæ	12	27
Crustacea: Decapods	26	100
Limulinæ	1	6
Fishes (Ganoids with 4 Elasmobranchii)	22	94
Reptiles (Chelonians and Saurians)	13	27

So great richness of various plants and animals of these divisions could scarcely be collected in any region of the sea within a few square leagues; not only are the marine Algæ abundant, but also the Sepiæ, which are derived entirely from the genera furnished with a shell (*Schulpe*), along with which shell-less species may also have existed; Nice has only 12 genera with 22 living species, including both those with and without a shell; 10 Libellulinæ, as representatives of the hexapod insects, would, in any local European fauna, form a considerable amount, and the larger species indicate a multitude of other flying insects. Six Limulinæ are as many as occur in the whole existing creation. Nowhere have the marine crustacea been so carefully collected for a long time as at Nice, where Verany cannot count above 72 (much-divided) genera with 108 species, among which are 44 genera with 72 species of decapods. It may enable us to judge of the importance of such a number as 94 species of fish, to observe that Risso could not bring together from the seas of Nice during many years, taking advantage of all seasons and with the assistance of fishermen, from the most different localities and depths, which are entirely wanting at Solenhofen, more than 105 genera with 310 species of marine fish of all orders. Finally, the whole of Europe would at present scarcely furnish 13 genera with 27 species of Chelonians and Saurians.

p. A similar relation prevails in the confined freshwater deposits of the North-German and English Wealden formation, into which only a few remains of marine animals have found their way. From these we know:

	In Germany.		In England.	
	Genera.	Species.	Genera.	Species.
Plants	18	50	7	8
Conchyliæ	17	82	15	33
Crustacea	2	10	2	4
Hexapod insects	—	—	48	60
Fishes	8	14 (?)	14	27
Reptiles (Chelonians and Saurians)	3	4	11	13

In the North-German basin alone the freshwater shell Cyrena appears with 38 species, that is, 1·5 times as many species as now live over the whole surface of the globe; the freshwater genera Limnæus, Planorbis, Paludina, Neritina, first occur genuine. On the whole, it would now be difficult to find a distinct basin of water with 8 genera and 14 species, or indeed with 14 genera and 27 species of fish, or in the limits of which 11 genera with 13 species of large reptiles of the orders of the Chelonians and Saurians alone could be discovered, and yet assuredly these numbers do not exhaust this very extensive basin.

r². The limited locality of Maestricht, so peculiar for its rock-formation, whether we leave it in the white chalk or conjoin it with the so-called Terrain danien, does not bespeak a longer interval than the 'life of a species.' It has furnished,—besides remarkable reptiles (Chelonians and Saurians), numerous conchyliæ, crustaceans and foraminifera,—9 genera with 19 species echinoderms, 4 genera with 8 species amorphozoa, and 11 genera with 51 species polypariæ of the groups of Anthozoa and Phytozoa, whereas Verany enumerates for Nice only 8 genera with 23 species echinoderms (without the Holothuriæ), and no calcareous polyps [??].

(s) r. Besides 13 species of fucoids, we are indebted to Monte Bolca for 71 genera with 128 species of fish, all of the order of the Teleostei, for which at Nice only 93 genera with 270 species would remain.

t. From the eocene deposits we would select the local freshwater formation of Rilly, which numbers not less than 14 genera with 39 species of non-marine (*Binnen*) conchyliæ, among which are 8 genera with 24 species of land conchyliæ, which can only have been washed in accidentally from the bank, whereas the most careful examination for a circuit of eight miles (4 *Stunden*) round Heidelberg has yielded us only 90–100 species of non-marine conchyliæ, of which perhaps the half are more or less common, the other half rare, or confined to small localities. Warm regions are not richer in non-marine conchyliæ than the temperate. The freshwater deposit, of about the same age with the former, of Castelnaudary in the Aude, department possesses, according to Marcel de Serres, the following fauna:—

	Genera.	Species.	
Mammalia	3	5	14 : 27;
Reptiles	4	4	
Non-marine conchyliæ	7	18	

of which the conchyliæ again are almost entirely terrestrial species, which are distinct from the former*.

u. The miocene marine remains which Michelotti† has recently described are procured from a thick mass of grey marls round Turin, Asti and Tortona, but which also occurs in the Piacentine country near Basedasco; yet, notwithstanding this very considerable extent, it only corresponds at most to one of our 'lives of a species,' as it must be placed on the parallel of u, or perhaps only of its upper portion. During its deposition no considerable change of conditions has taken place. Its fauna contains—

	Genera.	Species.	
Rhizopoda (Foraminifera)	8	19	171 : 740
Polypi	33	103	
Echinoderms	8	23	
Crustacea	1	1	
Cirripedes	3	6	
Annelids	1	1	
Conchyliæ	117	587	

But now there has been enumerated by

	Conchyliæ. Genera.	Conchyliæ. Species.	Cirripedes. Species.
De Gerville for the coasts of the Manche departments only	28	180	9
Vernay at Nice, not quite	100	250	9
Philippi for the Sicilian-Calabrian coasts	—	545	18

(both with the exclusion of naked and non-marine conchyliæ); hence the Tortona beds, even in respect to the Cirripeds, of which many are very friable or entirely without shells, have much the advantage.

u. For the middle-tertiary freshwater beds we select the two very limited localities, situated quite close to each other, of Wiesbaden and Hochheim, which, although they have not many species in common, yet assuredly do not fill up an entire 'life of a species' as we have above defined it. From these Thomä has described Helix with 32 species, and 12 other genera of non-marine conchyliæ with 23 species, or together 13 genera with 55 species of land and freshwater conchyliæ. According to Al. Braun, Hochheim furnishes 57 and Wiesbaden 22 species alone of land-shells, which together, as only 8 species are common, make 71 species. The entire miocene basin of Mayence, according to him, produces 74 species of land and 28 species of brackish and freshwater conchyliæ, together 102 species from 20 genera, or as many as we are now able to find living in this basin; for in it,

	In the Miocene time. Species.	At present. Species.
Helix has produced	41	32
Bulimus	10	4
Pupa	16	14
Littorinella	9	1 &c.

* Jahrbuch, 1845, p. 738; 1848, p. 637.

† In the Naturkund. Verhandl. van de Maatsch. te Harlem 1847, *b.* iii, ii. pp. 1–408.

On the whole the number of land-conchyliæ was formerly greater and that of marsh-conchyliæ smaller than at present, when we do not include the brackish-water conchyliæ (Dreissena, Littorinella, some Neritinæ, Potamides). This same miocene basin has also furnished to Kaup 17 genera and 32 species of land mammalia generally large, to which H. v. Meyer has added a considerable number of species mostly smaller. No spot on the surface of the earth of equal extent would now, it is probable, yield so many.

v. The peculiar, freshwater, molasse-marls of Öningen, in like manner belonging merely to a small unbroken time of deposition, have as yet furnished:

	Genera.	Species.
Plants according to Al. Braun*	32	55
Non-marine molluscs	∞	∞
Insects according to O. Heer, first Coleoptera	70	103
others	∞	∞
Freshwater fishes according to Agassiz	13	19
Reptiles according to H. v. Meyer (especially Batrachians)	12	16
Birds	*	*
Mammalia according to H. v. Meyer......	3	4
	130+x;	197+x.

All these remains, except those of the non-marine molluscs, fishes and some reptiles, have only come accidentally into this situation, and hence can in no way represent the entire fauna of that time. The Batrachians there appear more numerous and varied among the reptiles than in any other locality in Europe, perhaps on the whole face of the earth. Then of living freshwater fishes there were known by

	Genera.	Species.	
Hartmann in all Switzerland	13	44	
,, in the Boden-lake	—	36	The above is thus 4/7 of this amount;
Nau near Mayence	10	33	
v. Martens near Ulm	10(13)	35	

but it would be impossible to find these 4/7 of the species in any of the places mentioned collected in a single (small) basin of water. Parschlug is of the same age with Öningen, and has produced some identical insects, mammalia, and, according to Unger, also 67 genera with 140 species of plants, of which 19 likewise occur at Öningen. They are leaves, almost wholly of trees and shrubs, which could not be found assembled in such variety in any existing forest, so that Unger has been compelled to make the supposition that they have been brought together by floods from a wide circuit, although their state of preservation appears opposed to this view.

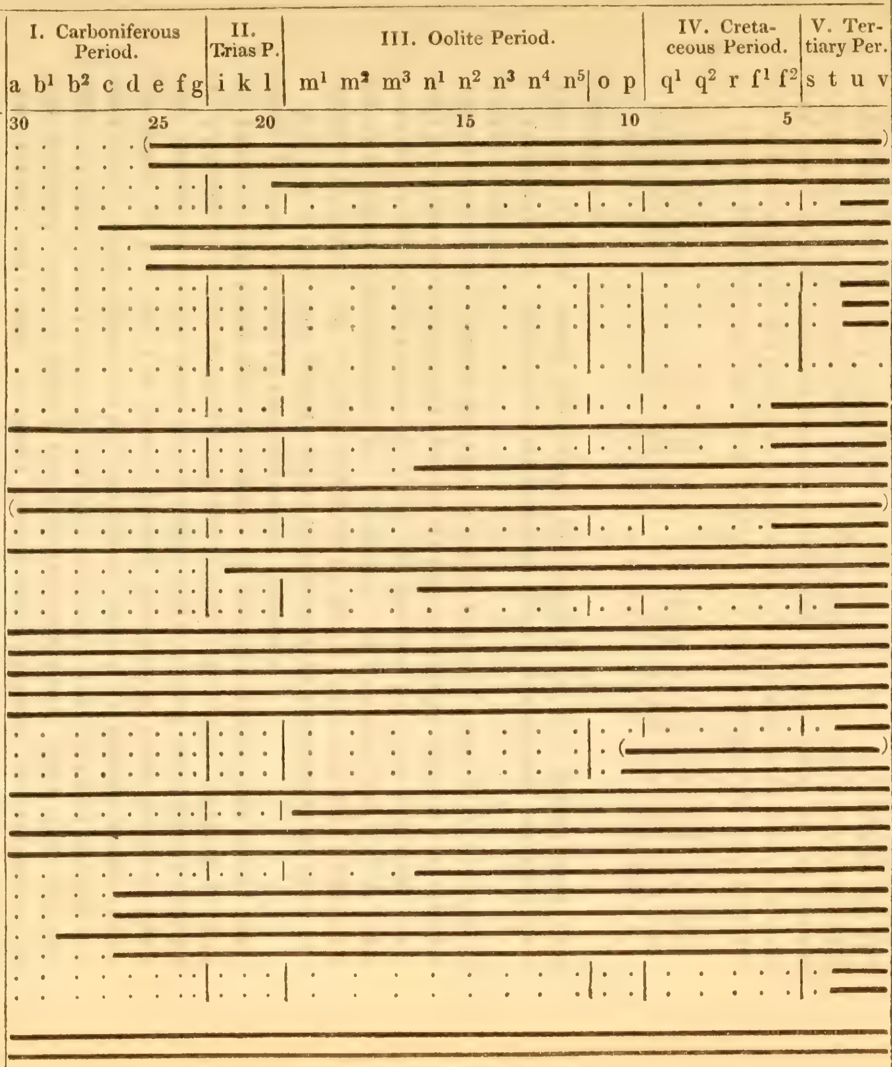
These examples may suffice to render it highly probable, even although all classes, orders, and families of our system may not have existed at all times on the surface of the earth, and although some

* Jahrbuch, 1845, p. 164.

few groups of them may have again vanished, yet that those which then existed were at all times almost as numerously represented by genera and species as at present; although naturally in a systematic point of view, greater or smaller oscillations both in a horizontal and vertical direction were not thereby excluded, and many groups might regularly be in reality somewhat less numerously, others also regularly always more numerously represented than at present. The objection, which some may make, that the species formerly were more widely dispersed, and hence, though on the whole fewer might yet be found as numerous, in one place, as we have seen above, cannot have any essential influence on the result.

It thus appears that we may base an estimate of the number of species which have gradually peopled the surface of the earth on the three following propositions:—(1) There has been at least thirty times a change of species, or there have been thirty 'lives of a species' on the globe; (2) in each of these 'lives of a species' each group of the vegetable and animal kingdom which then existed was represented by as numerous species and genera as at present; (3) notwithstanding minute oscillations up and down of individual groups, the present number of the species and genera of each group may be considered as unity, as the equivalent of each 'life of a species'; and these oscillations may even be taken into account by means of an exponent placed after the number of the existing species. We have assumed it in the Cephalopods (but still too small) as $= 100$, in the entozoa $= \frac{1}{4}$, because formerly there were not so many classes of animals, and consequently their entozoa must also be wanting. We have finally taken that of the insects as only $= \frac{1}{2}$, partly for similar reasons, and partly in order that we might not, by too large an increase of this number, which surpasses the sum of all the other species, possibly prejudice too much the correctness of the whole. Thus we obtain the following view of the duration and number of the various organic beings during geological time:—

Duration of the Groups.



	Number of lives of a species.	Number of existing species.	Exponent.	Product.
Fungi	25	5100	1/2	63,750
Algæ	25	1000	1	25,000
Lichenes	20	800	1/2	8,000
Cellulares foliosæ	3	600	1	1,800
Vasculares: Monocotyledoneæ	27	1629	1	43,783
Phanerogamæ	25	8543	1	213,576
Monochlamydeæ 1.	25	680	1	17,000
„ 2.	3	2566	1	7,698
Corollifloræ	3	23,900	1	71,700
Choristopetalæ	3	22,528	1	67,584
Plantæ: *Summa*	—	—	—	519,891
Pseudozoa	5	50	1	250
Amorphozoa	30	250	1	7,500
Polygastrica	5	500	1	2,500
Polypi Foraminiferi	16	1000	1	16,000
Bryozoa et Anthozoa	30	810	1	24,300
Entozoa	30	1500	1/4	11,250
Acalephæ	4	210	1	840
Echinodermata: Stelleridæ	30	286	1	8,580
Echinidæ	22	146	1	3,212
Fistulidæ	16	66	1	1,056
Malacozoa: Gymnacephala	3	70	1	210
Brachiopoda	30	48	4	5,760
Pelecypoda	30	2413	1	72,390
Heteropoda	30	23	1	690
Protopoda	30	64	1	1,920
Gasteropoda A—C	30	5989	1	179,670
„ DE	3	158	1	474
„ F	10	85	1	850
„ G	10	2441	2/3	16,270
Cephalopoda A.	30	2	100	6,000
„ B	20	126	1	2,520
Entomozoa: Vermes	30	770	2/3	15,390
Crustacea	30	790	1	23,700
Myriapoda	16	200	1	3,200
Arachnoidea	26	600	2/3	10,400
Hexapoda	26	65,000	1/2	845,000
Spondylozoa: Pisces	28	8000	2/3	149,324
Reptilia	26	1055	1/2	13,718
Aves	3	7000	1	21,000
Mammalia	3	2030	1	6,090
Animalia	—	—	—	1,450,064
Vegetabilia et Animalia	—	—	—	1,969,955

We thus obtain in round numbers 1,500,000 species of animals, and 500,000 of plants. By introducing more appropriate numbers and exponents, our calculation might perhaps be here and there amended, and thus a more correct result obtained; meanwhile it is sufficient for us at present to have pointed out the method, according to which we believe that such an estimate must be made; it is enough for us to have so far obtained a general result, from which the whole succession of the gradually originating and perishing organisms may be reckoned at two millions; and it is on the whole indifferent at present, whether this may become, in consequence of amended calculations, 1,000,000 or 3,000,000. On the whole, as was stated, only half so many plants are obtained in proportion to the animals; but in reality the commencing flora, until the appearance of the second half of the Monochlamydeæ, of the Corolliflorae and the Choristopetalæ, the number of which is almost three times as great as that of the lower plants, was much more uniform than the fauna, in which, indeed, the more perfect and some other classes in like manner also first appear along with the more perfect classes of plants; but these perfect classes of animals make (not three, but) only $\frac{1}{10}$ the number of the imperfect classes.

Of the 2,000,000 species of organisms thus estimated as once existing, probably not $\frac{1}{10}$ were adapted to leave their remains imbedded in a recognizable condition in the strata; or chance (*Zufall*) at least has not sufficiently favoured $\frac{9}{10}$ of the species for this purpose; and of the remaining 200,000 species which we might find in the earth's crust, chance will again prevent a large portion from ever coming to our knowledge.

Returning to the facts presented to us by our tables, we find that the species are most unequally distributed in the formations and periods:—

Periods.	I.	II.	III.	IV.	V.	or	I.	II.	III.	IV*.	V.
Plants: species	1017	98	241	84	623	=	0·49 :	0·05 :	0·11 :	0·04 :	0·31
Animals: species . . .	4445	1091	3892	4816	13,384	=	0·16 :	0·04 :	0·13 :	0·18 :	0·48
Both: species	5462	1189	4133	4900	14,007	=	0·18 :	0·04 ;	0·14 :	0·17 :	0·47

These inequalities are (independent of the accidental coincidence of our researches with richer or poorer fossil-localities) partly a consequence of the unequal preserving-powers of the kind of rock-mass composing each formation either generally or for certain classes and organisms in especial (the coal formation for plants), partly of the wider geographical development of the species and the unequal duration of the periods, which, however, it would be difficult to find a means of measuring, and finally, partly of the unequal richness of the successive formations, which we indeed express in numbers, but still are, from not knowing the value of the two previous influences, incapable of so measuring as to be able to say, which period estimated for times of equal length was the richer. We were for some moments disposed to estimate equal duration of the periods from equality in the numbers or quota of fossil species which passed from the first

* In the original the numbers in this column are, 0·040, 0·018, 0·017, but evidently from a misprint.—J. N.

rock-member of one period to the first member of the next period; nevertheless, this depends not only on the accidental character of the two kinds of rock, but also rests on the supposition of a uniform proportion between the time and the causes that destroy species. Would we lastly, without concerning ourselves about the time, equalize the periods with each other merely in this manner, that they should only contain an equally small number or quota of common species, it may be again asked, whether the continuous preservation and the relative extinction of old species forms an element better adapted for a measure, than the appearance of new species? For thus the cretaceous (IV.) has a larger quota of species in common with the existing period (VI.), than any two former periods immediately bordering on each other have in common, and yet no other periods are so distinctly separated from each other as the chalk is from the tertiary, by the above-mentioned appearance of the highest forms of plants and animals, in the former of a part of the Monochlamydeæ, the Corollifloræ and Choristopetalæ, in the latter of a part of the fishes (osseous fishes), of the reptiles (serpents and batrachians), and of the two classes of the warm-blooded vertebrata.

Were we to arrange the periods according to their absolute richness in fossil species they would stand thus:—

According to the Plants . . IV, II, III, V, I.
,, ,, Animals . II, III, I, IV, V.
,, both together, II, III, IV, I, V.

The carboniferous period, from the accumulation of carbonaceous and clayey materials in its rocks, was the most favourable for the preservation of plants, and hence it furnishes us with quite as many species of them as all the other periods together, though a portion of the system, now three times the most numerous, first appears in the last of them. The Trias period (II.) is evidently, not merely from accident, but in reality poorer, and undoubtedly shorter and of a more local character than the others. The Cretaceous period (IV.) contains almost no rocks adapted for the preservation of plants, and in especial entirely wants land and freshwater formations. The Oolite period (III.) may in this respect be designated as the true, indifferent mean (or centre) of the periods. The Tertiary period (V.) finally is essentially distinguished by a greater richness in organic species in general, and in animals in particular, which appears to be a consequence not merely of a greater capacity in the rocks for preserving them, nor of a probably longer continuance of the period, but of an essentially greater richness of the time in all grades of organic forms.

We reserve some other questions for illustration on another occasion. J. N.

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics, are also figured.]

THE END.

PRINTED BY RICHARD AND JOHN E. TAYLOR,
RED LION COURT, FLEET STREET.