THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE V. VOL. III.

JANUARY—DECEMBER, 1906.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCCXCIX TO DX.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S.,
F.G.S., V.P.R.M.S.

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PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY, PAST PRESIDENT OF THE MALACOLOGICAL SOCIETY;

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON: OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., V.P.G.S., &c.

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ERRATA.

p. 144, l. 21 from foot: after *from* insert *Eoliths.*

p. 159, l. 2 from foot: for "two lower" read "lower two."

p. 400, note 2, l. 5: for "Weymouth" read "Weybourne."

p. 513, l. 22: for "are" read "is."

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LONDON: DULAU & CO., 37, SOHO SQUARE.

Yours very truly
T McKenny Hughes

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. III.

No. I.—JANUARY, 1906.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

THOMAS McKENNY HUGHES, M.A., F.R.S., F.G.S., F.S.A.,

Woodwardian Professor of Geology in the University of Cambridge;
of Trinity College, Cambridge; Professorial Fellow of Clare College, Cambridge;
Chevalier of the Order SS. Maurice et Lazarus, Italia;
Corr. Memb. Geol. Soc. Belgium, France, Germany, Italy, etc.

(WITH A PORTRAIT, PLATE I.)

AMONG the great body of geologists, who are justly entitled by their work in this field of science to rank as "knights-commanders of the hammer," there is no one more distinguished, as well for his active services as for the geniality of his disposition and his bonhomie, than the amiable and accomplished occupant of the Woodwardian Chair of Geology in the University of Cambridge, Professor T. McKenny Hughes.

He was born at Aberystwyth, in Wales, and is the son of that most famous and popular Bishop of St. Asaph (1807–1889) well known as a prelate who preached and talked to his people fluently in Welsh, and was beloved by all in his diocese accordingly. Mr. T. McKenny Hughes is also brother of the present Bishop of Llandaff, and a grandson of Sir Thomas McKenny, Bart., who took a very prominent part in promoting Catholic emancipation and similar movements in Ireland.

Spending much of his early days in the Principality, Mr. Hughes naturally acquired a thorough knowledge of Welsh, and has never ceased to cherish a love for the Cambrian mountains and valleys of his native land, where he also imbibed from association much of the happy disposition and quickness of mode characteristic of the Welsh people, together with their love of music and anecdote. His early education was acquired at Leamington and Llandovery Colleges, whence he afterwards entered at Trinity College, Cambridge, in 1853. While an undergraduate he was an associate of the Ray

Club, and a constant attendant at Professor Sedgwick's lectures in the Woodwardian Museum. After taking his Bachelor's degree in 1857, he was engaged in tuition for two years, during which his geological tendencies were for the time in abeyance. Mr. Hughes did not proceed to take his M.A. degree until ten years later, in 1867.

At the commencement of the year 1860 a new career seemed to be opening to Mr. Hughes, when he received the appointment of Secretary to Mr. (afterwards Sir) C. T. Newton, K.C.B., H.B.M. Consul in Rome, where later in that year, and in 1861, Mr. Hughes was left in charge as Acting-Consul. During his residence in Rome he took the opportunity to study the sub-Apennine formations on the hills around the Eternal City, and made collections of fossils from them, and also from the more recent deposits of the Valley of the Tiber.

One of the most interesting episodes in his life was when he was left Acting-Consul in Rome in 1860 and 1861, when Garibaldi was marching on the city and all sorts of mercenaries were collected to meet him. Among them was a brigade of Irishmen, who gave more trouble to the Papal officers themselves than to the enemy. He was often called in to help to arrange matters *officieusement* between the officers and their men, who could not understand one another's language. This kind of training abroad gave him an experience in dealing with men which he has found useful ever since.

In 1861 he had the option of accompanying Lord Odo Russell to Berlin, and at the same time he received an invitation from Sir Roderick Murchison to join the staff of the Geological Survey of Great Britain. In this "meeting of the waters" his love for geology prevailed, he bade adieu to Rome, and to what seemed to promise in the future a brilliant diplomatic career, and he returned to England as a "Royal hammerer."

Accordingly we find Mr. Hughes later on in 1861 duly installed as an Assistant Geologist on the Geological Survey of Great Britain, Sir Roderick I. Murchison being then Director-General, and Professor A. C. Ramsay, Director. He commenced work, and was occupied during several field seasons in mapping the Chalk and Lower Eocene strata along the Medway Valley, and near Faversham and Sittingbourne; and his observations on this region were published in Mr. Whitaker's Memoir on the Geology of the London Basin (Mem. Geol. Surv., vol. iv, 1872). The Chalk was then divided into broad lithological divisions, which were carefully described with regard to their local features, economic products, and leading fossils; and Mr. Hughes remarked that "from the varying character of the beds and the irregular occurrence of the layers of flints, it is very probable that the same horizon may not have been everywhere taken as the base of the Upper Chalk." Attention was called to the accumulations of chalk and flint rubble that have attracted much notice during recent years; and also to the layer of unworn green-coated flints that usually occurs at the top of the Chalk, where it is covered by the Thanet Sand. Mr. Hughes (in a paper read before the Geological Society in 1866) gave reasons for believing that the layer was due to the dissolution of the top beds of the Chalk after the deposition of the Thanet Sand. He also dealt with Sheppey, the rapid waste of its coast, and the curious mounds in the adjacent marshes, that had been a puzzle to antiquaries, but might well be attributed to tidal action and the modifying effects of subaërial denudation. He pointed out that the Medway, below Cuxton, flows along the line of a gentle anticlinal axis in the Chalk, and he discussed the effects of denudation on the permanent water-level in the Chalk.

Working later (1865–6) in the country near Hertford and St. Albans, Mr. Hughes described the drift gravels under two heads; that of the Lower Plain, which for the most part is the ordinary mixed glacial gravel associated with the Chalky Boulder-clay, and that of the Higher Plain, consisting chiefly of pebbles of flint, quartz, etc., which he regarded as a marine deposit, and he hinted at its possible Pliocene age.

In 1866 Mr. Hughes was transferred to the Lake District where the Geological Survey had commenced operations under the superintendence of W. T. Aveline. In that region he had the satisfaction of meeting his old master, Sedgwick, on his own ground, working in the neighbourhood of Kirkby Lonsdale, Dent, and Sedbergh. There, too, he was ever a welcome guest in the country houses, and after a hard day's tramp across mountain and moor, he frequently rode many miles on horseback from his quarters to dinner or dance. His personality has always readily turned strangers into friends amongst rich and poor. Once, after a long day's work in the Crossfell country, he went into a lonely cottage and asked the good woman to give him something to eat. She did so, and when he had finished he said, "What is there to pay?" "Nowt at a', nowt at a'," she replied, "yer cumpany's good!"

He now zealously paid attention to the fossils of the Silurian and other rocks on the borders of Westmorland and Yorkshire, and his observations communicated to the Geological Magazine for 1867 led him to confirm the breach between the Upper and Lower Silurian, and to support the view of Sedgwick that the Coniston Flags formed the base of the upper division. The publication of these views was, we believe, received with some disapprobation on the part of the Director-General of the Geological Survey.

The main results of his field-work were printed subsequently in Memoirs on the geology of the neighbourhood of Kirkby Lonsdale and Kendal (written in conjunction with Mr. W. T. Aveline and Mr. R. H. Tiddeman), and on the geology of the country around Kendal, Sedbergh, Bowness, and Tebay (with W. T. Aveline).

In describing the "Upper Old Red Conglomerate" he remarked on the unfortunate introduction into the district of the term "Old Red," as the conglomerate was truly the Basement Bed of the Carboniferous Series. With reference to the Yoredale Rocks, he observed that "They thus form a kind of passage from the Mountain Limestone to the Millstone Grit, and should, perhaps, be considered as the upper part of the Mountain Limestone split up by shales and sandstones."

In all his notes published by the Geological Survey we find careful attention paid to the work of previous observers, and many acute observations on the facts and phenomena that came before him.

It was while serving as an Assistant Geologist on the Geological Survey that the Chair of Geology in Cambridge became vacant by the death, in his 88th year, of the illustrious Professor Adam Sedgwick, on the 27th January, 1873, after occupying that position for 55 years.

By Statute of the University, the appointment must take place within one month from the vacancy being declared, so that on the 20th February, 1873, the Heads of Houses, Professors, University Examiners, and resident members of the Senate proceeded to elect a successor, no fewer than nine candidates having offered themselves for the post. Most of these, however, withdrew without going to the poll, while other candidates early retired from the contest, which finally resulted in the election of Mr. Hughes by a small majority over Professor Bonney.

Both before and after his election to the chair, Professor Hughes was intimately associated with the late Sir Charles Lyell, with whom he made several foreign and British tours. Lyell frequently mentions his friend—" Mr. T. M'K. Hughes, *now* Woodwardian Professor at Cambridge"—in the fourth edition of his " Antiquity of Man," when, in the Spring of 1872, they visited together the cave of Aurignac and the caverns of Dordogne.

As a lecturer Professor Hughes is extremely fluent and clear in his delivery, and he makes excellent use of the chalk and blackboard to aid his demonstrations. He is also a most popular man with his students and at the meetings of his fellow-workers at the Geological Society of London.

The remarkable feature of Professor Hughes' work in Cambridge has been the large number of men of mark who have studied under him, and also the very strong list of graduates who have joined the teaching staff in what is now justly recognised as "*the* Cambridge School of Geology."

We recall with pleasure some of these who have taken distinguished places in the world, and a few who have already ended their work well :—

1874.[1] Walter Keeping, M.A., Professor of Natural Science, Aberystwyth University.
1875. Robert D. Roberts, D.Sc., M.A., F.G.S., University of London, etc.
1875. Aubrey Strahan, M.A., F.R.S., Geological Survey of England and Wales.
1878. Edward B. Tawney, M.A., F.G.S., Assistant to the Woodwardian Professor.
1879. J. E. Marr, M.A., Sc.D., F.R.S., President Geol. Soc. London (Reader in Geology in the University of Cambridge).
1879. T. H. D. La Touche, M.A., Superintendent Geol. Survey of India.
1880. C. S. Middlemiss, M.A., F.G.S., Superintendent Geol. Survey of India.
1880. Arthur S. Reid, M.A., F.G.S., Trinity College, Glenalmond.
1881. W. H. Herries, B.A., F.G.S., New Zealand.

[1] The date affixed is that of the first degree taken at Cambridge. Where the date could not be ascertained, a dash is put instead of the year.—Edit. Geol. Mag.

1882. Professor W. W. Watts, M.A., M.Sc., F.R.S., Sec. Geol. Soc. London; University of Birmingham.
1882. Alfred Harker, M.A., F.R.S. [Geol. Survey of Scotland (retired)], Fellow of St. John's College, Cambridge; University Lecturer in Petrology.
1883. Rev. W. M. Lower Carter, M.A., F.G.S., Sec. Yorks. Geol. Polyt. Soc.
1883. T. Roberts, M.A., F.G.S., Assistant to the Woodwardian Professor.
1883. Evan W. Small, M.A., B.Sc.
1884. J. R. Ainsworth Davis, Professor University College, Aberystwyth.
1884. Robert S. Herries, M.A., V.P. Geol. Soc.
1886. J. W. Carr, M.A., F.L.S., F.G.S., Professor University College, Nottingham.
1886. A. C. Seward, M.A., F.R.S., F.L.S., Fellow of Emmanuel College, Cambridge; University Lecturer in Botany, Cambridge.
1886. Professor E. J. Garwood, M.A., Sec. Geol. Soc. London; Professor of Geology, University College, London.
1887. Philip Lake, M.A., F.G.S., Lecturer at Colchester College.
1888. Professor T. H. Easterfield, M.A., Wellington, New Zealand.
1888. Arthur Hutchinson, M.A., Ph.D., F.C.S., F.G.S., Demonstrator in Mineralogy in the University of Cambridge.
1888. Robert Ludwig Mond, M.A., F.R.S. E., F.G.S.
1888 (took Tripos). Marie Wilman, South African Museum, Cape Town.
1889. S. F. Dufton, M.A., H.M. Inspector of Schools.
1889. Professor T. T. Groom, M.A., D.Sc. Lond., F.G.S., University College, Reading.
1889. C. H. Hawes, M.A., traveller and author.
1889. Professor S. H. Reynolds, M.A., F.G.S., Professor of Geology, University College, Bristol.
1889. Herbert Warington Smyth, M.A., LL.M., F.G.S., Secretary to the Mines Department, Transvaal.
1890 (Classical Tripos, 1st Class). C. B. Wedd, B.A., F.G.S., Geol. Survey of England and Wales.
1890. H. Woods, M.A., F.G.S., University Lecturer in Palæozoology, Cambridge.
1891. Harry Brownsword, M.A., The Leys School, Cambridge.
1891. H. Kynaston, B.A., F.G.S., Director of the Geol. Survey of the Transvaal Colony, Pretoria.
1891. E. A. Peters, B.A., M.D.
1891. F. R. Cowper Reed, M.A., F.G.S., Assistant to the Woodwardian Professor.
1892. L. J. Spencer, M.A., F.G.S., Department of Mineralogy, British Museum (Nat. Hist.).
1893. F. L. Kitchin, M.A., Ph.D., F.G.S., Palæontologist to Geol. Survey of Great Britain.
1894. A. W. Rogers, M.A., F.G.S., Director of the Geol. Survey of Cape Colony.
1894–5. Miss Gertrude L. Elles, D.Sc., Assistant to the Woodwardian Professor; Newnham College.
1895. R. Hawthorn Kitson, B.A., F.G.S., Leeds.
1895. Miss Ethel M. R. Wood, M.Sc., Birmingham University; Newnham Coll.
1896. E. H. Cunningham-Craig, B.A., F.G.S., Geol. Survey of Scotland (temporarily of Trinidad).
1897. H. H. Thomas, M.A., F.G.S., Geol. Survey of England.
1897. H. Stanley Jevons, B.A., F.G.S., University College, Cardiff.
1898. E. A. Newell Arber, M.A., Demonstrator in Palæobotany, Geol. Mus., Cambridge.
1900. W. G. Fearnsides, M.A., F.G.S., Fellow of Sidney Sussex College, Assistant Demonstrator, Geol. Mus., Cambridge.
1901. H. T. Ferrar, M.A., F.G.S., Antarctic explorer on "Discovery"; Survey of Egypt.
1901. K. A. K. Hallowes, B.A., Assoc.R.S.M., F.G.S., Geol. Survey of India.
1901. H. B. Muff, B.A., F.G.S., Geol. Survey of Scotland.
1902. E. B. Bailey, B.A., F.G.S., Geol. Survey of Scotland.
1902. R. H. Rastall, B.A., F.G.S., Assistant Demonstrator, Geol. Mus., Cambridge.
—— F. B. Smith, B.A., Agricultural College, Africa.
—— L. W. Hinxman, B.A., Geological Survey of Scotland.
—— G. W. Grabham, B.A., F.G.S., Geol. Survey of England.
—— Owen Thomas Jones, B.A., Geol. Survey of England.

The first man who joined Professor Hughes' teaching staff, by special invitation, was the well-known geologist Mr. Edward B. Tawney. He was not a graduate of the University in the ordinary sense of the term, having taken his honours and his training at the Royal School of Mines and elsewhere. He became Professor Hughes' earliest assistant in 1878. In the Academic year following the University conferred on him the honorary degree of M.A. (*propter merita*), but he did not long survive to carry on the splendid work of teaching. He died in 1882 at the comparatively early age of 42; but he accomplished much good work in his lifetime, as may be seen by reference to his published papers.[1] Another excellent teacher, T. Roberts, M.A., followed in 1883, and continued until his death in 1892, having taken up more especially the Jurassic rocks as his line of research. Dr. J. E. Marr, M.A., F.R.S., Pres. Geol. Soc., commenced teaching in 1879, dealing specially with the older rocks, and is "Reader in Geology" in the University of Cambridge. Mr. Alfred Harker, M.A., F.R.S., has also done much valuable work in advancing the study of petrology, and in teaching the nature of rock-structures, more especially of the igneous rocks. Mr. Henry Woods, M.A., F.G.S., Lecturer on Palæozoology, deals with a branch of study pursued also by Mr. F. R. Cowper Reed, M.A., F.G.S.; the latter also takes an earnest and active part in the Museum arrangements. Miss G. L. Elles, D.Sc., has likewise assisted the Professor of Geology as a demonstrator to his classes.

With such advantages afforded them, what wonder then, if the geologists who leave the Cambridge University are so well equipped that they now mostly occupy leading positions in Museums, upon Geological Surveys, and in the teaching of the science, not only at home but in India and in our Colonies. Nor must it be forgotten (if we except the Ashmolean Museum, opened in 1683) that Cambridge had its splendid Woodwardian Museum from an earlier date even than the sister University of Oxford, although, till late, far too "cabin'd, cribb'd, and confin'd" for want of adequate exhibition space. In 1835 it was decided by the University to build a museum for geology; and the popularity of Professor Sedgwick was so great that a sum of £23,400 was readily collected by public subscription, to which was added £4,000 from the Woodwardian Trust Funds. Cockerell's Building was erected with the help of these funds, and to the geological collection the two lower floors were assigned. But this accommodation, owing to the large accessions made to the geological collections, had been obviously inadequate for many years past.

On the death of Professor Sedgwick in 1873, it was decided that the memorial to him should take the form of a new and larger Museum; and in that year a public subscription was opened for this purpose, and a sum raised which ultimately amounted to over £28,000. The public recognition of the value of geology as a subject for University teaching in Cambridge has thus been demonstrated,

[1] Geol. Mag., 1883, pp. 140–144.

upon two occasions, in a very substantial manner. A writer at the time[1] says:—"After a long series of disappointments and difficulties the indefatigable energy and perseverance of Professor Sedgwick's successor, Professor T. McKenny Hughes, have triumphed over the countless obstacles which hindered the realisation of the scheme. . . . The Architect of the building is Mr. T. G. Jackson, R.A., and he has had the difficult task of designing a museum which should satisfy the needs of the Geological Department and the requirements of the various University syndicates. . . . Whatever may be the opinion of these bodies, the staff and students have good reason to be well pleased with the ample accommodation provided for them, and the collections are now adequately exhibited in the new galleries. Research and other laboratories are provided, and the principal lecture-room is capable of accommodating a class of 120 students. Midway between the galleries for Palæozoic and Neozoic fossils stands the bronze statue of Professor Sedgwick, with his geological hammer in one hand and a slab bearing the Cambrian Trilobite *Angelina Sedgwickii* in the other."

One who graduated more than fifty years ago, and knew the old Museum in Sedgwick's lifetime, strolled into the new building in Downing Street, Cambridge, the other day, and, seeing the glories of the Museum for the first time, was heard to exclaim: "How different all this is from what it was in my time! How I envy the students and the teachers who are privileged to study and work at geology under such favourable conditions as they now enjoy! I should like to have my time over again in 1906."

Remembering the removal of the geological collections of the British Museum from Bloomsbury to South Kensington in 1880, the writer can well understand the enormous difficulties which Professor Hughes must have encountered, with only a very small staff at his command, in carrying out the task of removing the Woodwardian collections from the old building into their new home, and their subsequent rearrangement.

But we must not dwell too long upon the "Sedgwick Memorial Museum," save to refer to it as one of the great and important objects carried out by Professor Hughes in connection with the teaching of geology in the University during his term of office.

After the death of the Rev. Canon Charles Kingsley, the founder and President of the Chester Society of Natural Science, in 1875, Professor T. McKenny Hughes was elected his successor, and delivered several addresses to its members during his term of office. He received the "Kingsley Memorial Medal," established in memory of Charles Kingsley by the Chester Naturalists. Professor Hughes was likewise President of the Kendal Literary and Scientific Society.

While devoting his energies so largely to the work of the University, Professor Hughes continued to carry on field-work in various parts of the country, notably in Wales, both among the more ancient rocks and among the caves and Drift deposits. The list of

[1] Geol. Mag., 1903, pp. 532–534.

papers appended to this memoir will sufficiently indicate these labours, but we may recall attention to one subject that has since attracted a good deal of notice.

In his paper "On the Brecciated Bed in the Dimetian at St. Davids" (Geol. Mag., 1883, p. 306), he discussed the origin of certain breccias and brecciated conglomerates in homogeneous rocks, and the breaking up and recementing of rock-masses in place. He gave a diagram of a brecciated granitoid rock near Bryngarn, composed of large and small subangular fragments, and this bed (which would now be spoken of as a "crush conglomerate") was described as "not of transport origin, but represents brecciation in place and subsequent weathering along the joint planes."

In February, 1891, Sir Archibald Geikie, F.R.S., the President of the Geological Society, announced that the Lyell Medal had been awarded by the Council to Professor T. McKenny Hughes, in appreciation of the value of his investigations in various departments of geology, especially among the older rocks. He referred particularly to Professor Hughes' researches in Caernarvonshire and Anglesey, which formed the starting-point to those later inquiries which had done so much to clear up the earlier chapters in the geological history of Wales. "You have," said the President, "not confined yourself, however, to the rocks of any one system or period, but have ranged freely from Archæan gneiss to raised beach . . . . with that happy faculty of enthusiasm which, reacting on younger minds, 'allures to older worlds and leads the way.' This medal will not only serve to mark the Society's appreciation of your work, but will also connect you by another link with the memory of our friend and master, Lyell."

Professor Hughes was elected a Fellow of the Geological Society in 1862 and a Fellow of the Royal Society in 1889.

At the meeting of the International Geological Congress held in Paris in 1878, Professor Hughes was appointed a member of the Commission for the unification of geological signs and geological nomenclature and classification. He was chosen President of the British Committee of Organisation to deal with the subjects of classification and nomenclature. Five sub-committees were formed and their reports were issued in 1885, and revised and amplified in a second edition in 1888. To the latter Professor Hughes contributed an interesting and philosophic preface on the rules which should guide us in our classification of strata, and in our descriptions of rocks, fossils, and geological sections.

Professor Hughes continued to attend the meetings of the Congress up to that at Zurich in 1894.

On the completion of the 25th year of his Professorship, he was entertained by his friends at a public dinner in London, February 26th, 1898, when he was presented with an illuminated address by his students and fellow-workers congratulating him upon the success of the Cambridge School of Geology under his charge.

Professor Hughes married, November 28th, 1882, Mary Caroline, daughter of the Rev. George F. Weston, Honorary Canon of Carlisle

Cathedral. Mrs. Hughes inherits the artistic skill of her father and mother; she is a good linguist and has extensive scientific knowledge, but she devotes herself now entirely to her husband's pursuits. She is a keen geologist, and, in the field on geological excursions, her presence is greatly appreciated.

The writer recalls a delightful excursion some years ago to the Wrekin, led by Professor Lapworth, in which Professor and Mrs. McKenny Hughes took part, and he remembers seeing the three happily engaged hammering at a block of Hollybush sandstone, from which Mrs. Hughes, with her own hammer, extracted some good remains of *Olenellus*, to the joy of the party.

In the far western wilds of America, when their commissariat broke down, Mrs. Hughes cooked for a party of 17, and was described by one of the speakers at the closing meeting as "un vrai rayon de soleil dans nos misères."

In Russia, after announcing Mrs. Hughes' arrival, the Report (Comptes Rendus, p. cclxxxii) adds, "depuis le charme de notre société."

She was the only lady member of the Reichstag at Berlin when old Von Dechen began his Presidential address "Madame et Messieurs."

Mrs. Hughes worked long and diligently at the Pleistocene deposits in the neighbourhood of Cambridge, and published an excellent paper thereon in the GEOLOGICAL MAGAZINE for May, 1888 (pp. 193–207, illustrated by five sections). She also gave a very exhaustive list of the molluscan and other fossil remains found in the gravels and brickearth.

Professor and Mrs. Hughes have a family of three sons: the eldest is a B.A. of Cambridge, and is studying to become an architect; the second son goes up next October; the third is still a schoolboy, but will, if he does not change his mind, take up geology.

Professor Hughes has always been a keen student of archæology (as may be seen from his list of published papers), and has served the office of President of the Cambridge Antiquarian Society. He takes an active part in agricultural organisations, and has for the past two years been President of the Cambridge and Isle of Ely Chamber of Agriculture. A good hall on the ground floor of the new Museum is allotted to Economic Geology, and a collection illustrative of this branch is being formed after the plan of De la Beche's Museum, now unhappily removed from Jermyn Street.

In looking back for half a century of our geological life, and recalling the long line of familiar faces, especially of those who in the days of our novitiate occupied the front rank, one is conscious of the changes which the fleeting years have wrought. Sir Archibald Geikie, addressing his friend Professor Hughes at the Geological Society in 1891, recalled the days of their early friendship, now faded so far into the dim past of life, when, as colleagues on the Geological Survey, they attended together the meetings of the Geological Society in Somerset House, taking seats on a back row, and gazing down upon the magnates of the science seated beneath. "Little," said he, "did either of us dream that the whirligig of time would eventually place us where we find ourselves to-day."

Sir Archibald Geikie, although retired and no longer the official head of the Survey, occupies the important post of one of the Secretaries to the Royal Society, and is still full of energy and work. Professor T. McKenny Hughes carries on the duties of the Chair of Geology, and maintains active interest in all scientific matters connected with the University, more especially whatever concerns his beloved "Sedgwick Memorial Museum," which is naturally his joy and crown of rejoicing for life, and the outward and visible sign of the high place which geology, palæontology, and petrology hold in Cambridge.

The following is a list of Professor T. McKenny Hughes' published papers and memoirs:—

1866. "Note on the Silurian Rocks of Casterton Low Fell, Kirkby Lonsdale, Westmoreland": Geol. Mag., Vol. III, pp. 206–208 (with a section).

,, "Note on the Junction of the Thanet Sand and the Chalk, and of the Sandgate Beds and Kentish Rag": Quart. Journ. Geol. Soc., vol. xxii, pp. 402–404.

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Professor Hughes has been a frequent contributor to *Nature* and other scientific periodicals.

II.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

By R. M. Brydone, F.G.S.

(PLATES II AND III.)

THIS paper is primarily a record of observations made at Trimmingham since those recorded in a pamphlet entitled "The Stratigraphy and Fauna of the Trimmingham Chalk."[1] But as the Polyzoa of the Trimmingham Chalk comprise a remarkably large number of species which appear to be at present undescribed and are very characteristic of this horizon, I have taken this opportunity of describing some of the most prominent of these forms, partly in the hope of directing the attention of other collectors to their range and partly to facilitate the classification of the very large quantity of material I have accumulated. I have also taken this opportunity of giving a list of species from the Chalk between Cromer and Weybourne.

[1] London: printed separately, Dulau & Co., 1900.

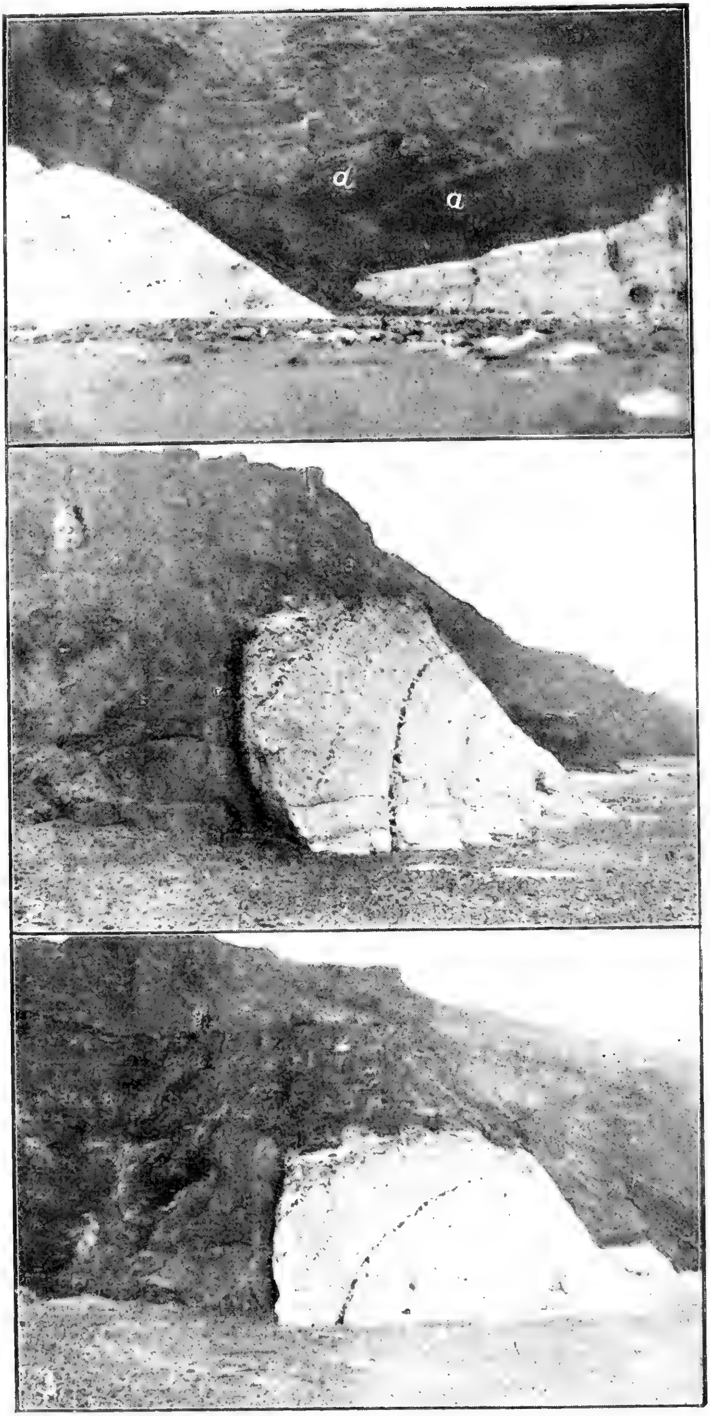
In the recently published memoir of the Geological Survey on the Upper Chalk of England Mr. Jukes-Browne has established a zone of *Ostrea lunata* for the Trimmingham Chalk. It is clearly desirable that a formal zone should be so created now that the fauna is known to be so distinctive, in spite of the present impossibility of identifying its upper or lower boundary, but the choice of *O. lunata* as a zone-fossil, though natural, is unfortunate. *O. lunata* has two characteristics of an ideal zone-fossil in that it is, as far as we know, almost confined to the Trimmingham Chalk, and that in that Chalk zone it always occurs abundantly, if at all. But it fails to fulfil the most important requirement for a good zone-fossil in that it is not distributed all through its so-called zone. There are at least ten, and probably more, distinct horizons occurring in four sequences at different points. The relations of the members of each sequence to one another are quite clear; the relations of the sequences to one another are at present doubtful (except that 3 is clearly identical with part of 4), but I believe that series 1 is the uppermost and series 4 the lowest, and I often fancy that series 2 is composed of the bottom bed of series 1 and the upper beds of series 3. The series (in descending order in each case) is as follows:—

1. Grey chalk with abundance of small *Ostrea vesicularis*.
   White chalk with *O. lunata*.
   ,, without *O. lunata*.
   ,, with *O. lunata*.
   ,, without *O. lunata*.
   Grey chalk with *O. canaliculata*, *O. inæquicostata*, *Terebratula obesa*, and *Stegaster*.
2. Grey chalk with *O. canaliculata*, *O. inæquicostata*, *T. obesa*, and a grit seam or bed at base.
   White chalk with *O. lunata*.
   ,, without *O. lunata*.
3. White chalk with *O. lunata*.
   ,, without *O. lunata*.
   Hard chalk, weathering very lumpy.
4. White chalk with *O. lunata*.
   ,, without *O. lunata*.
   Hard chalk, weathering very lumpy.
   White chalk very much mottled by grey blue streaks. (It has only just been disclosed below the hard chalk, and I cannot yet say anything of its fauna except that it does not contain *O. lunata*.)

Now a remarkable thing about *O. lunata* is that it occurs *exclusively* (with the exception of one specimen) at the horizons noted as characterised by it. It will be seen that there are, at most, five of these, and at least nine without *O. lunata*. It is true that the horizons with *O. lunata* are all of some thickness, and owing to the vast profusion of beautiful specimens of this very striking form which they contain, and to their supplying the greater part of the two bluffs—the only chalk always accessible—they figure very prominently in one's impressions of the Trimmingham Chalk as a whole. But it is safe to say that in more than half of the total thickness of Chalk exposed *O. lunata* is not to be found, and this without reckoning in the thickness of the anomalous northern part of the south bluff, which may fairly be quoted as not containing *O. lunata*, as only one specimen has been found in it, and that very dwarfed. But there are fossils which do occur throughout the Trimmingham Chalk, yet, as far as I know, are confined to it, such as *Terebratulina gracilis, T. Gisei, Pentacrinus Agassizi*, and *P. Bronni*, to take well-marked and fairly plentiful forms. There could be no hesitation in selecting as the zone-fossil *Terebratulina gracilis* if it were not for the unfortunate but universal misapplication of this specific name to the characteristic fossil of the upper zone of the Middle Chalk. *T. Gisei*, considered by itself as a possible zone-fossil, is too small to be found with certainty, even if abundant, and it is hardly that. But *T. gracilis* is such an ideal zone-fossil that I propose to remove the objection to it stated above by naming the Trimmingham Chalk "zone of *Terebratulina gracilis* and *T. Gisei*," or, for familiar use, "zone of *Terebratulina*," it being understood that *T. Gisei* is not conclusive when occurring by itself, but that *T. gracilis* is. *Pentacrinus Agassizi* and *P. Bronni* could, of course, be used to characterise a "zone of *Pentacrinus*," but that would create great difficulty with the chalk of the erratics between Overstrand and Sidestrand, a part of the cliff which is unfortunately being ruined for geological observation by sloping and path-making operations. Before the era of sloping set in these erratics were about ten in number, and all (with one exception) lay on a thick bed of boulder-clay, which ran with great regularity at a practically unvarying height above the beach from the Overstrand breakwater to the grounds of the new hotel at Sidestrand. My attention was first drawn to these erratics by Miss Mary Townsend, of Oatlands Park, Weybridge, who happened to be staying at Overstrand in 1896, at a time when a storm had swept away the sand on the beach and exposed a great number of chalk boulders, no doubt all that had fallen from above for some years. I had then just become keenly interested in the Chalk of the Norfolk coast, and she, being aware of this, picked out for me all the fossils she could with a penknife, including a perfect *Micraster cor-anguinum* of the typical Norwich shape, a very creditable performance for a lady with no previous experience of fossils and armed only with a penknife. I have on several occasions been able to add to this collection, the salient points of which are the presence of *Rhynchonella Reedensis*, which occurs freely in the Cromer Chalk but not at all at Trimmingham, and the abundance of a *Pentacrinus* which is neither *Agassizi* nor *Bronni*, and does not occur either at Trimmingham or in the Cromer Chalk. The occurrence of a *Pentacrinus* is a strong link to the Trimmingham Chalk with its abundance of *Pentacrinus*, and this association is strengthened by the character of the chalk itself, which is often white, much mottled with blue-grey patches, just like so much of the white chalk at Trimmingham, and it is tempting to group this chalk with the Trimmingham Chalk rather than with the Cromer Chalk. At the same time the presence of *R. Reedensis* indicates that it is definitely older than the Trimmingham

Chalk, and this is just what one would expect if, as is probable from their unaltered condition, these boulders are of quite local origin.

The exception above mentioned was a large boulder, quite 30 feet high, immediately under the new hotel at Sidestrand. Unfortunately this was overlaid by a soft bed full of water, which kept its surface constantly obscured by a downwash of mud, and it was impossible to collect from it. It has now been destroyed in the sloping of the cliffs, or, if anything be left of it, it is turfed over and concealed for good. I did get from the foreman of the works a promise to let me know when they began to cut into the boulder, but the promise was not kept, and the operation was carried out in my absence, and a valuable opportunity thereby lost. One thing about it, however, was not entirely obscured by the mud, and that was the presence at about 4 feet from the base of a bed of laminated marl some 2 inches thick. This remarkable occurrence may mark the boundary between the zone of *Terebratulinæ* and the Cromer Chalk (which is decidedly identical in age with that now exposed near Norwich, and therefore belongs to the zone of *B. mucronata*). Some well-marked line of demarcation seems not unlikely, as there is a considerable palæontological break. Not only *Rh. Reedensis* but also *Terebratula sexradiata* are not uncommon in the Cromer Chalk, but still unknown at Trimmingham, and *Micraster cor-anguinum*, which is abundant (relatively speaking) in the Cromer Chalk, is so scarce at Trimmingham that I have not yet found a fragment of *Micraster* there, though Mr. Savin has two specimens, apparently from the hard basement bed. There are also four very characteristic Upper Senonian Polyzoa, which in the South of England are found in the uppermost beds (with abundant specimens of *Magas pumilus*) of the *B. mucronata* zone, but which are not found at Trimmingham, though the environment there must have been so very favourable to Polyzoa that they might be fairly expected to occur there if they still persisted in the English seas. I have described and figured three of these, which I cannot identify with published figures. It so happens that I have not yet recognised any of these three in the *B. mucronata* chalk of Norfolk, but the fourth, *Membranipora* (? *Homalostega*) *clathrata*, is abundant in the Cromer Chalk, and adds increased significance to the disappearance of *Rh. Reedensis* and *Terebratula sexradiata*. Under these circumstances I should be very chary at present of adopting a zonal description of the Trimmingham Chalk which would allow of the Sidestrand erratics containing *Rh. Reedensis* being included with it. Of course, if the great erratic was representative of the cliff from which the other erratics were derived, it would be quite conceivable that the marl band should be the boundary of the two zones, and the mixture of *Pentacrinus* and *Rh. Reedensis* in the fossils obtained be due to the presence of boulders both from above and below the boundary. (Many puzzling records are probably due to an assemblage of fossils gathered from a section containing the boundary of two zones being regarded as a naturally contemporaneous series, and assigned to the more prominent of the two zones.)



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

Should it ever be ascertained that there *is* a point at which the forms above mentioned all disappear, that point may safely be taken as the upper limit of the *B. mucronata* zone of Norfolk. [I do not say 'Norwich Chalk,' because I have a very strong opinion that that term is wholly unscientific. If it implies, as presumably it does, that all the chalk which has ever been exposed within two or three miles of Norwich is of the same zone, that zone must be the zone of *B. mucronata*, and the term 'Norwich Chalk' is a mere synonym. It is undoubtedly the fact that the sections now accessible (Trowse, Thorpe, and Whitlingham) are all in chalk which contains *B. mucronata* freely, and cannot on any pretext be assigned to any other zone. But many of the fossils recorded from the 'Norwich Chalk,' e.g. the Cephalopoda, seem decidedly unlikely to occur in such chalk as that now exposed, and probably the chalk in which *Baculites* was abundant was very different stuff from that now to be seen. In that case the 'Norwich Chalk' is a 'hotchpotch' of an unknown number of zones which should, with its so-called fauna, be discarded as soon as possible in all attempts at zonal classification. I have really very little doubt as to the danger involved in treating the Norwich Chalk as a zonal unit, and many of the peculiar species would probably find a place as synonyms if Samuel Woodward's types could be found. Some can be so treated from the plates; e.g., *Serpula accumulata* is almost certainly a synonym of *S. vortex*, *S. pentangulata* of *S. canteriata*, *S. carinata* of *S. fluctuata*, *S. contracta* of *S. gordialis* (if Professor Deecke rightly identified the specimens to which he assigned the latter name, which has not been very freely admitted by other collectors), and *Plagiostoma granulosum* of *Lima granulata*. At any rate, we are not warranted by any accessible information in taking it for granted that the recorded fauna of the 'Norwich Chalk' has been derived from pits exclusively in the same zone. Most of the pits named are now inaccessible and cannot be re-examined.] Unfortunately, in discussing the limits of the zones of the Upper Chalk in Norfolk we get very little assistance from the nearest area in which those zones occur again at all freely, i.e. in Sussex and Hants. The zone of *B. quadrata* south of the Thames is often very fossiliferous, and the zone of *B. mucronata* is often even more so, both zones being conspicuous for abundance of free-growing Polyzoa. But in Norfolk, and indeed generally on the north of the Thames, both these zones are much less fossiliferous and practically devoid of free-growing Polyzoa. In fact, they present quite a different aspect; they are much more uniform and much finer apparently in texture. It may be only due to increased depth, but I have always felt tempted to postulate the existence in the Cretaceous sea of a submerged ridge separating the two areas or basins. The connection of the Norfolk area with the Rügen sea, which is so marked in the Trimmingham Polyzoa, must have existed at least as early as the age of the chalk round Norwich and near Cromer, in which *Homalostega pavonia*, described from Rügen in 1839 but not recorded from any other locality except Trimmingham, is quite abundant. Though Polyzoa are abundant at the top of the

B. mucronata chalk of Hampshire, I have not yet found any Rügen forms there, and this may well be more than a mere coincidence.

Stratigraphy.

In this department I have to acknowledge my indebtedness to Mr. G. P. Bidder, who was staying at Mundesley during late September and October of 1905, a time of very rough weather and great variety of exposures. Though not a geologist, he took great interest in the local geology and gave me much assistance in many ways. Amongst other things he pointed out to me that in my previous pamphlet I had overlooked the fact that the magnetic north is about 20° west of true north, and that I ought to mention that all my bearings were magnetic. I have, for convenience, continued to use magnetic bearings in this paper.

South Bluff.

Very little further development has taken place here, but the accuracy of the partly hypothetical presentation of the low southern prolongation in fig. 2 of my previous pamphlet has been established by fuller exposures both as to the continuity of the flint lines and their identification with those to the right of A B. It also turned out that at the furthest point to which they are shown extending they bend sharply down, and all but the highest of the lines shown to the right of A B come in on the slope. The highest of these was found to be dipping at quite 75° almost due south. (This very high dip on the south side of a ridge is by no means uncommon elsewhere in this area.)

A great number of cavities have recently appeared in the upper beds of the southern part of the bluff, and it *appears* as if these cavities expand as they penetrate the bluff. This is just what would be expected if they were cavities formed in a cliff facing to the south or south-west, and tends to confirm the view that this part of the bluff, at any rate, is the remains of a headland which faced a sea lying to the south or south-west.

A good deal of the sand in the gap between the two parts of the bluff has been cleared away and the south-easterly face of the northern part exposed to a point directly behind and on the same level as the northern end of the southern part and only 8 yards away from it (Plate II, Fig. 1). The marked difference in the physical characters of the two parts remains unaffected, and the conclusion that they are separated by a fault seems now inevitable *if* the north part is not an erratic, as to which no further evidence has been obtained. I have found a single specimen of *O. lunata* in the northern part.

North Bluff.

Here there have been some most interesting developments owing to the rapid erosion which has taken place, and is still proceeding. A great deal of erosion took place in the Winter of 1900–1 all round the bluff, and I was fortunate enough to obtain through Mr. Savin, of Cromer, the assistance of a local amateur photographer, who took in February, 1901, the photographs reproduced as Plate II, Figs. 2 and 3, and Plate III, Figs. 4 and 5. Fig. 2 shows the bluff as seen from a point on a line drawn through the bluff parallel with the beach-line. It will be noticed that one of the lines of flints appears to be vertical. That this is an illusion can be seen from Fig. 3, which was taken from a point approximately on the strike of the same line of flints, which (as I stated in my previous pamphlet, and have several times since checked) is *not* parallel to the beach-line. The appearance of verticality is due to the surface presented being oblique both to the line of vision and to the horizontal plane.

Fig. 4, Plate III, shows a very interesting development on the north side of the bluff. A deep bay had been hollowed out with a long south side and very short north side. The south side was formed by first the bluff itself and then chalky clay, as shown in fig. 1 of my previous pamphlet. But the clay now proved to be only a narrow triangular mass, succeeded by a sloping bank of chalk which formed the rest of that side of the bay. The head of the bay was formed of talus from the cliffs above, and apparently concealing the connection of the sloping bank of chalk with the chalk which emerged again to form the short north side. This north side ended in a clean-cut cross section, which showed it to consist of a layer of chalk from two to three feet thick resting on chalky clay with an apparent bedding parallel to the base of the chalk, the junction plane dipping seawards at an angle of about 55°. The whole of the chalk exposed behind the triangular mass of clay was grey, and exhibited many peculiarities which will be dealt with fully later on.

Fig. 5, Plate III, gives a close view of the pinnacle of clay and its immediate surroundings, and there are a number of points of interest about it. One is the distance from which the clay runs in under the chalk on either side. Shortly before the photograph was taken the sand was still further cleared away and the clay extended quite two feet further under the bluff. In this connection it is to be observed that a junction between the chalk and the clay has been seen on the foreshore close by for a distance of some 30 yards, throughout the whole of which the clay is running in under the chalk for a distance of at least nine inches, and may, for all appearances, underlie it altogether. There are many other points on the foreshore where the junction of chalk and clay has been observed, and in all the plane of junction is either vertical or else almost horizontal with the clay running under the chalk. Again, in the case of a fault on the foreshore almost opposite the north bluff, the chalk on either side of the fault has at one point been broken away so as to form a long narrow steep-sided pool about 18 inches deep. The bottom of this pool is formed by what appears to be the truncated top of a dome of clay, composed of fairly regular concentric layers of clay of varying colours, suggesting very strongly that the clay has been forced up from beneath into a cavity or crack. The point at which this occurs is at least 30 yards from the nearest exposure of clay.

Another point is the pseudo-stratification of the clay roughly parallel to the sides of the fissure. This point is not well brought out by the photograph, in which it only appears by the light-coloured band. It was, however, much more apparent to the eye, being more or less marked all through the mass owing to slight variations in colour of the different bands, a reproduction of which is hardly to be expected by photography. Here again we have appearances strongly suggesting that a pseudo-stratified mass of clay has been forced upwards into a cavity.

Another point which is not clearly shown by the photographs, is that the face presented by Fig. 4 was an almost plane surface apparently representing a clean section through the bluff, the clay and a homogeneous mass of grey chalk at the back.

A fourth point which cannot, owing to the shadow, be distinguished at all in the photographs, is that there was a slender arch of chalk not more than two feet thick extending over the clay pinnacle and connecting the bluff with the chalk behind. I was only just able to reach the arch and ascertain that *Ostrea lunata* occurred in it. The seaward face of the bluff was at this time too steep to climb with any comfort, and the highest chalk which could be reached from the beach was normal *O. lunata* chalk, which apparently continued up to the point where the nature of the chalk was completely obscured by dirt.

Since the Spring of 1901 there has been steady denudation at this point. Unfortunately I was not able to obtain any photographic record until the Autumn of 1904, but the course of denudation in the meanwhile may be summarized as follows :—

1. *The Original Bluff.*

The top of the bluff remained inaccessible and obscured by sand for some time. It became gradually cleaner and more accessible, but during 1901 I found nothing but *O. lunata* chalk exposed. By 1902 the downwash of mud had practically ceased and the face of the bluff had been considerably stepped, and it was gradually revealed that the bluff was capped by a bed of grey chalk of a fairly uniform thickness of two feet and with a perfectly clean-cut boundary between it and the *O. lunata* chalk. (As this grey chalk will be referred to again later on, I take this opportunity of saying that its appearance is sometimes only to be detected by the change in colour. But, as a rule, it is separated from the *O. lunata* chalk which is invariably found beneath it by an exceedingly thin seam of fine grit, containing scattered flint pebbles of various sizes up to that of a good-sized potato. In places this seam swells out into a definite bed as much as two inches thick containing small rolled pieces of chalk. The presence of rolled flints has not to my knowledge been before recorded in the English or, indeed, any Chalk. It throws an important light on the time of consolidation of the flints, which must have taken place in this case almost simultaneously with the deposition of the Chalk in which they were formed.) The grey chalk was plainly unconformable to the *O. lunata* chalk below, for the three upper lines of flint shown in fig. 1 of my previous pamphlet ran steadily and strongly up to the grit seam at the base of the grey chalk, and were then cut off by it. A fairly accurate representation of this state of things can be got by adding to the last-mentioned figure two feet of chalk resting horizontally on the truncated ends of the lines of flint. As the bluff was cut back these lines of flint sank, and after a time the lowest came wholly below the base of the grey chalk and formed a perfect arch.

2. *The Fissure and its immediate surroundings.*

The triangular mass of clay filling the fissure was denuded much more rapidly than the chalk, and soon there was produced a definite inlet between two faces of chalk, which gave partial cross-sections of the masses of chalk. It became almost at once apparent that the grey chalk was really only a thin coating (thicker at the top and bottom on the slope than in the middle, but nowhere more than 18 inches thick) of a sloping surface of *O. lunata* chalk. The filling of the gap by clay proved in places to be incomplete, so that a considerable space was left between the top of the clay and the chalk arch, indicating that the clay was either very slightly fluid or not under great pressure when forced in. The latter cause seems the more probable, as if there *had* been great pressure at this point it is hardly possible that an arch of chalk, with a maximum thickness of two feet, should have remained unbroken. The grey chalk soon appeared in the arch forming the upper part of it in a gradually increasing proportion and connecting the grey chalk on the bluff with that on the 'slope,' but it never completely cut out the *O. lunata* chalk which still formed the lower six inches or so when it was destroyed by the waves. About two-thirds of the way up the slope, was one of the points where the grit seam swelled out into a regular bed with pebbles and rolled chalk.

3. *The Bay of Grey Chalk.*

The first event was the removal of the talus at the head of the bay and the exposure of a continuous surface of grey chalk beneath it. Then the grey chalk became thinner and finally disappeared altogether, both at the head of the bay and along the median (horizontal) line of the 'slope.' But while in the latter case the underlying stratum was *O. lunata* chalk, as might be expected, in the former case it proved to be clay similar to that at the back of the bluff. Further denudation of the grey clay exposed at a number of points *O. lunata* chalk coming in between the grey chalk and the clay as the edge of the grey chalk shrank back from the cliff (Pl. IV, Fig. 9).

4. *The Bay on the South of the Bluff.*

This is but poorly shown in our Pl. II, Fig. 2, which was taken at a time when there was no particular feature of interest in the south bay. It only offered a section through the bluff and a mass of clay immediately behind it, and behind and above both a tumbled mass of glacial beds, separated from the chalk by a thin layer of dark laminated clay.

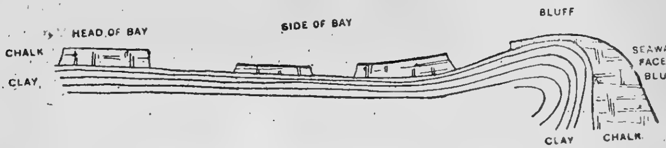


Diagram of Chalk Bluff, showing the mass of clay immediately behind it and the discontinuous line of chalk masses round the Bay.

Towards the end of 1903 the grey bed which had been exposed at the top of the bluff began to throw out a 'stringer' (or broken horizontal line of grey chalk) over the mass of clay behind it, and early in 1904 there was a discontinuous line of chalk masses visible for a considerable way round the bay. They were apparently supported by a mass of clay, which was turned under itself against the bluff, judging from the banding of the clay as sketched very roughly in the above diagram.

EXPLANATION OF PLATES.

Views of Trimmingham Chalk Bluffs, Norfolk Coast.

PLATE II.

FIG. 1.—South Bluff; gap between northern and southern part. *a, a,* masses of coarse shingle.

FIGS. 2 and 3.—Two views of North Bluff as seen from the south (1901).

PLATE III.

FIG. 4.—North Bluff; view of north bay (January, 1901).

,, 5.—Pinnacle of clay separating the North Bluff from the chalk at the back of it (January, 1901). The connecting roof of chalk is in deep shadow, and therefore very indistinct.

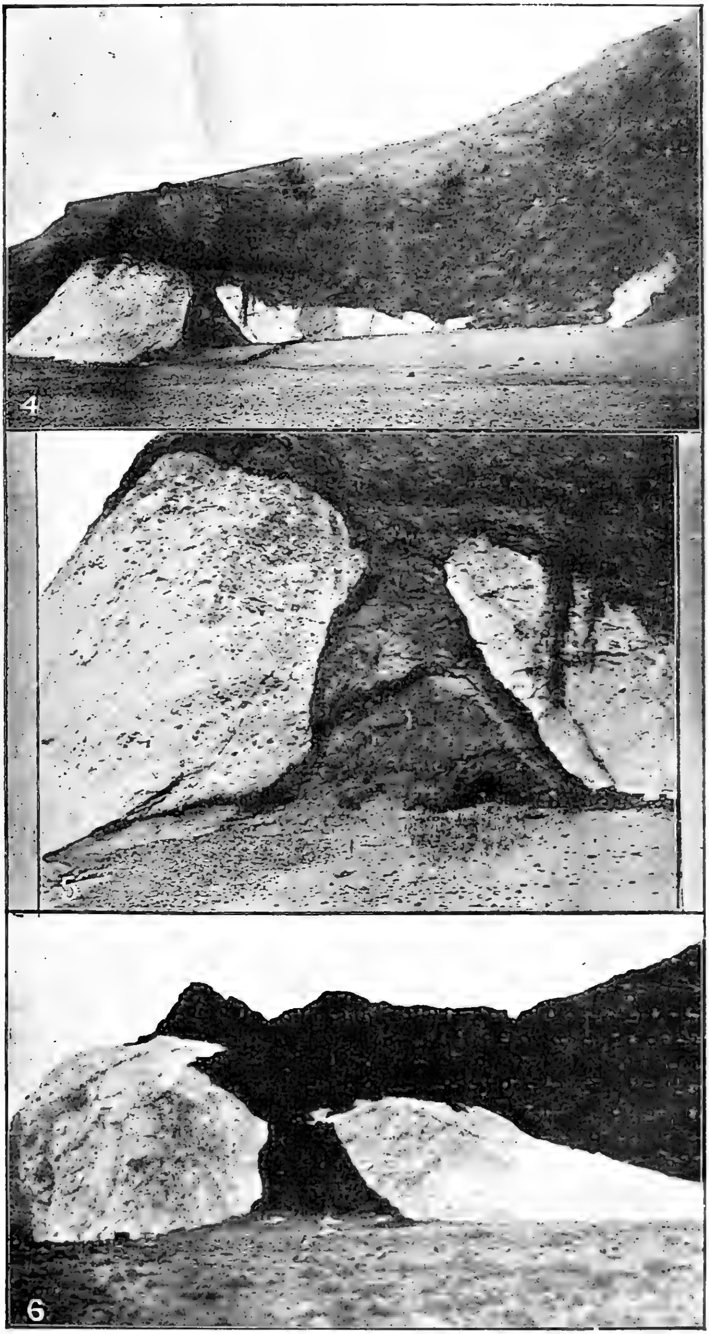
,, 6.—View of the North Bluff and the exposure of chalk in the bay (November, 1904).

(To be continued.)

III.—ON THE RAISED BEACHES OF THE GEOLOGICAL SURVEY OF SCOTLAND.

By T. F. JAMIESON, F.G.S.

IN the maps and memoirs of the Geological Survey of Scotland there is frequent mention of raised beaches at 50 and 100 feet above the present sea-level. Mr. James Geikie, too, in his well-known book on the Great Ice Age, confidently assumes the existence of beaches at these two levels. It is therefore with some degree of reluctance that in the following remarks I venture to question the reality of these supposed beaches; but it will lessen the field of controversy if I confine my observations to the east side of Scotland. Matters may probably differ somewhat in regard to the west side.



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

In a paper on the last stage of the Glacial period in the Quart. Journ. Geol. Soc., 1874 (vol. xxx, p. 337), I maintained that subsequent to the last great glaciation of Scotland no submergence of the country has taken place beyond that slight change of level which is marked by the estuary beds and raised beaches a little above the present coastline. Along the shores of the Firth of Forth this change of level does not seem to me to have been more than about 30 feet. Such was also the opinion of Charles Maclaren, a careful and accurate observer, who spent a long life in that locality and knew it well. At the Firth of Tay the amount does not seem to be any greater, and on going farther north the change of level appears to me to become less. At Montrose, for example, it does not seem to exceed 15 or at most 20 feet. Between Montrose and Bervie the raised beach is well marked in many places, but I could see no trace whatever of any higher ones at 50 or 100 feet. On reaching Aberdeen the height is still less, apparently not more than eight or ten feet along the coast of that county, nor does it seem to be any more on the Banffshire coast. In the estuary of the Ythan, half-way between Aberdeen and Peterhead, the change of level can be well estimated and does not appear to exceed what I have stated. I have examined that locality carefully and repeatedly, but have never been able to perceive the least sign of a raised beach at either 50 or 100 feet.

In the valley of the Forth the old estuary-mud, or carse land, extends west a long way past Stirling, up to near the Loch of Menteith and Gartmore, rising gradually as we follow it inland to a level of 40 or 45 feet. This gradual rise seems to be always the case with a tidal mud as we trace it inland. The tidal wave rises often considerably in moving up a valley, as we see on the Severn at the present day. The fact of the carse land and alluvial loam of the Forth rising to 40 or even 50 feet at its inland extremity does not therefore imply a raised beach of that height at the coast. The Loch of Menteith is bordered by a fine group of old moraines which come down to the level of the carse, the lake itself being only 55 feet above the sea. These moraines were left during the retreat of the last great mantle of ice. Now, if there had been any subsequent submergence to the extent of 100 feet, it could not fail to have left its mark on the front of these moraines. The absence of anything of the sort is, I think, a proof that no such submergence has taken place. The basin of the lake should also have been filled with marine silt, of which there is no trace.

At Aberdeen we have moraines which come down close to the present beach, as for example at the Broadhill on the east side of the town. This Broadhill is one of the moraine heaps left by the glacier of the Dee during the last great extension of the ice. It is 94 feet high, and has been truncated apparently to some degree, or cut into, along its seaward side by the raised beach, but we look in vain for any evidence of sea-action upon it higher than a few feet above the present reach of spring tides. At Belhelvie, a few miles north of Aberdeen, we have another group of gravelly moraines left by the glacier when it reached the coast. A submergence to the extent of 100 feet should surely have made some impression on these also. It was no small development of ice that brought the glacier of the Dee down to the coast when it left these moraines. During this last glaciation I believe the whole of Scotland was more or less covered with perennial snow and ice; but the ice was probably very thin in many places along the east side, where the thick streams descending from the Highland valleys had room to spread out freely. This would account for considerable portions of the older clay-beds having escaped destruction, and in point of fact some of these Belhelvie moraines overlie wasted masses of the clay.

If there was a raised beach at 100 feet we ought to find beds of estuary-mud with its characteristic fossils in our wider valleys near the 100 feet contour-line, but where are they? We have such beds with shells and whale-skeletons in these valleys at heights corresponding to the real old beach whose existence I have mentioned; but we have absolutely nothing of the sort corresponding to a submergence of 100 or even 50 feet. Is not this sufficient proof that there has been no such submergence? In Aberdeenshire the river Ythan (which enters the sea half-way between Aberdeen and Peterhead) flows along a wide little valley with a very small gradient, so that a submergence to the extent of 50 feet would send the tide ten miles up it. That basin should have certainly been filled to some extent with estuary silt, but no trace of anything of the sort is to be seen beyond a few feet above the limit of spring tides. A like submergence in the valley of the Dee would have sent the tide six or seven miles up that river with a similar result, and a submergence to the extent of 100 feet would have sent it on a few miles further; but no sign can be perceived of any such event having happened after the last glaciation which brought the Dee glacier down to the coast. Evidence of this sort could be multiplied along valleys on the east side of Scotland, but perhaps the above will suffice.

It would surely be time enough to talk of a hundred feet beach when we could point to some beds of littoral shells at a corresponding height, taking care that no shell heaps of edible mollusks left by man were mistaken for the real article, because on the shores of our estuaries such heaps are often to be found.

The notion of raised beaches at 50 and 100 feet seems to have arisen in 1879 in mapping Sheet 31 by the Geological Survey, for it is in the explanatory memoir of that sheet that we find this idea first brought forward, and ever since then it seems to have become a settled article of faith with the Scottish Survey. Beds of clay in the neighbourhood of Falkirk are described in that memoir having a flattish terraced aspect, which seems to have led to the belief that they were old beaches; but no good evidence, fossil or otherwise, is adduced to substantiate this opinion, and surely the mere flatness of a bed of clay is no sufficient proof that it is a beach. This clay was no doubt accumulated under water, possibly sea-water, but the evidence of denudation and disturbance which it shows in many places harmonizes better with the idea that it has been afterwards exposed to the action of land-ice, which has moved over it with more or less damaging effect according to the thickness of that ice. We may consequently infer that the deposition of the clay took place previous to the last general glaciation. Such, it seems to me, is clearly the case with the red clay of Aberdeenshire, and the illustrations of disturbance in the beds at Portobello and elsewhere given by Mr. Geikie in his book convey the same impression. Moreover, such fossil evidence as these clays do present at Errol, Elie, Montrose, and other places points to deeper water than a submergence of even 100 feet would imply. I see no reason, therefore, to depart from my opinion that subsequent to the last general glaciation of Scotland there has been no submergence along the eastern side of that country beyond what would be accounted for by a depression of the land, amounting to from about 30 feet on the Firth of Forth to 10 feet on the coast of Aberdeen. The history of the Glacial period has proved a difficult subject to unravel, and we have all made mistakes about it. It is therefore in no captious spirit that I have been led to make these strictures on the raised beaches, but rather with the view of promoting a better knowledge of this passage in the last geological changes which our country has undergone.

Briefly, then, my reasons for disbelieving in the existence of these raised beaches at 50 and 100 feet on the east side of Scotland after the last general glaciation of that country are:—

1. Because at and below these levels there are moraine heaps which show no evidence of sea-action on them up to such heights.
2. Because there is an absence of estuary-mud with its characteristic fossils in the valleys at levels where such a submergence should have produced it.
3. Because there are no beds of littoral shells at levels corresponding to such beaches.
4. Because the beds of clay supposed to have been formed during the time of the 100 feet beach contain remains of mollusca and starfishes, which indicate deeper water and an older stage of the Glacial period.
5. Because these clays also show evidence of having been wasted and disturbed by subsequent glacial action, and are therefore anterior to the last general glaciation.

IV.—A Fossil Insect from the Coal-measures of Longton, North Staffordshire.

By Henry Woodward, LL.D., F.R.S., F.G.S.

SOME time since Mr. John T. Stobbs, F.G.S., obtained a very well-preserved impression in clay ironstone of the wing of a Neuropterous insect from the rich plant-bed at Foley, near Longton, North Staffordshire, which he very obligingly submitted to me for study. The geological horizon is that of the "Peacock Marl" (i.e., the marl overlying the Peacock Coal), and it therefore comes from near the top of the workable Coal-measures.[1]

[1] See letter by Mr. John T. Stobbs in Geol. Mag., 1903, p. 524.

The impression is that of the hinder wing of the left side of a Neuropterous insect, the wing being fully 5 cm. long and 2 cm. in breadth. The distal extremity is wanting, but from the scar left on the matrix the lost tip probably did not exceed 1 cm., and the point has been restored in dotted lines in the figure. At the point in the figure marked by a * the pinnule of a fern, *Neuropteris,* overlies the wing, but, for the sake of clearness, has been omitted from the drawing, and the nervures of the wing are continued by dotted lines over the obstacle; near the point of attachment to the body the structure of the wing is also obscured. For the convenience of description, small Roman numerals, marking the principal nervures, have been added to the figure of the wing (as used by Mr. Charles Brongniart).[1] The following is a brief description of the specimen as far as I am able to define it:—

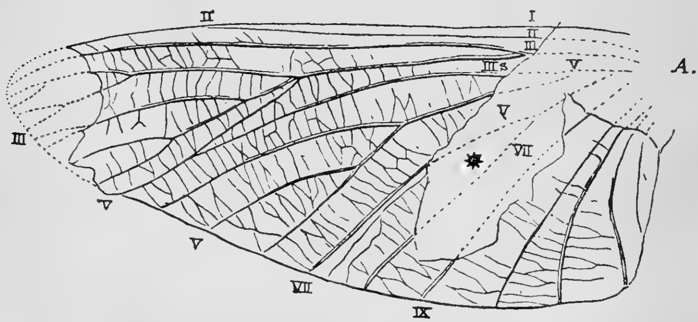


Fig. 1.—Left posterior wing of *Lithomantis carbonarius* (?), H. Woodw., from the Coal-measures, Foley, near Longton, North Staffordshire. I, the costal nervure; II, the sub-costal nervure; III, the radial nervure; V, the median nervure; VII, the cubital nervure; IX, etc., the anal or basal nervures.

The costal nervure (I) is strong, and forms the anterior margin of the wing; it gives off no branch. It is connected with the sub-costal (II) by a series of very fine straight nervules.[2] The costal and sub-costal converge distally at about two-thirds of their length from the body. The radius (III) runs in a parallel course for some distance from its commencement below the sub-costal, giving off a branch-nervure at III, *s*, one-third of its length, which, diverging rather more as it advances, is again subdivided at two-thirds of its length into three branches, the upper and middle ones subdividing again into two, and these into two more

[1] "Recherches pour servir à l'histoire des Insectes Fossiles des temps Primaires," etc., par Charles Brongniart; St. Etienne (Théolier et C^ie^), 1893. 4to; pp. 494, and Atlas, pp. 44, and 37 double 4to and folding plates. This accomplished naturalist, grandson of the celebrated botanist Adolphe Brongniart, died at the early age of 40 on April 18th, 1899, having, even in so few years, achieved much splendid work in fossil entomology. (See Geol. Mag., 1900, p. 430.)

[2] These fine straight nervules, not being easily seen, have not been shown by the artist in the above figure of the wing.

dichotomies before reaching the margin at III. The median nervure (V) commences singly at the base of the wing and gives off two branches; the upper one, curving slightly upwards, unites with the lower or third subdivision of III, *s*, and reaches the lower distal border at V; the lower branch subdivides into two, the upper nervure reaching the margin singly, the lower subdividing into two before ending about the middle or lower half of the posterior border; the cubitus (VII) is mostly hidden by the pinnule of a fern-leaf, but the direction it follows is indicated by a dotted line. It reaches the margin in two branches. Four anal or basal nervures follow, all of which are simple and have no dichotomies.

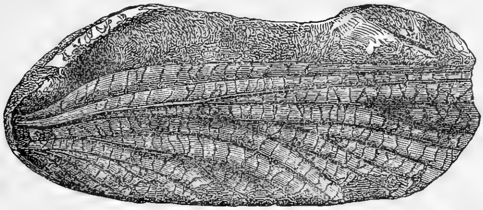


FIG. 2.—Wing of *Lithomantis* (*Corydalis*) *Brongniarti*, Mantell, sp. Coal-measures: Coalbrookdale, Shropshire.

I have already suggested[1] to the discoverer of this interesting specimen that it was probably nearly related to *Lithomantis carbonarius*, H. Woodward, figured and described by me (Quart. Journ. Geol. Soc., 1876, vol. xxxii, pp. 60–65, pl. ix, fig. 1) from the Coal-measures of Scotland, and also to the much earlier described wing of *Lithomantis* (*Corydalis*) *Brongniarti* (Audouin), G. A. Mantell, from Coalbrookdale.

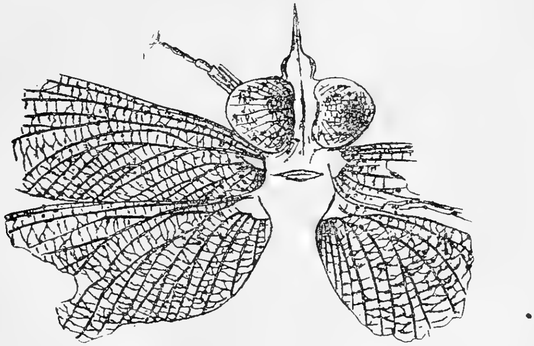


FIG. 3.—*Lithomantis carbonarius*, H. Woodw. Coal-measures: Scotland. One-third less than nat. size.

In his great work on the "Histoire des Insectes Fossiles des temps Primaires" (1893), M. Charles Brongniart has figured and

[1] GEOL. MAG., 1903, p. 524.

described another fossil insect closely allied to the above, which he has there named *Homoioptera Woodwardi* [pl. xxxvi (20), fig. 10], but had originally described in 1890 (Bull. Soc. Philom. Paris, tome ii, pl. i) as *Lithomantis Woodwardi*, Brong. M. Brongniart,

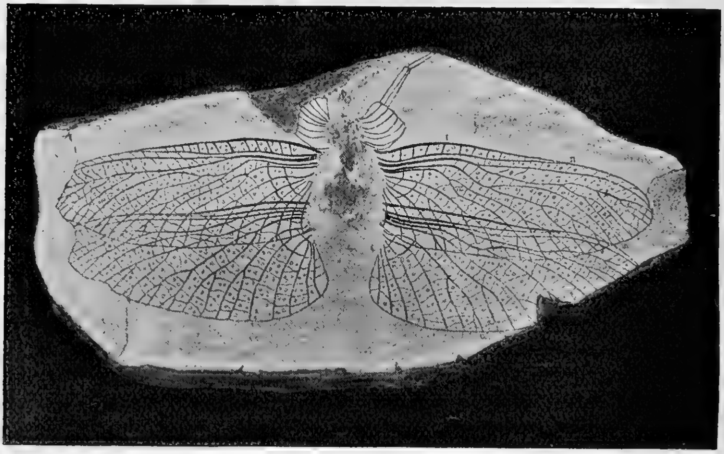


Fig. 4.—*Homoioptera* (*Lithomantis*) *Woodwardi*, Brong., 1890. Coal-measures: Commentry, France. One-half nat. size.

however, justified the adoption of the later generic name *Homoioptera*, on the ground that he found the Commentry insect did not actually agree with the living Mantidæ. But although they ought to be referred to different genera, they are not far removed from one another, and they both possess wing-like expansions on the prothorax. These forms, *Lithomantis*, *Fouquea*, *Homoioptera*, and thirteen other genera enumerated by M. Brongniart, are arranged by him under the family Platypterida.

He considers all these insects to be Neuroptera in their general characters; they attain to a large size, the smallest not being less than nine centimetres across the wings. They are all extinct forms, the group to which they may best be compared being the Ephemeridæ. They differ in the character of the nervation of their wings; the radius is not simple, but more or less dichotomising, as well seen in our Fig. 1 (III); furthermore, the second pair of wings are larger and more developed than the first pair, which is not the case in living Ephemera. These insects, as is common with nearly all the fossil genera, are only known to us (as a rule) by their wings, their bodies and limbs being extremely rare, and seldom found complete in the Coal-measures or in other old deposits yielding fossil insects.

It is doubtful whether the wing, now figured for the first time, from Mr. Stobbs' collection, is specifically distinct from *Lithomantis* *carbonarius*, but it is certainly important to record its discovery in the Staffordshire Coalfield.

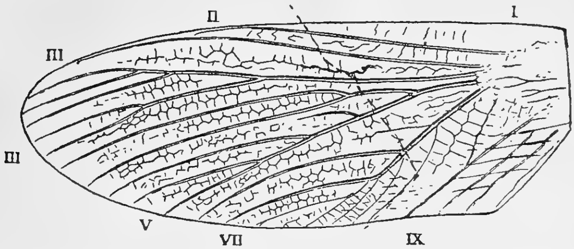


FIG. 5.—Wing of *Fouquea cambrensis*, n.sp., from the Coal-measures of South Wales. × 2. Reproduced from Mr. H. A. Allen's paper (see GEOL. MAG., 1901, p. 66).

It is very distinct in general form from *Fouquea cambrensis*, figured and described by Mr. H. A. Allen, F.G.S., from the Coal-measures of South Wales, but it certainly belongs to the same group as *Lithomantis* and to the family PLATYPTERIDA.

V.—ON THE PERMIAN AND TRIASSIC FAUNAS OF SOUTH AFRICA.

By Professor R. BROOM, M.D., D.Sc., Victoria College, Stellenbosch.

UNTIL recently very little attempt has been made to classify the reptilian fossils of the Karroo Beds according to their geological horizons. Seeley recognised certain zones—(1) the zone of Mesosaurs, (2) the zone of Pareiasaurs, (3) the zone of Dicynodonts, (4) the zone of specialised Theriodonts, and (5) the zone of Zanclodonts. While the order of these zones is correctly given they do not cover the whole period, and the third zone is an unnatural one.

As the result of the work of the last few years, it is now possible to subdivide the Karroo Beds with some degree of accuracy into a number of fairly well-marked distinct faunas. At the recent meeting of the British Association a paper was read, which will appear elsewhere, giving the details of recent work. As, however, much interest is at present being taken in the Triassic faunas of both Europe and America, a summary of the conclusions come to may be of use to workers in the northern hemisphere.

The most recent rocks of the Karroo Series are the Upper Stormberg Beds. These contain remains of the Dinosaurs *Massospondylus*, *Euskelesaurus*, and *Hortulotarsus*, and of the small crocodile *Notochampsa*. As *Notochampsa* is a true crocodile, we may safely refer the beds to Lower Jurassic, more especially as the Lower Stormberg or Molteno Beds immediately below have been referred by Seward from the evidence of the plant remains to the Rhætic.

Below the Molteno Beds we come to the *Cynognathus* Beds, corresponding to the 'specialised Theriodont' zone of Seeley. In these beds there is a very rich fauna, of which the most characteristic forms are the extremely mammal-like Cynodont reptiles, *Cynognathus, Gomphognathus,* etc. Other noteworthy forms are the large Phytosaur, *Erythrosuchus*; the Gnathodont, *Howesia,* a small form allied to *Hyperodapedon*; a species of *Cyclotosaurus,* and a species of *Ceratodus.* There seems little doubt that these beds are of Upper Triassic age.

Underneath these we come to a distinct but allied fauna characterised by the abundant remains of the primitive reptile *Procolophon.* Other forms are *Paliguana,* the oldest known true lizard, and *Proterosuchus,* a Rhynchocephalian which shows some affinity to the Phytosaurs. These beds are called the *Procolophon* Beds, and may be of Middle Triassic age.

Below these are extensive beds in which land forms are very rare, but in which are abundant remains of the aquatic Anomodont, *Lystrosaurus,* and the fish *Atherstonia.* These are called the *Lystrosaurus* Beds, and they are believed to be of Lower Triassic age.

Underneath these *Lystrosaurus* Beds we come to rocks in which land forms are again numerous. Three fairly well-marked zones are recognised: (1) *Kistecephalus* Beds, (2) *Endothiodon* Beds, (3) *Pareiasaurus* Beds. In all of these remains of *Dicynodon* are met with, but it is in the *Endothiodon* Beds that *Dicynodon* and *Oudenodon* are met with in greatest abundance. All the carnivorous reptiles of this period are either Therocephalians or Dinocephalians. All three zones are believed to be of Upper Permian age.

Below the *Pareiasaurus* Beds a few reptiles have been found in the Ecca Beds, but most of the remains are very imperfect. *Mesosaurus* is found in the Upper Dwyka, and may be assumed to be of Lower Permian age.

While it is perhaps unwise to place too much weight on the evidence, the South African faunas seem to afford a little new light on the age of the Elgin sandstones. The *Stagonolepis* Beds, which contain *Stagonolepis, Ornithosuchus, Erpetosuchus, Stenometopon, Hyperodapedon,* and *Telerpeton,* seem to correspond to the *Cynognathus* Beds of South Africa, which contain *Erythrosuchus, Howesia,* and *Thelegnathus,* forms all allied to those of Elgin. If this be so, then the *Stagonolepis* Beds may be regarded as Upper Triassic.

The *Gordonia* Beds, containing *Gordonia, Geikia,* and *Elginia,* resemble most closely the *Pareiasaurus* Beds of South Africa with *Dicynodon, Oudenodon,* and *Pareiasaurus.* The resemblance, however, is much closer to the Russian forms of the Upper Permian of the Dwina, and it seems probable that the Elgin forms are descendants of the Russian, as the Russian probably are of the African. We may conclude that the *Gordonia* Beds are either Upper Permian or Lower Triassic, more probably the former.

(See also Abstract of paper by Prof. Broom on the Classification of the Karroo Beds of South Africa, p. 36.)

VI.—Remarks on the Irregular Echinoids of the White Chalk of England as exhibited in the British Museum (Natural History).

By C. Davies Sherborn, F.G.S.

HAVING been asked by Dr. Smith Woodward and Dr. Bather to look over the collection of Irregular Echinoids from the English Chalk in the British Museum with a view to bringing the exhibition up to date, it appears a favourable opportunity to say a few words as to the nomenclature and distribution of these animals.

Until Dr. A. W. Rowe has completed his study and given us the result of his examination of his own splendid collections, it is impossible to give more than a brief outline of the subject, for he, and he alone, has the material necessary for a detailed report. The bulk of the material in our National Collection has been acquired by donation or purchase, and that at a time when zones or localities were considered of little importance, whereas Dr. Rowe's material has all been collected by two persons, with the definite object of showing the evolution of the animals and the resulting progressive change into forms of more or less value. While, therefore, the National Collection is invaluable from a zoological point of view, it is practically valueless for Evolutional Palæozoology. The present exhibit has been obtained by the help of others, and the authorities have to thank Messrs. Bather, Chatwin, Dibley, Rowe, Sherborn, and Withers for specimens which show more or less completely the history of each species as it is followed successively upward in the zones of the White Chalk of this country. It has not been possible to acquire specimens from each zonal occurrence of the rarer species.

I will take the forms *seriatim*, making such notes as seem necessary as I proceed :—

Echinocorys scutatus, Leske : Addit. ad Klein, Nat. Dispos. Echin., 1778, p. 175, pl. xv, figs. A, B. This is the earliest name for this urchin. Leske does not say where the type came from, but it is a *cor-anguinum* form. The synonyms of this species are *E. ovatus*, Leske, Addit. ad Klein, etc., p. 178 ; *E. vulgaris*, Orbigny (*ex* Breyn), Pal. Franç. (Cret. Ech.), 1854, p. 62, pls. 805, 806. Range : *H. planus* zone to Danian.

Conulus albogalerus, Leske : Addit. ad Klein, Nat. Dispos. Echin., 1778, p. 162, pl. xiii, figs. A, B. This is the earliest name for this urchin. Leske does not say where his type came from, but it is a somewhat low (depressed) form from the *cor-anguinum* zone. The synonyms are *Galerites albogalerus* (Leske), Lamarck, Anim. sans Vert., iii, 1816, p. 20, and *Echinoconus conicus*, Orbigny (*ex* Breyn), Pal. Franç. (Cret. Ech.), 1860, p. 513, pl. 996. Range : *M. cor-testudinarium* to *A. quadratus* zones.

Conulus orbignyanus (Ag.). *Galerites orbignyana*, Agassiz, Mon. Ech. (*Galerites*), 1842, p. 22, pl. iii, figs. 5–8. This is the little bun-shaped *Conulus* found at Trimingham and in (?) the upper part of the *mucronata* zone at Norwich. Brydone, in his "Stratigraphy and Fauna of the Trimmingham Chalk," 1900, p. 12, refers this to '*Echinoconus* (*abbreviatus* ?),' but Dr. Bather has carefully gone into the matter with me and agrees that the determination with *orbignyanus* of Agassiz is correct. Range: (?) upper part of *B. mucronata* zone and the Danian Chalk of Trimingham.

Conulus globulus (Desor). *Galerites globulus*, Desor [*non* Leske], Mon. Echin. (*Galerites*), 1842, p. 18, pl. iv, figs. 1–4. Range: *Marsupites* zone.

Conulus subrotundus, Mantell: Geol. Sussex, 1822, p. 191, pl. xvii, figs. 15–18. Range: *T. gracilis* and *R. cuvieri* zones.

Conulus castaneus (Brongniart). *Nucleolites castaneus*, Brongniart, Géol. environs Paris, 1822, pl. ix, fig. 14. Range: *T. gracilis* and *R. cuvieri* zones.

Discoidea dixoni, Forbes. *Galerites* (*Discoidea*) *dixoni*, Forbes, in Dixon, Geol. Sussex, 1850, p. 341, pl. xxiv, figs. 13, 14. Range: *R. cuvieri* to *H. planus* (1 example) zones.

Micraster cor-anguinum (Leske). *Spatangus cor-anguinum*, Leske, Addit. ad Klein, Nat. Dispos. Echin., 1778, p. 221, pl. xxiii, fig. c (*anglicum*). Range: *M. cor-anguinum* to *B. mucronata* zones.

Micraster cor-testudinarium (Goldfuss). *Spatangus cor-testudinarium*, Goldfuss, Petref. German., 1829, p. 156, pl. xlviii, fig. 5. Range: *H. planus* to base of *M. cor-anguinum* zones.

Micraster præcursor, Rowe: Quart. Journ. Geol. Soc., vol. lv (1899), p. 530. Range: top of *T. gracilis* (1 example) to base of *M. cor-anguinum* zones.

Micraster leskei (Des Moulins). *Spatangus leskei*, Des Moulins, Etudes Echin., 1837, pt. 3, p. 392. Range: *R. cuvieri* to *H. planus* zones.

Micraster cor-bovis, Forbes: in Dixon, Geol. Sussex, 1st ed., 1850, p. 342, pl. xxiv, figs. 3, 4. Range: *R. cuvieri* to base of *M. cor-testudinarium* (2 examples) zones.

Epiaster gibbus (Lamarck). *Spatangus gibbus*, Lamarck, Anim. sans Vert., iii, 1816, p. 33. Range: *M. cor-testudinarium* (1 example) to *Marsupites*, and *B. mucronata* zones.

Infulaster excentricus (Rose). *Spatangus excentricus*, C. B. Rose, in Woodward, Geol. Norfolk, 1833, p. 37, pl. i, fig. 5. Range: *M. cor-anguinum* to *B. mucronata* zones (*teste* Cret. Rocks Brit., iii, Mem. Geol. Surv., 1904, p. 500). Recorded by Burnet (Geol. Mag., 1904, p. 175) from the *Holaster planus* zone of Lincolnshire. The type came from the Norwich gravels. Only known to Rowe and myself from the *M. cor-anguinum* zone; not seen from *Marsupites* or *A. quadratus* zones; not in the Fitch Collection, and not found by us in the *B. mucronata* zone at Norwich or elsewhere. If a specimen were found below the *M. cor-anguinum* zone, we should suspect it to be *Cardiaster cotteauanus*, but the material yet known is not sufficient to work out the relationships and differences of these two forms.

Hagenowia rostrata (Forbes). *Cardiaster rostratus*, Forbes, Fig. Brit. Org. Rem., Mem. Geol. Surv. U.K., dec. iv, 1852, p. 3, pl. x. *Infulaster rostratus*, Wright: Pal. Soc. (Cret. Ech.), 1881, p. 307. *Hagenowia rostratus*, Duncan: Journ. Linn. Soc. (Zool.), xxiii, 1889, p. 211. Range: *M. cor-testudinarium* (1 example, Yorkshire) to *A. quadratus* zones.

Hemiaster minimus (Agassiz). *Micraster minimus*, Agassiz, Echin. Suisse, i, 1839, p. 26, pl. iii, figs. 16–18. Range: *R. cuvieri* to *M. cor-testudinarium* zones.

Holaster planus (Mantell). *Spatangus planus*, Mantell, Geol. Sussex, 1822, p. 192, pl. xvii, figs. 9 and 21. Range: top of *R. cuvieri* (1 specimen) to base of *M. cor-testudinarium* zones.

Holaster placenta, Agassiz: Cat. Syst. Ect. Ech., 1840, p. 1; Modèle 2; Ann. Sci. Nat. (3), viii, 1847, p. 27. Range: top of *R. cuvieri* (1 specimen) to *A. quadratus* zones. Very rare except in the *Micraster* zones.

Cardiaster ananchytis (Leske). *Spatangus ananchytis*, Leske, Addit. ad Klein, Nat. Dispos. Echin., 1778, p. 243, pl. liii, figs. 1, 2. Range: *M. cor-anguinum* (1 specimen) to Danian. Common in *quadratus* chalk, Yorkshire; common in *mucronata* chalk, Norwich.

Cardiaster pygmæus, Forbes: Ann. Mag. Nat. Hist. (2), vi, 1850, p. 444 (name only); Forbes, Fig. Brit. Org. Rem., Mem. Geol. Surv. U.K., dec. iv, 1852, p. 4. Range: *R. cuvieri* zone.

Cardiaster cotteauanus, Orbigny: Pal. Franç. (Cret. Ech.), 1855, p. 140, pl. 830. Range: *H. planus* and *M. cor-testudinarium* zones.

Cardiaster cretaceus (Sorignet). *Holaster cretaceus*, Sorignet, Oursins fossiles Eure, 1850, p. 69. Range: *R. cuvieri* and *T. gracilis* zones.

Offaster pilula (Lamarck). *Ananchytes pillula* (sic), Lamarck, Anim. sans Vert., iii, 1816, p. 27. Range: *Marsupites* (2 or 3 known), *A. quadratus* zone (common); known from *B. mucronata* zone.

The information as to range has been obtained from Rowe and Sherborn's papers on the White Chalk in the Proc. Geol. Assoc., 1900–1904 (see Index to, etc., idem, vol. xviii, pt. 7, 1904, pp. 375–384), and Dr. Rowe's unpublished notes; and the exact distribution and history of the genus *Micraster* can be seen in Quart. Journ. Geol. Soc., vol. lv (1899), pp. 494–546. I have received much assistance from Dr. Bather during the progress of this work.

VII.—Lists of Wenlockian Fossils from Porthluney, Cornwall; Ludlowian Fossils from Porthalla; and Taunusian Fossils from Polyne Quarry, near Looe, Cornwall.

By Upfield Green, F.G.S., and C. Davies Sherborn, F.G.S.

In the Autumn of 1904 we had the good fortune to find in the "Slates with inclusions" at Porthluney, near Gorran, Cornwall, a lenticle of limestone which has yielded a small but satisfactory series of forms allowing its reference to the Wenlockian beds.

In the GEOLOGICAL MAGAZINE, July, 1904, p. 289, one of us had the pleasure of recording the occurrence of Ludlow fossils at this spot in the same beds, and that discovery renders the present one of additional interest. The fossils, which have been handed over to the Geological Survey, are as follows:—

Ptilodictya lanceolata, Lonsd.
Fenestella assimilis, Lonsd.
Fenestella cf. B.M., D 571, from Wenlockian of Dudley.
Fenestella sp.
Millepora cf. *repens* (L.).
Monticuliporid, ramifying through the whole mass of the lenticle.
Rhynchotreta cuneata (Dalm.).
Amphicœlia striata (Sow.).
Pterinæa sp.

In the Autumn of 1905 we again visited Porthalla, and after working three days found another fossil in the "Slates with inclusions" on the beach of Nare Cove. This was a pyritized *Orthoceras* comparable with *O. bullatum*, Sow., and *O. virgatus*, Sow., both of Ludlow age, and distinct from the forms found similarly mineralized in the Devonian beds, by reason of the casts of its siphuncular chambers being barrel-shaped instead of parallel-sided. It is preserved in the British Museum and registered as B.M., C 10529.

Three days work at Polyne Quarry, in the Taunusian beds, yielded thousands of fossils. The bulk of these are in so bad a state that it is difficult to recognize even the genus, but careful collecting and a knowledge of the better specimens to be obtained in Germany render it a comparatively easy task to select sufficient identifiable examples. The following list shows the fossils obtained, the more interesting of which have been placed in the British Museum (Nat. Hist.):—

Fenestella.
Pachypora.
Petraia pauciradiata (Phillips). B.M., R 7502, 7503.
Petraia celtica (Lamouroux). B.M., R 6079.
Petraia radiata, Muenster. B.M., R 7496, 7561.
Petraia punctatocrenulata, Roemer. B.M., R 6978.
Petraia gigas, McCoy. B.M., R 2833, 613.
Pleurodictyum problematicum, Goldfuss. B.M., R 6072, 6973.
Lodanella mira, Kayser. B.M., P 7697.
Neritopsis. A fine series, some showing a broad expanded mouth. B.M., A 1158–1160.
Phacops ferdinandi, Kayser. Six quite typical eyes, one of which showed part of the head-shield. B.M., I 7233, 7234.
Strophodonta gigas, McCoy.
Streptorhynchus.
Athyris cf. *undata*, Defr.
Rhynchonella.
Rensellæria.

Orthis personata, Zeill.
Orthis vulvaria, Schl.
Orthis circularis, Sow.
Spirifer primævus, Stein.
Spirifer subcuspidatus, Schnur.
Spirifer cf. *hystericus*, Schl.
Crinoid columnars, some very large, $\frac{3}{4}$ inch across. B.M., E 14062.

The *Lodanella*, which was obtained by the last drive of the crow-bar, is magnificent and quite equal to the type-specimen.

It is hoped that these lists will stir up others to search for fossils in this interesting area. We are much indebted to Mr. G. C. Crick and Mr. W. D. Lang, who have most carefully examined and helped us with some of our material.

NOTICES OF MEMOIRS, ETC.

British Association for the Advancement of Science. Meeting in South Africa, August 15th to Sept. 1st, 1905. Papers read before Section C, Geology.

I.—On the Relation between Ore Veins and Pegmatites. By Professor R. Beck.

THE author gave a summary of the latest investigations on the origin of pegmatites, by W. C. Brögger, H. Rosenbusch, S. Arrhenius, J. H. L. Vogt, U. Grubenmann, and others. In conformity with these authors, he explained pegmatites as products of crystallisation from the superheated water, which remained, after the consolidation of a plutonic magma, as a concentrated solution containing many of the rarer chemical elements and compounds formerly distributed through the whole fluid mass. Being retained in the depths of a plutonic focus under high pressure, these remains of magmatic water could pass through a very gradual process of cooling; whereas the so-called 'juvenile' thermal waters (*Juvenile Quellen*) of similar origin found their way to the upper parts of the earth's crust, and caused there the formation of minerals at lower temperatures and pressures.

Most ore veins belong to the second class, but a considerable number of occurrences may be styled metalliferous pegmatites.

The best known examples of these are found in the group of tin ores, and as such were discussed the ore veins of Zimwald, Graupen, Embabaan, and others.

As examples of copper ores were cited those of Telemarken in Norway; and finally some gold-bearing quartz reefs were described which are very nearly related to pegmatites, and that not merely by their characteristic mineralogical composition (Berezowsk, Southern Appalachians, Yukon District, Passagem, and other instances in Brazil). It may be mentioned in proof of this that certain gold quartzes contain tourmaline, the characteristic mineral of all pegmatites.

II.—The Classification of the Karroo Beds of South Africa. By Professor R. Broom, M.D., B.Sc.

An attempt is made from the study of fossil remains to give a more satisfactory subdivision of the Karroo System than has hitherto been possible. The larger subdivision into the Dwyka, Ecca, Beaufort, and Stormberg Series is retained.

The Beaufort Beds are divided into series. The lowest is characterised by the presence of Therocephalians and Anomodonts. These lower beds can be again divided into an earlier series, in which occur *Pareiosaurus* and *Titanosuchus*, and a later series characterised by the prevalence of *Dicynodon* and *Oudenodon*.

Above the Lower Beaufort Beds occur a Middle series, characterised by the rarity of reptilian remains other than of *Lystrosaurus*, which is very abundant.

The Upper Beaufort Beds are characterised by the presence of the Theriodonts. In the earlier subdivision of these upper beds *Procolophon* is the most characteristic fossil, and in the upper the Theriodont *Trirachodon*.

The Stormberg Beds appear to be divisible into two groups—a lower, the Molteno Beds, and an upper, which includes the Red Beds, the Cave Sandstone, and the Volcanic group.

The Dwyka and Ecca Series are believed to represent the Lower and Middle Permian of Europe, and the Lower Beaufort Beds the Upper Permian.

The Middle Beaufort and Upper Beaufort Beds are believed to correspond to the Lower and Upper Trias of Europe.

The Stormberg Beds are believed to be Lower Jurassic or Rhætic, and the Upper Stormberg Beds Lower Jurassic.

III.—The Stormberg Formation in the Cape Colony. By Alex. L. du Toit, B.A.

The Stormberg Formation is the uppermost division of the Karroo System in South Africa, and builds up the whole of Basutoland and the adjoining portions of the Cape Colony, the Orange River Colony, and Natal. In the Cape Colony the tract occupied by this formation is confined to the immediate neighbourhood of the Drakensberg Range, widening out considerably in the south-west over what is known as the Stormberg area.

The Stormberg series is subdivided as follows in downward succession :—

(4) Volcanic Beds,
(3) Cave Sandstone,
(2) Red Beds,
(1) Molteno Beds.

The strata lie nearly horizontally, or are only inclined at low angles, consequently the lower divisions crop out along the foot of the mountain ranges, while the upper beds form all the higher ground. The Molteno Beds consist of a thickness of 1000–2000 feet of sandstones, with thin, dark shales and mudstones and occasional coal-seams. Arenaceous material is predominant, and the sandstones vary from fine-grained grey felspathic varieties to coarsely crystalline 'glittering' sandstones, with small pebbles of vein-quartz. Boulders of hard white or brownish quartzite, derived evidently from the Cape Formation, are common, usually scattered irregularly throughout the sandstone beds, but occasionally forming conglomerate bands. The coals are thin, and contain from 15 to 30 per cent. of ash, but are the only workable deposits in the Cape Colony. Fossils are almost entirely those of plants, e.g., *Thinnfeldia, Tæniopteris, Callipteridium,* etc., from which the Rhætic age of the beds has been deduced.

The Red Beds are more argillaceous in character, and consist of 600 – 1600 feet of strata, in which red and purple shales, mudstones, and sandstones are predominant, though thick beds of fine-grained white sandstone are also common. Fossil remains are chiefly those of carnivorous Dinosaurs, such as *Euskelesaurus* and *Massospondylus.*

The Cave Sandstone is a thick bed of fine-grained felspathic sandstone, usually white or yellowish in colour, and of very striking appearance. As a rule, it is unbedded throughout, except towards its summit, or less commonly towards its base. In some places it attains a thickness of 800 feet, but as a rule it varies from 150 to 350 feet. In a few places the Cave Sandstone is entirely absent, and the volcanic beds rest directly upon the red beds. The Cave Sandstone weathers into most fantastic outlines, and gives rise to very peculiar scenery along the Drakensberg.

The sediments of the Karroo System were deposited in a great inland sea, 'the Karroo Lake,' in which the water was either fresh or slightly brackish, and not very deep. During the formation of the Stormberg rocks the shore-line stretched where the coast ranges of the south of the Colony now rise, and extended eastwards into the Indian Ocean, and then north-eastwards parallel to the coastline of Natal. This old land surface was formed of rocks belonging to the Cape and Pre-Cape Systems, quartzites, granites, and metamorphic rocks.

During Cave Sandstone times volcanoes came into existence, and great eruptions of basic lavas took place. Over 100 volcanic necks have been mapped by the Geological Survey, some of which are over a mile in diameter. Many of the pipes are filled with siliceous breccias, or with fine-grained sandstone-like tuffs. The erupted material consists almost entirely of basic lavas, compact to vesicular, the most interesting variety of the latter being the 'pipe-amygdaloid'; enstatite-andesites occur in a few places. Beds of volcanic ash are met with in Barkly East and around Jamestown. In the former district there are frequent alternations of lava, ash, and sandstone, the even bedding and passage of sandstone into ash, either laterally or vertically, pointing conclusively to sub-aqueous eruptions. The later flows were probably subaerial.

At the close of the volcanic outbursts, after 2000–5000 feet of lavas had been erupted, the area was affected by gentle folds by which the direction of flow of the Kraai and Orange Rivers was determined. Then followed the gigantic and extensive intrusions of dolerite, which at the present day form such a conspicuous feature in the scenery of the Karroo.

The interior of the colony was intermittently elevated, and the old land surface in the south disappeared beneath the waters of the Indian Ocean. A series of peneplains, or plains of river-erosion, mark the periods of rest and elevation of the country, the highest of which is now found at an altitude of a little over 8,000 feet above sea-level. The plateau of the Drakensberg has been deeply cut into on the west and south-west, but on the south-east it presents an almost unbroken face, over 300 miles in length, rising from 2,000 to as much as 6,000 feet above the ground at its base.

IV.—Index Generum et Specierum Animalium.—Report of a Committee, consisting of Dr. Henry Woodward (Chairman), Dr. F. A. Bather (Secretary), Lord Walsingham, Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, and the Hon. Walter Rothschild.

SATISFACTORY progress has been made by Mr. David Sherborn in the recording of literature from 1801 onwards. Among other works now indexed up to 1850 may be mentioned the "Annals and Magazine of Natural History," the "Academia Cæsarea," and the "Neues Jahrbuch für Mineralogie." Various tracts dealing with the collation of difficult books have been issued, and a reprint of the descriptions of new species of birds drawn up by Pallas for "Vroeg's Catalogue," 1764, has been published by the Smithsonian Institution, under Mr. Sherborn's care, from the unique copy in the Linnean Society's Library. The search for rare books still continues, and any such acquisitions are made available for public use by transference to one or other of the accessible libraries. Special thanks are due to the Italian Government, the University of Padua, and Professor Dante Pantanelli for enabling the Committee to examine the "Tavola alfabetica delle conchiglie adriatiche" of Stefano Andrea Renier (1804). Help of this nature, as well as valuable criticism, is continually forthcoming from home and abroad, and the general interest taken in the published volume (1758–1800) is highly gratifying to Mr. Sherborn and satisfactory to this Committee, which, in this connection, desires to return its thanks especially to Mr. L. B. Prout and Mr. C. W. Richmond.

REVIEWS.

I.—Mesozoic Plants from Nagato and Bitchu. By M. Yokoyama. (Journ. Coll. Sci. Univ. Tokyo, vol. xx, art. 5, pp. 13, and 3 pls. 1905.)

PROFESSOR YOKOYAMA has continued his studies of the Mesozoic floras of Japan, and in the present communication confirms his previous conclusion as to the Rhætic age of the fossil plants of the Coal-bearing series of Nagato. Eight species are described, including such well-known Rhætic fossils as *Cladophlebis nebbensis* (Brongt.) and *Polozamites lanceolatus* (L. & H.). Several other specimens, mostly fragmentary, are figured from the province of Bitchu and are probably of similar age. A number of excellent figures of most of the species described are given. E. A. N. A.

II.—New Species and a New Genus of Batrachian Footprints of the Carboniferous System in Eastern Canada. By G. F. Matthew, D.Sc., LL.D. Trans. Roy. Soc. Canada, ser. ii, vol. x, sec. 4, pp. 77–110, with 5 plates, 1904–1905.

THIS article contains descriptions of species that more fully present the characters of the genera described from the type species in an article published last year in the Canadian Record of Science, Montreal. It also contains descriptions of the new genus *Dromillopus*, founded on the footprints of a small Batrachian of the Coal-measures of Joggins, Nova Scotia.

This article also refers the species *Dromopus celer* of the preceding article provisionally to Woodworth's genus *Batrachichnus*.

The full descriptions of the genera and species described in the article in the Canadian Record of Science are here re-presented, with additional notes.

Six plates of figures accompany this article and show clearly the generic and specific characters of the species of footprints described.

In conclusion, the writer makes comparisons of these footmarks with those of the frog and the alligator, and finds that they show closer resemblances to those of the latter than to the footsteps of the former, but he concludes that there are peculiarities of form in the fossil footprints not to be found in either of the recent forms used for comparison, and that Labyrinthodonts and Microsauria are responsible for many of these tracks.

III.—Rocks of Cape Colville Peninsula, New Zealand. By Professor Sollas, F.R.S. With an Introduction and Descriptive Notes by Alexander McKay, F.G.S., Government Geologist, New Zealand. Vol. I. pp. 289. (Wellington, 1905.)

THIS volume on the rocks of Cape Colville Peninsula is chiefly devoted to the description by Professor Sollas of the specimens which were submitted to him by the New Zealand Government. Some diversity had arisen in the nomenclature of the igneous rocks which are the source of the gold in the Thames Goldfield, and it was decided to obtain an authoritative opinion by submitting a selection of the rocks to a competent petrologist. The principal object of the report is therefore to place on a satisfactory footing the nomenclature of the rocks of the Peninsula.

The present volume contains only the descriptive notes on the first 204 specimens sent to Professor Sollas. That he is not responsible for the form in which they are published is evident from a somewhat pathetic footnote on p. 126, in which he disclaims responsibility for their literary style. As almost all the rocks belong either to the Andesite or Rhyolite group, the detailed petrographical notes given of each individual specimen certainly prove somewhat monotonous reading. Professor Sollas himself states that the substance of the report may be regarded as mere statement of matter of fact: we have hopes, however, that these 'dry bones' may yet live, since he holds out the expectation of a more comparative study for the final report, in which also the question of the origin and structure of spherulites will be considered.

In a general note preceding the systematic descriptions of the specimens we have a foretaste of this final report in some interesting remarks on the nature of the 'pilotaxitic' matrix of the andesites, and also on the supposed re-fusion of rhyolites, for which Professor Sollas finds no evidence, since the so-called felspar-'glass' is really only a decomposition product.

To supplement the descriptions of the specimens an introductory and explanatory account of the geological position of the rocks is given by Mr. McKay.

Perhaps the most remarkable feature of the volume is the wealth of illustrations; plates of photographs of scenery and of microphotographs of the thin slices of the rocks are almost interleaved with the letterpress.

IV.—Geology in the Federated Malay States.

By the kindness of a friend we have seen several Reports issued by this Government, but as copies have not been sent to the Library of the British Museum (Nat. Hist.) we are unable to give a comprehensive notice of the whole of the work done. Those Reports before us are No. 8, dealing with the Geology of the Residency of Sarawak, and of the Sadong District, Borneo,[1] and the Geologist's Report for 1904.[2] Mr. J. B. Scrivenor, the geologist to the Federated Malay States, after acknowledging help obtained from the staff of the British Museum (Nat. Hist.) in the naming of fossils found, reports on his journey through the areas of the four Federated States. He describes the serpentine areas of Kuala Pilah and Negri Sembilan, some of which is used for road-metal and some for ornaments. He failed to find a trace of platinum, the object of his search. Ornamental building-stone seems to be abundant, and the granites would work up on a large scale. The occurrence of tin is next dealt with and occupies the bulk of the Report. The main object of the visit to Sarawak and Borneo was economic (gold and coal). Mr. Scrivenor gives a brief but careful sketch of previous work, and proceeds to make supplementary notes. The coal-seam at Sadong is 2′ 9″ in thickness, but varies considerably. It is a black bituminous coal, light in weight and easily fractured, and contains a considerable amount of calcite and some pyrites locally. It burns well and leaves little ash, but owing to its friable nature

[1] Geol. Dept. F.M.S. (Kuala Lumpur), 1905, 12 pp.
[2] Ibid., 7 pp.

the furnace bars have to be especially arranged. Gold is worked down to 93 and 120 feet, and details are given of the various deposits now opened. As for the geology of Sarawak, the author refers to the papers of R. B. Newton in the GEOLOGICAL MAGAZINE, while for the whole island the works of Molengraaff and Verbeek are the standard books of reference. The Tertiary and Secondary rocks are now well made out, but as yet fossils from the Primary rocks do not seem to have been found. Mr. Scrivenor was appointed for three years, but we hope his time will be considerably extended in order that he may have an opportunity of finishing what promises from these two reports to be a valuable piece of surveying.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 22nd, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

A Special General Meeting was held before the Ordinary General Meeting at which Horace Woollaston Monckton, Treas. L. S., was elected Treasurer, and Richard Hill Tiddeman, M.A., was elected a Member of Council.

The following communications were read:—

1. "On a New Specimen of the Chimæroid Fish, *Myriacanthus paradoxus*, Ag., from the Lower Lias of Lyme Regis (Dorset)." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., F.G.S.

The author, having proved that the dorsal fin-spine of the so-called *Ischyodus orthorhinus* is identical with an ichthyodorulite which has been named *Myriacanthus granulatus*, inferred that the larger ichthyodorulite *M. paradoxus* belonged to the same fish as the larger dentition named *Prognathodus Guentheri* by Egerton. This question has been settled by the discovery by Mr. S. Curtis, in the Lower Lias of Black Ven, of a dorsal fin-spine in direct connection with a mass of decayed cartilage, dermal plates, and teeth. On the specimen the following parts are recognised:—the left and left palatine dental plates, right mandibular dental plate, cartilage of the pectoral arch, præsymphysial tooth, rostal cartilage, frontal spine or tentaculum, and vomerine dental plate, dermal plates, and the dorsal fin-spine. The new fossil warrants the conclusion that *Myriacanthus* is a Chimæroid, closely similar to the Upper Jurassic *Chimæropsis*, with (i) a median chisel-shaped tooth in front of the lower jaw, (ii) a few tuberculated dermal plates on the head, and (iii) a tuberculated dorsal fin-spine. In these respects it differs from all other known Chimæroids—even from the comparatively primitive types which have been discovered during recent years in the Japanese seas. The Myriacanthidæ, in fact, have still no nearer ally than *Callorhynchus*, with which Egerton originally compared his so-called *Ischyodus orthorhinus*.

2. "The Rocks of the Cataracts of the River Madeira and the adjoining portions of the Beni and Mamoré." By John William Evans, D.Sc., LL.D., F.G.S.

The crystalline rocks of the cataracts of the River Madeira and the lower waters of its tributaries are part of a ridge with a north-westerly and south-easterly strike, similar to that of the Andes, in the same latitudes. The strike is especially prevalent in Equatorial regions. With the exception of comparatively recent alluvial deposits and a few pebbles of chert, pronounced by Dr. G. J. Hinde to be of marine origin but uncertain date, only crystalline rocks are met with in the falls. They all appear to be igneous, and are mostly massive in character, though some dyke-rocks occur. In places they are typical gneisses, and they are often banded, but in some cases they show no sign of foliation. The prevailing type is acid, with a considerable proportion of alkalies, especially soda; but some of the rocks are distinctly basic in character. Analyses of several of these rocks, made by Mr. G. S. Blake, are tabulated; and in one case the chemical analysis is compared with one made from the proportion of minerals washed out from the thin sections. Accounts of the megascopic and microscopic characters of all the rocks encountered are given. The more acid rocks are usually fine in grain, and are often granulitic in structure. In most cases the quartz seems to have crystallized out before the felspar. The occurrence of andalusite of chiastolitic type and of sillimanite as inclusions in a felspar is referred to, as well as the presence in one rock of an unusual type of allanite. An altered basalt is described, which contains minute concentric structures allied to those of a pyromeride. Above and below the regions of the cataracts is a wide expanse of country covered with alluvium, either of recent or later Tertiary date.

3. "The Doncaster Earthquake of April 23rd, 1905." By Charles Davison, Sc.D., F.G.S.

The Doncaster earthquake of 1905 was a twin, with its principal epicentre half a mile north of Bawtry, and the other about four miles east of Crowle and close to the centre of the disturbed area of the Hessle earthquake of April 13th, 1902. The distance between the two epicentres is about 17 miles. The disturbed area contains about 17,000 square miles, including the whole of the counties of Lincoln, Nottingham, Derby, Stafford, Leicester, and Rutland, the greater part of Yorkshire, and portions of Lancashire, Cheshire, Shropshire, Worcestershire, Warwickshire, Northamptonshire, Cambridgeshire, and Norfolk. The originating fault runs from about E. 38° N. to W. 38° S., and appears to be nearly vertical within the south-western focus and inclined to the south-east in the north-eastern focus. The first and stronger movement took place within the south-western focus. A twin earthquake is probably due to the differential growth of a crust-fold along a fault which intersects it transversely, the first movement as a rule being one of rotation of the middle limb, accompanied by an almost simultaneous slip of the two arches, and followed soon afterwards by a shift of the middle limb. The movements in which the Doncaster earthquake originated presented a slight variation in this order. They consisted of successive but continuous displacements, first of the south-western arch, then of the middle limb, and finally of the north-eastern arch.

II.—December 6th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Physical History of the Great Pleistocene Lake of Portugal." By Professor Edward Hull, LL.D., F.R.S., F.G.S.

The formations bordering the lower banks of the Tagus near Lisbon are arranged by the author in the following order of succession:—

6. RECENT and QUATERNARY.	Alluvia of the Tagus.
5. LACUSTRINE.	Marls with *Lymnæa* (Lacustre superior). Sands and gravel.
4. POST-PLIOCENE and PLIOCENE.	Not represented, unless by some land-glacial beds due to elevation.
3. MIOCENE.	'Almada Beds.' Calcareous marls and limestones, with marine fossils.
2. EOCENE (?).	Unfossiliferous sands and gravels (Lacustre inferior).
1. UPPER CRETACEOUS.	Hippurite Limestone.

A description is given of the Lacustre superior; the Almada Beds are considered to be Miocene, and as the Pliocene is not represented, except possibly by certain glacial deposits, the author considers that that period was one of great uplift, when the suboceanic gorge, an extension of the present course of the River Tagus, was excavated. The margin of the lake was probably formed by the granite of Das Vargans and Cunheira. There is evidence that the general level of the lake-bed was nearly that of the outer sea, and that the sea-waters gained occasional access to the lake during the earlier stage of its formation. The lake was eventually drained by the channel cut by the Tagus at the harbour of Lisbon, upon the elevation of the land to about its present level.

2. "The Geological Structure of the Sgùrr of Eigg." By Alfred Harker, M.A., F.R.S., F.G.S.

The pitchstone which forms the Sgùrr of Eigg is a massive sheet, some 400 feet thick, reposing with discordance upon the succession of alternating basalts and dolerites which make up the greater part of the island. The lower surface of the pitchstone is irregularly undulating, and in two places fragmental accumulations are seen immediately beneath it. The generally received interpretation regards the pitchstone as a lava-flow, or series of flows, occupying an old river-valley excavated in the basalts, and the fragmental deposits have been regarded as river-gravels of the pitchstone age. This is the view put forward by Sir Archibald Geikie.

After a detailed survey of the ground, the author finds it impossible to accept this view, and he gives reasons for considering the pitchstone to be intrusive. The form of its base, as mapped out, does not seem to be reconcilable with that of a river-valley, and its character is that of an intrusive junction rather than an erosion surface. The fragmental deposits are believed to be of volcanic origin and of the basalt age. The one exposed at the seaward termination of the ridge is a volcanic agglomerate, probably filling a small vent. The other, seen at the southerly base of the Sgùrr, is a bedded agglomerate, partly rearranged by water action. The Torridonian and Oolitic sandstone blocks which are abundant in it are held to have been brought up from below, and fossil wood of Oolitic age has been brought up in the same manner. The absence of fragments of the sill-dolerites (themselves younger than the lavas, but cut off by the pitchstone) in both accumulations seems to assign them unequivocally to the age of the basalt, and their conjunction with the pitchstone must then be considered accidental.

The conclusions arrived at bring the rock of the Sgùrr of Eigg into relation with the other British Tertiary pitchstones, which are all intrusive. Thus also is avoided the difficulty of assuming a great erosion in inter-volcanic times, a hypothesis for which the supposed river-valley was the sole evidence.

Dr. J. W. Evans, in showing a new method of determining the optic axial angle of a biaxial mineral, by rotating it in parallel polarized light, on an axis at right angles to the optic axial plane and to the axis of the microscope, said that the position in which the relative retardation was zero corresponded to the optic axes, and the angle between these positions was the optic axial angle in air or in the medium in which the mineral was immersed. To determine when the relative retardation is *nil* the nicols are placed at angles of 45° with the axis of rotation; the double wedge described in the Mineralogical Magazine for May last (vol. xiv, p. 29) is then inserted, and the position noted when the bands on the two halves of the wedge are in exact continuation of one another.

This method is applicable to sections of minerals in rock-slides which are cut at right angles to the optic axial plane; for the observation can be made with a low power, which admits of the slide being freely rotated in a stage goniometer. With the higher powers which are necessary for microscopic observations in convergent light, a rock-slide could only be rotated within very narrow limits.

Dr. F. A. Bather exhibited fossils from various localities in New Zealand, hitherto known as "the Mount Torlesse Annelid," described in the Geological Magazine (December, 1905, p. 532). Adds further information thereon; for which see his letter, p. 46 below.

III.—Mineralogical Society of London.

November 14th, 1905; Professor H. A. Miers, F.R.S., President, in the chair. — The Determination of the Angle between the Optic Axes of a Crystal in Parallel Polarised Light, by Dr. J. W. Evans. The crystal plate is rotated on the optic normal as axis, and the positions are determined in which the relative retardation is *nil.* This may be observed by using a gypsum plate or the double quartz wedge devised by the author. In the latter case the positions in question are marked by the coincidence of the bands in the two halves of the wedge. This gives a very exact reading if strictly parallel light be employed.—Mineralogical Notes (Diopside and Albite), by Professor W. J. Lewis. A large tabular crystal of white diopside, a brown diopside of unusual habit, and a Carlsbad twin of albite were described.—Note on the Crystallisation of Drops, especially of Potash-alum, by Mr. J. Chevalier. The President described observations made by Mr. Chevalier on the crystallisation of drops of solution of potash-alum. These generally yield in succession (*a*) birefringent spherulites, (*b*) octahedra, and (*c*) a fine rectangular network. (*a*) is probably a less hydrated alum, and it becomes isotropic on exposure to moist air by conversion into (*b*). (*c*) is ordinary alum which is in a state of strain, owing to its rapid crystallisation, and becomes white and opaque after a time owing to the development of cracks. Drops observed upon a slide under the microscope behave differently according as they are in the metastable or labile condition. A metastable drop inoculated with (*a*) or (*b*) or (*c*) deposits octahedra. A labile drop inoculated with (*a*) deposits spherulites, but inoculated with (*b*) or (*c*) deposits the rectangular network. When a metastable drop containing either octahedra or spherulites, or both, passes into the labile condition (by cooling or by evaporation) they may continue to grow unchanged. If, however, a fragment or germ of octahedral alum be introduced into a labile drop, the network (*c*) is immediately produced. An alum crystal growing in a labile solution is surrounded by a zone of metastable liquid which prevents it from starting the network (*c*) characteristic of a labile drop. Experiments were made upon the action of various mineral substances in inducing crystallisation in metastable and labile drops. Among these the holosymmetric cubic crystals, and especially galena, exercise a remarkable effect in producing the network (*c*) in labile drops.—Note on the Formation of Gypsum Crystals in a disused Well at Chemical Works, by C. J. Woodward. Groups of gypsum crystals were exhibited which were found thirty years ago studding the walls of an old well at Messrs. Chance's Chemical Works at Oldbury.—Notes on Minerals recently found in the Binnenthal, by Mr. R. H. Solly. The minerals described were: (1) Ilmenite, in brilliant crystals, displaying marked hemihedrism and showing five new forms. It is associated with quartz, adularia, magnetite, and mica, on mica-schist. (2) Seligmannite; an exceptionally large and well-developed crystal in dolomite. Unlike any previously described, it is untwinned; altogether 45 forms were observed, of which 21 are new. (3) Marrite; two more crystals of this rare mineral were found, one tabular and the other sharply pointed in habit. (4) Proustite; a minute crystal deposited on a crystal of rathite. (5) Trechmannite; a crystal of this rare mineral displaying asymmetric hemihedrism, deposited on a crystal of binnite. (6) Hyalophane, in crystals of an unusual green colour.

CORRESPONDENCE.

THE AGE OF 'THE MOUNT TORLESSE ANNELID.'

SIR,—In my paper on these fossils (GEOL. MAG., Dec. V, Vol. II, pp. 532–541; December, 1905) it was said that the beds containing them were "usually regarded as the uppermost division of the Maitai Series"; but the stratigraphical position of that series was treated as an open question, though "probably not below Upper Carboniferous and not above Trias." The paper was unfortunately written without reference to a valuable series of articles by Professor James Park, of Otago University, contained in the *Transactions of the New Zealand Institute*, vol. xxxvi. From these papers it appears that "a good deal of doubt must attach to the determinations" of the fossils found by Mr. M'Kay in the Maitai Limestone; the fossils collected by Professor Park in the same bed are identified by him as "*Spiriferina* (two sp.), *Athyris*, *Rhynchonella*, *Pleurotomaria*, *Inoceramus*, *Pentacrinus* [presumably *Isocrinus*], and corals (three sp.)." These, as well as other fossils in corresponding beds, indicate that the limestone in question, so far from being Lower Carboniferous, is really Upper Triassic. On this ground alone the conformably succeeding shales, etc., would probably be of Jurassic age. Further, the "shell like *Inoceramus*" alluded to on pp. 535, 536 of my paper, is regarded by Professor Park as *Inoceramus* itself, and as indubitable proof of Mesozoic age. The Maitai shales, etc., of the Nelson district are correlated by Professor Park with the Mataura formation of Otago, and since the name 'Maitai' has become so ineradicably associated with the idea of Carboniferous age, he adopts Hutton's 'Mataura Series' with its familiar Jurassic connotation. He further adopts Hutton's 'Hokonui System' to include the Mataura Series and the conformably underlying Shaw's Bay Series of Triassic (and ? Permian) age.

The Mount Torlesse Annelid beds are mentioned by Professor Park on p. 392, only to say that "in the absence of shell beds it is impossible to fix the position of the plant and annelid beds in relation to known horizons elsewhere . . . . the strata at Mount Torlesse do not afford the data necessary for their subdivision into groups and series of beds." It seems, however, to result from Professor Park's work that the horizon of *Torlessia Mackayi* and *Dentalium Huttoni* is "not below Trias and not above Jurassic." Perhaps it would be permissible to say "probably Lias"; and here one recalls that the Yakutat slates with *Terebellina* are also probably Lias.

To Professor Park and to readers of the GEOLOGICAL MAGAZINE an apology seems necessary for the omission of the preceding remarks from my original paper. Their omission was due mainly to the fact that the volume containing Professor Park's articles, though issued in August, 1904, has not yet been received either by the British Museum (Natural History), "to whom this volume is presented by the Governors of the New Zealand Institute," or by the Science Library of the Education Department, which has been attempting to procure it through the usual agents. My attention was drawn to it by Dr. Wilckens' excellent abstracts in *Neues Jahrbuch für Mineralogie*, 1905, II, which reached England after my paper had gone to press. It is intelligible that Professor Park should send his fossils to Freiburg for determination; but it is hard that British palæontologists, who at least try to do their best, should have to learn of the admirable work of their New Zealand brethren from a German publication. F. A. Bather.

December 5th, 1905.

THE SEPARATE EXISTENCE OF GEOLOGY AS A SCIENCE.

Sir,—I observe in the Anniversary Address of the President of the Geological Society (John Edward Marr), 17th February, 1905, p. xi, the following paragraph:—"It is not wonderful that in these circumstances there appears to be a feeling among some that geology as a separate science will become extinct." I have met with statements somewhat akin to this which have drawn my attention to the subject. Geology is the history of the earth, and therefore includes all other sciences and all natural knowledge (except the abstract sciences). Therefore, if geology as a science is to become extinct it can only be as regards the name (unless, indeed, it is meant that the human race is to become extinct), for as long as a reasoning being exists on the earth there must be some kind of a history of the earth. Astronomy, biology, mineralogy, etc., are merely branches of this science.

I would remark also on a statement in the Address of H. A. Miers to the Geological Section of the British Association in South Africa, wherein he says he has no claim to be called a geologist. If a man who has a profound knowledge of some departments of geology, and, it may be presumed, a good general knowledge of geology likewise, is not to be called a geologist, then who is?

R. J. Lechmere Guppy.

Port of Spain, Trinidad.

MESSRS. HATCH & CORSTORPHINE'S "GEOLOGY OF S. AFRICA."

Sir,—It may prevent some confusion subsequently, to point out that in Hatch & Corstorphine's recently-issued work on "The Geology of South Africa" there is an error in the naming of one of the fossils from the Umtamvuna Series (Pondoland) depicted in fig. 71 on p. 259. Fig. 71*b* should have been described as *Ammonites gardeni*, and not *Ammonites soutoni*, the figure having evidently been copied from one of Baily's original figures of that species (Quart. Journ. Geol. Soc., vol. xi, 1855, pl. xi, fig. 3*a*).

British Museum (Natural History). G. C. Crick.

OBITUARY.

PROFESSOR GILLES-JOSEPH-GUSTAVE DEWALQUE,

For. Memb. Geol. Soc. Lond.

Born December 2, 1826. Died November 3, 1905.

We regret to record the death, in his 79th year, of our valued friend and frequent correspondent of many years past, Monsieur Gustave Dewalque, Professor Emeritus of the University of Liége, founder and Honorary Secretary-General of the Société Géologique de Belgique, Membre de l'Académie Royal de Belgique, and of many other Learned Societies in Belgium, Moscow, Vienna, Luxembourg, etc., etc., Commandeur de l'Ordre de Leopold, and Officier de l'Ordre des Sts. Maurice et Lazare. He was born at Stavelot 2nd December, 1826, and died at Liege 3rd November, 1905.

Professor Dewalque contributed various papers to this Magazine in 1875, 1878, 1895, and 1899, and has always taken a very lively interest in English and Belgian geology. He was elected a Foreign Correspondent of the Geological Society of London in 1871, and a Foreign Member in 1880. We hope to give a full account of his scientific work later on.

PROFESSOR EMILE OUSTALET,

Muséum d'Histoire Naturelle, Paris.

Born August 24, 1844. Died October 23, 1905.

Monsieur Emile Oustalet, who had succeeded Professor Dr. Alphonse Milne-Edwards as Professor of Mammalogy and Ornithology at the Paris Muséum d'Histoire Naturelle, passed away on October 23rd, aged 61. Born at Montbéliard, 24th August, 1844, he has been on the staff of the Museum for 32 years. Professor Oustalet is chiefly known as an ornithologist, but has done also some good work on fossil insects. A list of his publications on the latter subject is here appended :—

"Recherches sur les Insectes fossiles des Terrains tertiaires de la France": Part I, 'Insectes fossiles de l'Auvergne,' pp. 178, 6 plates; Part II, 'Insectes fossiles d'Aix en Provence,' pp. 347, 6 plates. (Annales des Sc. Géol., etc., vol. ii, No. 3, and vol. v, No. 2. 1870–4.)

"Sur les Insectes fossiles." Paris. (Soc. Philom. Bull., viii, 1872, pp. 59–64.)

"Sur quelques espèces fossiles de l'ordre des Thyanoptères." Paris. (Soc. Philom. Bull., x, 1878, pp. 20–27.)

Errata.—In Messrs. Dakyns & Greenly's article, December Number, 1905, p. 542, line 21, for "overlie the *felspar* of Moel Meirch," read "overlie the *felstone*," etc.—In Dr. Andrews' article, 1st paragraph, p. 562, for *P. minus* read *P. minor.*

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., Dr. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

FEBRUARY, 1906.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. III.

No. II.—FEBRUARY, 1906.

ORIGINAL ARTICLES.

I.—*Mastodon* in the Pleistocene of South Africa.

By Professor Dr. Richard Beck, Freiberg.

LAST Summer, when I travelled in South Africa with the British Association, I examined the diamantiferous gravels on the Vaal River near Kimberley. During this visit Mr. Krumbelt, apothecary in Barkly West, had the kindness to give me three fossil teeth which he had found in the local gravels. Nos. 1 and 2 were obtained from the so-called breakwater workings of the river-side, while No. 3 was found in the Waldeck Plant in the higher terrace of gravels at an elevation of 60 to 80 feet. The state of preservation of all these teeth is that of real fossil remains.

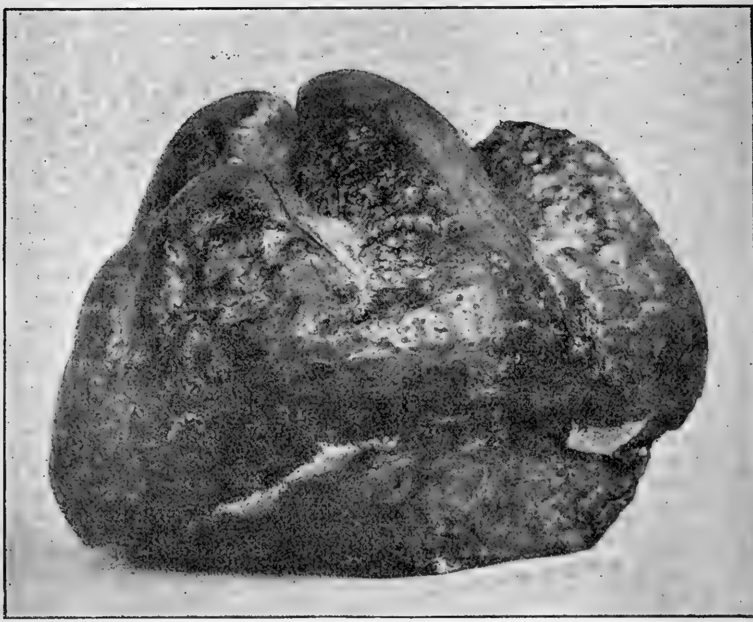
Mr. G. A. Boulenger was kind enough to compare the teeth numbered 1 and 2 with recent specimens in the British Museum, and communicated to me his determinations as follows:—

No. 1 is a molar of *Equus*, perhaps of a Zebroid species, as inferred from the locality.

No. 2 is a lower canine of a young *Hippopotamus*.

Tooth No. 3 is of much more interest, for, according to an examination kindly made by my friend Dr. Johannes Felix, Professor of Palæontology in Leipzic, it is a fragmentary molar of *Mastodon* (subdivision *Bunolophodon*). A determination of the species is impossible because the fragment is not sufficiently complete; but, as shown by the accompanying photograph of the fossil (Fig. 1), there can be no doubt as to its generic relationship.

The existence of *Mastodon* in South Africa, hitherto unknown, is of great importance for geology and biology. According to the latest memoir on the subject,[1] the younger Tertiary beds of Egypt,



Portion of unworn tooth of a *Mastodon* (subdivision *Bunolophodon*) from the Pleistocene, Waldeck Plant, higher terrace of gravels (60 to 80 feet) above the Vaal River, near Kimberley, South Africa.

Tunis, and Algeria have afforded the only African *Mastodons.* Now we are able to record this extinct Proboscidian from the Pleistocene of the far south of the Continent.

II.—On a Collection of Fossil Corals from Eastern Egypt, Abu Roash, and Sinai.

By J. W. Gregory, D.Sc., F.R.S., F.G.S.,
Professor of Geology, Glasgow University.

(PLATES VI and VII.[2])

THE corals described in this report were collected by members of the Egyptian Geological Survey, and were sent to London in September, 1899. I then examined most of the specimens, and submitted a preliminary report to the effect that they belong to three horizons:—

[1] Depéret, "Découverte du *Mastodon angustidens* dans l'étage carténnien de Kabylie": Bull. Soc. Géol. France, vol. xxv (1897), pp. 518–521 and plate.

[2] Plate VII will appear with the second part of paper in the March Number.

(1) The Cretaceous limestones of Abu Roash.
(2) A series of Pleistocene reefs on both shores of the Gulf of Suez, of which the corals have solely Red Sea affinities, and show no greater trace of the influence of intermixture with the Mediterranean fauna than is shown by the living corals of the Red Sea.
(3) A series of older corals, which show some points of resemblance to the existing Red Sea coral fauna, but are decidedly of pre-Pleistocene age; but as the sections of some of these corals were not ready when my preliminary report was closed, I could not express a final conclusion as to whether they were of Miocene or Pliocene age.

The completion of this report was sadly delayed, owing to the heavy pressure of work in Australia; and I am very grateful to Captain Lyons, the Director of the Egyptian Survey, for the consideration with which he has allowed me to retain the material for so long.

The full examination of the material, with the aid of sections, confirms the opinion formed from my preliminary inspection. The bulk of the material is of Pleistocene, and apparently late Pleistocene age. This conclusion is in agreement with Mr. R. B. Newton's long list of fossil mollusca from the same localities. The specimens from Jebel Mellaha, and most of those from Abu Sha'ar, are Miocene; but one specimen reported as from Abu Sha'ar appears indistinguishable from a living variety of a Red Sea species —*Acanthastræa hirsuta*, var. *megalostoma*, Klunz. This specimen was the first from Abu Sha'ar which I had examined, and thus I was first led to the view that the limestones of that locality were Pleistocene. But when sections of the other specimens from that locality were available, they all proved to be of Miocene age. Either this one species has an abnormally long life or there is some error in the localization of the specimen.

The Miocene coral fauna resembles that of the Miocene of the Mediterranean and of Sind, and it lacks several of the commonest of the modern genera of Red Sea corals, e.g. *Madrepora* and *Stylophora*.

The geology of the area is described in Messrs. Hume & Barron's valuable memoir, "Topography and Geology of the Eastern Desert of Egypt" (Cairo, 1902).

A previous collection was described in the Geol. Mag., Dec. IV, Vol. V, 1898, pp. 241–251, Pls. VIII and IX.

I. CRETACEOUS.

Smilotrochus (?) sp.

There is one specimen (No. 3795) from the eastern end of the Abu Roash village, which appears to me to belong to this genus, but I cannot recognize the septal structure, as the specimen has been so greatly altered; the chances that a thin slice would show the internal characters do not seem to me to justify the injury that would be caused to the specimen. It is figured (Pl. VI, Fig. 1) in the hope of the discovery of fresh material.

II. MIOCENE.

FAVIA, Oken, 1815.

Favia humei, n.sp. (Pl. VI, Fig. 2.)

Diagnosis.—Corallum massive; surface subplane. Compact and dense in texture, with the exotheca well developed in horizontal, platform-like layers.

Corallites mostly elliptical and deformed; rarely circular. Their diameter is small. Corallites crowded, but the calicular edges are separated by well-marked furrows, 1–1½ mm. across.

Septa, 3 complete cycles; an incomplete fourth cycle may be present. Paliform lobes indistinct.

Calices shallow.

Dimensions.—The fragment of corallum measures:—

Length	80 mm.
Width	56 ,,
Thickness	45 ,,

Corallites:—

Diameter ... ... 3 or 4 mm. wide, by 4½ mm. long.

Calicinal centres:—

Distance ... ... 5–6 mm.

Distribution. — Miocene. From Reef No. 2, plateau between Camps 27 and 28, Wadi Belih, Abu Sha'ar. Collected by Mr. T. Barron, H 1780.

Figures.—Pl. VI, Fig. 2, part of the surface of the corallum, by 1½ diameter.

Affinities.—This species is easily distinguished from those that most nearly resemble it, by the small size of the corallites. Its nearest ally seems to me to be *F. savignyi*, Ed. & H.,[1] in which the calices are 12–15 mm. wide and 4–5 mm. deep.

Favia corollaris (Reuss)[2] has corallites from 7 to 8·5 mm. in diameter, and they are more constantly circular in form.

ORBICELLA, Dana, 1848.

1. Orbicella mellahica,[3] n.sp. (Pl. VI, Figs. 3 and 4.)

Diagnosis.—Corallum large, massive, with subplane upper surface, which is ornamented by the slightly raised calicinal borders; by the long and often confluent costæ, between which are occasional large granules.

Corallites long, circular, or elliptical; diameter from 4–5 mm. Walls of medium strength, being about half a millimetre in thickness. Calices very shallow in well-preserved corallites; borders low. Septa 3 cycles, with an occasional rudimentary septum of a fourth cycle in the largest corallites. In larger corallites, with the best

[1] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 437.

[2] Von Reuss, Kor. ost. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi (1872), p. 238, pl. xii, fig. 3.

[3] After Jebel Mellaha, the locality of the type-specimen.

developed columella, the septa of the first and second cycles reach the columella. Exotheca coarsely vesicular, abundant.

Columella well developed.

Dimensions :—

	Type-specimen (a fragment of a much larger mass) H 1862.		H 1856.
Length	128 mm.	...	155 mm.
Width	75 ,,	...	120 ,,
Thickness	40 ,,	...	95 ,,
Corallites :—			
Diameter ...	4 mm., occasionally 5 ,,	...	4 ,,
Calicinal centres :—			
Distance ...	6–9 mm., average 7 ,,	...	5 and 7 mm.

Distribution.—Miocene. West flank of Jebel Mellaha, H 1862; H 1856. Reef No. 2, plateau between Camps 27 and 28, Wadi Belih, Abu Sha'ar, H 1818*b*. "Beach Plateau," Abu Sha'ar, H 1780*a*.

Figures.—Pl. VI, Fig. 3, part of the surface of H 1862, by $1\frac{1}{2}$ diam. Fig. 4, some corallites of H 1818*b*, by 2 diam.

Affinities.—This species is a typical *Orbicella* with corallites of medium size. It is nearest to *O. defrancei* (Ed. & H.)[1] from the Miocene of Bordeaux, Turin, and Asia Minor. But it differs as the corallites are much smaller, having an average of $4\frac{1}{4}$ mm. in diameter instead of 6–7 mm., and in most cases the corallites have only 3 cycles of septa. *O. defrancei* has a fourth cycle, sometimes incomplete; but *O. mellahica* has 3 cycles with an occasional corallite with a rudiment of the fourth. In *O. humphreysi*, Felix,[2] the diameter of the calices is only 2·5 to 3 mm.

It differs from *O. schweinfurthi*, Felix,[3] in the same characters as those whereby it differs from *O. defrancei.*

Of the three Miocene *Orbicellæ* from Sind described by Duncan, it is nearest to *O. digitata*, Dunc.,[4] which has smaller calices and a smaller columella, and an average distance between the calicinal centres of only 4 mm.

2. Orbicella schweinfurthi (Felix), 1884. (Pl. VI, Fig. 5.)

Heliastræa schweinfurthi, Felix, 1884, Kor. ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

Orbicella schweinfurthi, Gregory, 1898, Egypt. Foss. Madrep.: Geol. Mag., Dec. IV, Vol. V, p. 246, Pl. IX, Fig. 3.

Distribution.—Miocene: Wadi Ramlieh (Felix); north side of Jebel Attaka, near Suez (Gregory); west flank of Jebel Mellaha, H 1862; "Beach Plateau," Wadi Belih, H 1782; "Beach Plateau," Abu Sha'ar, H 1818.

[1] Edwards & Haime: Ann. Sci. nat., ser. iii, vol. xii (1850), p. 106; Hist. nat. Cor., vol. ii, p. 465.

[2] Felix, Stud. tert. und quart. Kor. ägypt. und Sinaihalbinsel: Zeit. deut. geol. Ges., vol. lvi (1904), p. 171, pl. x, fig. 2.

[3] Felix, Korallen ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

[4] P. M. Duncan, Mon. Foss. Corals and Alcyonaria of Sind: Pal. Ind., ser. xiv (1880), pp. 90–91, pl. xxi, figs. 7–8.

Figure.—Pl. VI, Fig. 5, a few corallites of H 1862, nat. size.

This species is a very close ally of *O. defrancei* (Ed. & H.), from which it differs by the walls of the corallites being thinner, and by having some of the exothecal dissepiments arranged concentrically like a second wall, as shown in a figure (Geol. Mag., 1898, Pl. IX, Fig. 3). This feature is well shown among the present collection by specimen No. H 1862, of which the corallites are figured on Pl. VI, Fig. 5.

3. Orbicella defrancei (Edwards & Haime), 1850. (Pl. VI, Fig. 6.)

Astrea defrancei, Edwards & Haime, 1850: Ann. Sci. nat., ser. iii, vol. xii, p. 106.
Heliastrea defrancei, Edwards & Haime, 1857: Hist. nat. Cor., vol. ii, p. 465.
Heliastrea defrancei, Von Reuss, 1872, Kor. öst. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi, p. 239, pl. ix, fig. 3; pl. x, fig. 1.
Orbicella cf. *defrancei*, Felix, 1904, Tert. quart. Kor. ägypt.: Zeit. deut. geol. Ges., vol. lvi, p. 172.

Distribution.—Miocene. France, Italy, Austria, Crete, and Asia Minor. Egypt, west flank of Jebel Mellaha, H 1862*b*; Abu Sha'ar, H 1768. East of Cairo (Felix).

Figures.—Pl. VI, Fig. 6, a few corallites from a transverse section, by 1½ diameter. These show the relation of the species to its ally *O. schweinfurthi.*

SOLENASTRÆA (Edwards & Haime), 1848.

Solenastræa elliptica, n.sp. (Pl. VII, Fig. 11.)

Corallum large, massive; the corallites are long and cylindrical. Corallites extremely crowded. They are elliptical in section, separated by a narrow band of cellular exotheca, while on the surface the walls sometimes appear confluent. Calicular edges only slightly raised.

Septa, three complete cycles, of which the primary and secondary are subequal in size.

Columella very imperfectly developed; rudimentary in many corallites.

Dimensions.—The specimen is a fragment:—

Length	110 mm.
Width	82 ,,
Thickness	115 ,,
Corallites:	
Diameter	2 mm. by 1·25 ,,
Calicinal centres:	
Distance	2–3 ,,

Figures.—Pl. VII, Fig. 11*a*, part of the surface, by 2 diam.; Fig. 11*b*, part of a transverse section, by 4 diam.

Distribution.—Miocene: Abu Sha'ar, H 1818*a*.

Affinities.—This agrees very closely with *S. chalcidicum* (Forsk.) in the size of its corallites, the subequal size of the primary and secondary septa, and rudimentary development of the columella. It differs by the elliptical shape of the corallites, and the fact that the septa are larger and more conspicuous on the surface, and the edges of the calices are less raised. It is allied to *S. turonensis* (Mich.),[1] from the Miocene of Turin, but that has rounded corallites. It differs markedly from *S. tenera* (Reuss),[2] its nearest ally in the Austrian Miocene, owing to the much greater distance between the corallites in that species; they are also more circular. I feel doubtful whether this species is not merely an elliptical variety of the recent Red Sea species, *S. chalcidicum* (Forsk.), of which a specimen from the raised reefs of Qosseir is shown on Pl. VII, Fig. 12. *S. anomala*, Felix,[3] from east of Cairo has round and crowded calices.

STYLINA, Lamarck, 1816.

Stylina tetramera, n.sp. (Pl. VI, Fig. 7.)

Corallum massive; upper surface subplane.

Corallites long and narrow; generally round and oval; crowded. The walls on the surface occur sometimes as sharp ridges, while in other parts they are separated by narrow depressions. Sections in the interior of the corallum show that the corallites are nearly always separated by interspaces crossed by some of the costæ.

Calices very deep.

Septa irregular; those of the first cycle very distinct; one series of septa is much more conspicuous than the other; and as this series often consists only of 4 or 5 septa, some corallites have a tetrameral aspect. This structure is less often noticed in sections through the interior of the corallum. There are two complete cycles, and the third cycle is usually incomplete.

Columella irregular. Seen from above it is conspicuous and joined to the 4, 5, or 6 largest septa, and it often projects into the calice as if it were styliform. Sections show that its structure is less regular; but a central styliform columella is often recognizable.

Dimensions.—Corallum :—

Length	160 mm.
Width	78 ,,
Thickness	80 ,,

Corallites :

Average diameter	3 by 2 ,,

Calicinal centre :

Average distance	3 ,,

Distribution.—Miocene: Plateau, Abu Sha'ar, H 1818.

Figures.—Pl. VI, Fig. 7, part of the surface of the corallum, by 2 diam.

Affinities.—This species is one of those that serve to link *Stylina* to the Orbicelloids, as it is in all respects a *Stylina* except that the columella shows a tendency to become trabecular.

[1] Michelin: Icon. Zooph., p. 312, pl. lxxv, figs. 1–2.

[2] *Explanaria tenera*, Reuss: Polyp. Wien. Tert., 1847, p. 18, pl. iii, fig. 2. *Solenastræa tenera*, Reuss, Kor. öst. ung. Mioc.: Denk. Akad. Wiss. Wien, vol. xxxi (1872), p. 242, pl. vii, fig. 5.

[3] Felix, op. cit.: Zeit. deut. geol. Ges., vol. lvi (1904), p. 173, pl. x, fig. 3.

The tetrameral arrangement reminds me of *Stylina faujasi*, Ed. & H.,[1] but in that species the primary and secondary septa are equal.

LEPTASTRÆA, Edwards & Haime, 1848.

LEPTASTRÆA BARRONI, n.sp. (Pl. VI, Fig. 8.)

Diagnosis.—Corallum large and massive, with subplane upper surface; and the corallum is built up of long, narrow, cylindrical corallites; but on weathered edges, and in sections, it appears to be made of successive layers.

Corallites long and cylindrical; narrow; 2–3 mm. in diam., and often oval in section. On fresh surfaces the edges of the corallites are slightly raised. The walls, seen in section, are thin and connected by fine, vesicular exotheca. The corallites are close together, being separated by a very narrow band of exotheca, which is marked on the surface as a narrow groove around the calicular edges; but occasional calices are so crowded that the calicular edges are in contact.

Septa thin; they are long in the primary cycle; those of the secondary cycle may reach half-way to the axis, but in the interior they may reach the enlarged trabecular columella. The third cycle is little more than rudimentary. Primary septa exsert.

Columella appears as a small tubercle from the surface, but sections show that it is trabecular. It is of medium size, and then joins the two first cycles of septa.

Dimensions.—Corallum :—

Length	185 mm.
Width	155 ,,
Thickness	75 ,,

Corallites :—

Diameter	2–3 ,,

Calicinal centre :—

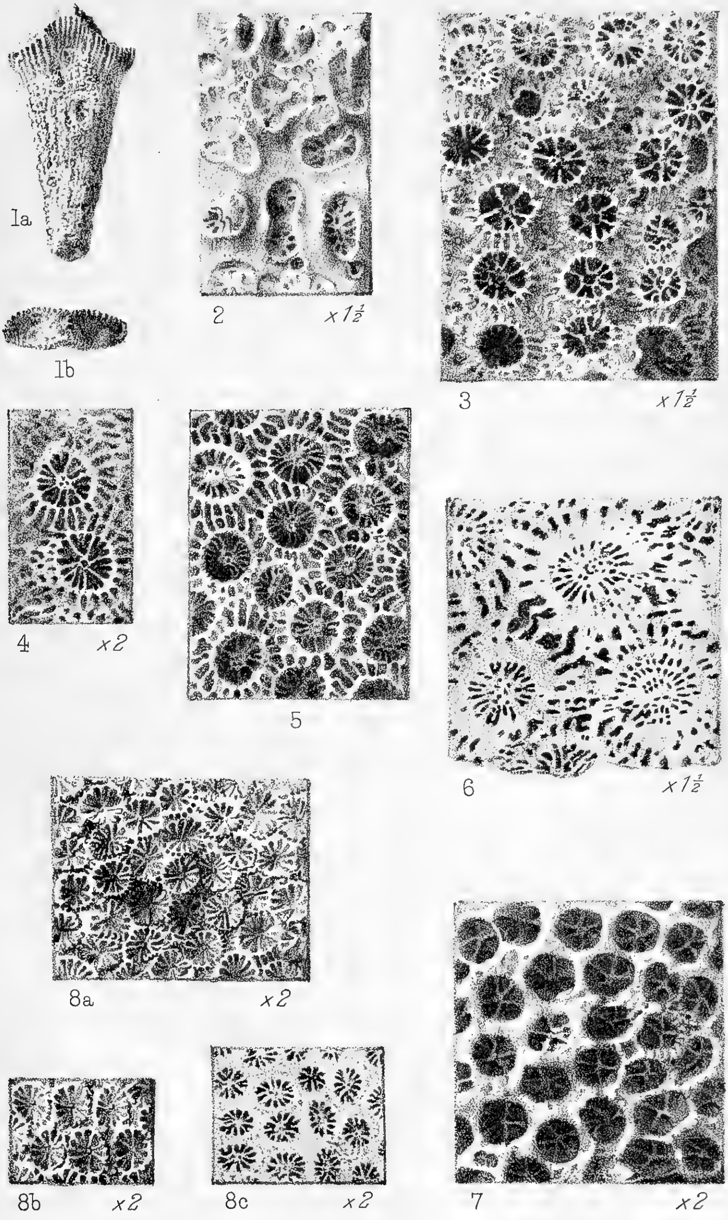
Average distance	3–3·5 ,,

Distribution.—Miocene: top of the Abu Sha'ar Plateau, west of the Red Sea, south-west of Jebel Zeit, H 1864.

Figures.—Pl. VI, Fig. 8*a*, part of surface, by 2 diam.; Fig. 8*b*, another part of the same specimen, by 2 diam.; Fig. 8*c*, section of interior of the same specimen, by 2 diam.

Affinities.—This coral is well preserved and its features are very distinct. The narrow diameter of its corallites gives it a close resemblance to *Plesiastræa*, but it has no pali. The coral which seems to be its nearest ally is the recent Red Sea coral, *Leptastræa bottai* (Ed. & H.),[2] which has a less conspicuous, less substyliform columella. *L. bottai*, moreover, may have a fourth cycle of septa, and its primary and secondary septa are described by Klunzinger as equal; and its corallites are from 3 to 4 mm. in diameter.

[1] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 243.
[2] Edwards & Haime: Hist. nat. Cor., vol. ii, p. 486, pl. D 7, fig. 1. Klunzinger: op. cit., pt. 3, p. 44, pl. v, fig. 9.



E. Drake del. et lith. West, Newman imp.

Fossil Corals from Eastern Egypt.
Fig. 1. Cretaceous. Figs 2–8 Miocene.

ACANTHASTRÆA, Edwards & Haime, 1848.

ACANTHASTRÆA HIRSUTA, Ed. & H., 1850, var. MEGALOSTOMA, Klunzinger.

Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 145; 1857, Hist. nat. Cor., vol. ii, p. 502, pl. D 5, fig. 4.
Klunzinger, 1879: Korallth. roth. Meer., pt. iii, p. 42, pl. v, figs. 1–2.

Distribution.—Recent: Red Sea and Indian Ocean. Fossil, Pleistocene: Egypt (*fide* Edwards & Haime). Miocene: "Beach Plateau," Abu Sha'ar, H 1812.

I can recognize no specific distinction between this coral and the recent species, and it even appears to be referable to one of Klunzinger's two varieties of the species.

STYLOCŒNIA, Edwards & Haime, 1848.

STYLOCŒNIA TUBERCULATA, n.sp. (Pl. VII, Figs. 9*a*, *b*.)

Diagnosis.—Corallum massive, nodular, contracted below to a subpedunculate form; upper surface convex and well rounded.

Corallites about 2·5 mm. in diameter, very crowded, separated by thin, well-raised walls, with the angles raised as short, blunt tubercles. The tubercles, however, are low, and not always present, so that parts of the surface appear like *Astrocœnia.* Corallites polygonal to circular. Calice shallow.

Columella conspicuous, styliform, sometimes laterally compressed. Septa, 3 cycles; those of the first and second cycles are equal and reach the columella; those of the third cycle are much smaller.

Dimensions.—Corallum:—

Length	61 mm.
Width	40 ,,
Thickness	50 ,,
Corallites:—	
Diameter	2–3 ,,
Columella:—	
Diameter	about ·5–·6 ,,
Calicinal centres:—	
Average distance	3 ,,

Distribution.—Miocene: on plateau, 1,200 feet above sea-level, between Camps 27 and 28; Wadi Belih; eastern side of the Red Sea, to the south of Jebel Zeit. No. H 1814.

Figures.—Pl. VII, Fig. 9*a*, the corallum from the side, nat. size; Fig. 9*b*, part of the surface, by 2 diam.

Affinities.—In the absence of recorded species of *Stylocœnia* in Egypt it is natural first to compare this species with *Astrocœnia ægyptica*, Felix,[1] which appears to be a true *Astrocœnia.*

Its nearest ally appears to be *Stylocœnia vicaryi*, Haime, which has been well described and figured by Duncan[2]; his account shows

[1] J. Felix, Kor. ägypt. Tert.: Zeit. deut. geol. Ges., vol. xxxvi (1884), p. 438, pl. iv, figs. 5–6.

[2] P. M. Duncan: Mon. Foss. Corals and Alcyonaria of Sind, 1880, pp. 32–33, pl. xiii, figs. 4–7.

that the Indian coral has more rounded corallites, which are often separated by a well-marked furrow; the furrow is sometimes absent, and then the corallites become polygonal. The columella of *S. vicaryi* is also rounded.

PRIONASTRÆA, Edwards & Haime, 1848.

PRIONASTRÆA LYONSI, n.sp. (Pl. VII, Fig. 10.)

Diagnosis.—Corallum heavy, massive, with apparently subplane upper surface.

Calices apparently shallow.

Corallites large, average diameter of 16 mm.; polygonal and very crowded.

Septa coarse. An incomplete fourth cycle. Usually the primary and secondary cycles are united to the columella.

Columella large, but loosely trabecular, and not very well developed.

Walls inside the corallum are thin and inconspicuous.

Dimensions.—Corallum (fragment of a large corallum):—

	H 1814 A.	H 1812.
Length	110 mm.	120 mm.
Width	50 ,,	85 ,,
Thickness	75 ,,	130 ,,
Corallites:		
Diameter	16–17 ,,	
Calicinal centre:		
Distance	16–17 ,,	

Distribution.—Miocene: plateau, 1,200 feet above the sea, between Camps No. 27 and 28; Wadi Belih, H 1814*a*; plateau of Abu Sha'ar, H 1812.

Figures.—Pl. VII, Fig. 10*a*, part of worn surface of the corallum (of H 1814*a*) showing the rudimentary open columella, nat. size; Fig. 10*b*, part of thin section of the same specimen, nat. size.

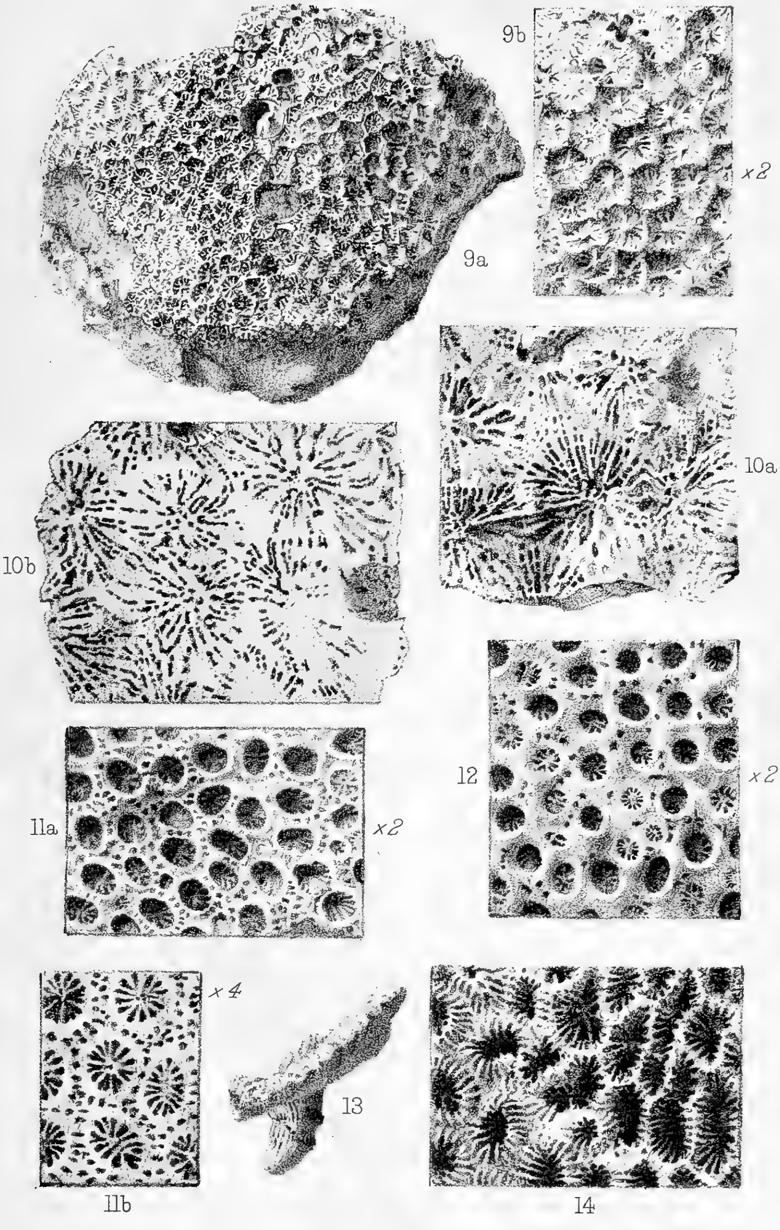
Affinities.—The two nearest allies of this species appear to be *P. irregularis* (Defr.),[1] from the Miocene of Dax and Turin, which has the same general characters and very thin walls. But that species differs in that its corallites are only 10 mm. in diameter, and its septa are described by Milne Edwards & Haime as very thin. The nearest ally of *P. lyonsi* among living corals is *P. australiensis* (Ed. & H.),[2] which has corallites only 10 mm. diam. *P. tesserifera* (Ehrb.)[3] is the nearest of the living Red Sea species, and has corallites of the same size; but it has much thinner septa, and larger, more compact columella.

[1] *Astrea irregularis*, Defrance: Dict. Sci. nat., vol. xlii (1826), p. 381. *Prionastræa irregularis*, Edwards & Haime, 1850; and 1857, Hist. nat. Cor., vol. ii, p. 522.

[2] Edwards & Haime, 1857: op. cit., p. 520.

[3] *Astrea tesserifera*, Ehrenberg, 1834, Beitr. Corallenth.: Abh. k. Akad. Wiss. Berlin für 1832, p. 321. See Klunzinger, 1879, pt. iii, p. 37, pl. iv, fig. 9.

(*To be concluded in our next Number.*)



E. Drake del. et lith. West, Newman imp.

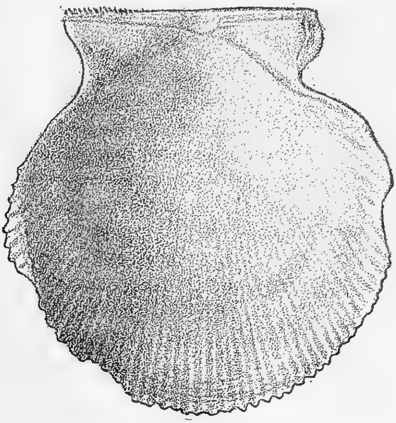
Fossil Corals from Eastern Egypt &c.
Figs. 9-11 Miocene. Figs. 12-14 Pleistocene.

III.—Note on the Characters of the Hinge Plate in *Aviculopecten semicostatus*, Portlock, sp.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

Mr. JOHN SMITH, of Kilwinning, has been fortunate enough to obtain from the Lower Limestone series of Auchenmade, Ayrshire, a specimen of the left valve of *Aviculopecten semicostatus*, Portlock, sp., which shows the hinge plate and interior most perfectly preserved. Hitherto a study of the hinge plate of *Aviculopecten* has been made from specimens which were merely casts of the interior, and consequently it has been impossible to observe that portion of the hinge plate immediately interior to the umbo. The Auchenmade specimen advances our knowledge of the anatomy of the genus, and establishes a character denied for it by its author, M'Coy.

We now know that *Aviculopecten* possessed a median cartilage pit, in the centre of the elongate, somewhat hollow, flattened hinge plate. The pit is comparatively large and transverse; the rest of the hinge plate is feebly striate longitudinally. Along the upper edge of the posterior part of the hinge-line is a row of erect tubercles.



Left valve of *Aviculopecten semicostatus*, Portl., sp., showing the hinge-plate and interior view of valve. Lower Limestone series, Auchenmade, Ayrshire.

The name *Aviculopecten* was given by M'Coy to those Palæozoic forms of *Pecten* in which the posterior ear was larger than the anterior, and the supposed absence of a mesial ligamentary pit in the hinge plate caused him to imagine that the affinity of the genus was structurally nearer to *Avicula* than *Pecten*. We now know that typical *Pecten* characters existed in Carboniferous times, and that *Aviculopecten*, as at present restricted, is very closely allied to *Pecten*, yet sufficiently distinct to merit a different generic name. M'Coy included *Pterinopecten* with *Aviculopecten*, but unfortunately we know very little about its hinge plate, only that of *P. rigidus* having been observed. There is no doubt of the propriety of Hall's subdivision of the Palæozoic Pectinidæ, one which I have adopted in my monograph on the British Carboniferous Lamellibranchs.

IV.—The Reptant Eleid Polyzoa.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

THE Eleidæ are a very natural family of extinct Polyzoa, remarkable for exhibiting characters relative to both the groups Cyclostomata and Cheilostomata. It is not, however, the affinities of this with other families that are here considered, but a means of determining by zoœcial characters the reptant 'species' within the group; the validity of the 'genera' forming it; the occurrence in England of one of the 'genera'—*Semimultelea*—hitherto unrecorded from Britain; the description of a new species of this 'genus'; and the phenomenon of local groups of zoœcia having characters differing from those of the rest of the zoarium.

The systematic position of the Eleids has been discussed by Gregory,[1] whose account of the group in the British Museum Catalogue this paper may be considered as summarising and as supplementing.

Before considering the points mentioned it will be convenient to tabulate the 'genera' of Eleids as at present established. As in the families of Cyclostomes, the Eleidæ fall into series founded on the habit of the whole colony (the zoarium). The general sequence is from single series of individuals to encrusting sheets, to foliate erect sheets, to erect cylindrical branches. The following table shows this sequence in the Eleidæ and in two families of Cyclostomes[2]:—

	Tubuliporidæ.	Clausidæ.	Eleidæ.	
			No avicularia.	With avicularia.
1. Encrusting zoarium composed of uniserial rows of individuals (zoœcia).	*Stomatopora.*	×	×	×
2. Encrusting zoarium composed of biserial to pauciserial rows of zoœcia.	*Proboscina.*	×	×	×
3. Encrusting multiserial zoarium composed of sheets (laminæ) of zoœcia. Unilaminar.	*Berenicea.*	*Cryptoglena.*	*Reptelea.*	*Repto-ceritites.*
4. Encrusting zoarium of superimposed laminæ. Bilaminar-multilaminar.	*Repto-multisparsa.*	*Clausi-multelea.*	*Semi-multelea.*	*Repto-multelea.*
5. Erect bilaminar-multilaminar foliate zoarium.	*Diastopora.*	*Ditaxia.*	*Elea.*	×
6. Zoarium of unilaminar cylindrical branches.	*Entalophora.*	*Clausa.*	*Nodelea.*	*Meli-ceritites.*
7. Zoarium of multilaminar cylindrical branches.	×	*Multiclausa.*	*Multelea.*	*Inversaria.*

[1] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899).
[2] See also for a small table of this kind, Gregory, British Museum Catalogue of Jurassic Bryozoa, 1896, p. 29.

This table shows that the Eleid 'genera' fall into two groups, those with avicularia and those without them. The former series has no term corresponding with *Elea* in the other series, that is, no erect foliate 'genus.' Both series are wanting in the more primitive types of zoarium, those that are encrusting and consist of zoœcia arranged either in single series or two or three abreast.

I. The Determination of Species and the Morphology of the Zoœcium.

The individuals (zoœcia) of an Eleid colony, exclusive of gonœcia and of gonocysts, may be of three kinds—

1. Normal zoœcia.
2. Avicularia.
3. Closed zoœcia.

In half the 'genera' avicularia are absent. Closed zoœcia only differ from normal zoœcia in the possession of a calcareous covering to the apertures. Therefore, it is only by means of the normal zoœcia that the specific characters of the whole family can be brought into line. For this purpose the characters of the aperture appear most useful on account of their variety and the ease with which they can be seen. The shape of the zoœcia, the character of their boundaries, and the frequency or rarity of the apertures vary so much in a single zoarium that they are of little use as specific indices. In one species at least, *Semimultelea acupunctata* (Novak), the character of the punctation of the front wall is used. Consideration of this character in the Jurassic forms of *Stomatopora* has led the author to consider that it is of little practical use in specific determination, because it is only clearly shown under favourable conditions of preservation or of subsequent weathering.[1]

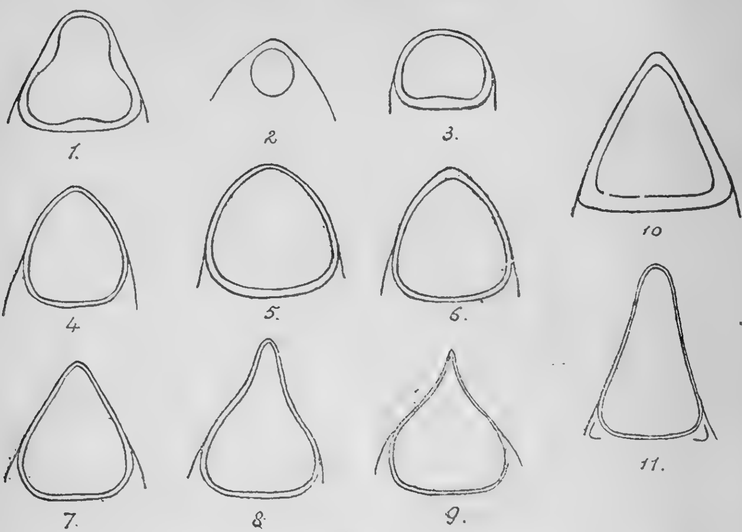
In some species the distal end of the zoœcium in the neighbourhood of the aperture is on the general level of the surrounding zoœcia. Such zoœcia are described as *immersed.* When the distal parts of the zoœcium rise above the general level of the surrounding zoœcia the zoœcium is said to be *emergent.*

The apertures in the various species differ in their actual size, the relation of their diameter to that of the zoœcia, their shape, and the nature of their border. In any given zoarium the shape of the apertures will vary considerably; for instance, from triangular with rounded angles to circular. Therefore, in determining a species, the shape of the majority of apertures must be taken, and if this is done the use of the table below should not prove difficult.

A triangular shape of aperture may be taken as morphologically typical of the family. This triangle may be equilateral; or isosceles with a small distal angle (Fig. 11); or the equilateral triangle may

[1] W. D. Lang: "Jurassic Forms of the 'genera' *Stomatopora* and *Proboscina*," Geol. Mag., 1904, p. 318; and "*Stomatopora antiqua*, Haime, and its related Liassic Forms," Geol. Mag., 1905, p. 258.

be modified and the distal angle be replaced by a sharp point (Fig. 9); again, the distal angle or the two proximal angles, or all three angles, may be rounded off (Fig. 10); and when this is extreme the aperture becomes subtriangular (Figs. 4, 5, and 6) and finally circular (Fig. 2). The extreme rounding of the distal angle only gives a semicircular aperture (Fig. 3). Finally, by the bulging inwards of the sides a triangular aperture becomes trifoliate (Fig. 1).



FIGS. 1–11.—Diagrammatic representations of the apertures of Eleids. (See explanation of figures at the end of the text, p. 68.)

The following table determines the species of the reptant Eleids regardless of zoarial characters. Species marked F occur abroad, those marked B in Britain. Of those marked M the British Museum has examples.

The two species placed in brackets are repetitions, put where they are in case variations in the shape of the aperture have caused specimens of these species to be misplaced in the first instance, when identified according to the table.

The character of the presence or absence of closed zoœcia is put in the table, although its value as a specific index is considered doubtful.

A. Apertures trifoliate. No closed zoœcia	*Reptelea ligeriensis* (d'Orbigny). F.
B. Apertures circular.	
a. Apertures about $\frac{1}{3}$ the diameter of the zoœcia. No closed zoœcia	*Reptelea pyriformis* (Michelin). F.
b. Apertures about $\frac{2}{3}$ the diameter of the zoœcia. No closed zoœcia	(*Reptoceritites Rowei*, Gregory. B, M.)
C. Apertures semicircular. No closed zoœcia	*Reptelea actæon* (d'Orbigny). F.

Characters	Species
D. Apertures subtriangular to nearly circular.	
a. Apertures large (about ·33 mm. diameter).	
α. Zoœcia immersed. Closed zoœcia numerous	*Semimultelea Dixoni*, n.sp. B, M.
β. Zoœcia emergent. No closed zoœcia ...	*Reptoceritites Rowei*, Gregory. B, M.
b. Apertures small (about ·16–·25 mm. diameter).	
α. Some apertures drawn out distally to a point; rim of apert. low, hardly thickened distally. Closed zoœcia numerous ...	(*Semimultelea acupunctata* (Novak). F, M.)
β. All apertures blunt distally, surrounded by a fairly high rim which is generally thickened distally. Closed zoœcia numerous	*Semimultelea irregularis*, d'Orbigny. B, F, M. *Reptelea pulchella*, d'Orbigny. F, M.
E. Apertures triangular.	
a. Apertures equilateral triangles, with the distal angle produced to a point. Closed zoœcia numerous	*Reptomultelea sarissata*, Gregory. B, M.
b. Apertures isosceles triangles, with small distal angle. Closed zoœcia numerous	*Reptomultelea tuberosa*, d'Orbigny. B, F, M.
c. Apertures equilateral triangles, with the angles, especially the distal angle rounded. Rim thick and of equal thickness throughout. No closed zoœcia	*Reptomultelea Reussi* (Pergens). F.
d. Apertures equilateral triangles, with the angles rounded, the proximal angles more than the distal. Rim thick and of equal thickness throughout. No closed zoœcia	*Reptelea oceani* (d'Orbigny). F, M.
e. Apertures equilateral triangles, with the angles rounded, but some are drawn out distally. Closed zoœcia numerous	*Semimultelea acupunctata* (Novak). F, M.

In the above table the following species mentioned in the British Museum Catalogue have been omitted :—

1. *Reptelea* (?) *parasitica* (von Hagenow). The specimens referred by Gregory to this species are indeterminable worn fragments. Von Hagenow's[1] and d'Orbigny's[2] figures are also of specimens too worn for reference to any species.

2. *Semimultelea cupula*, d'Orbigny. This, if an Eleid, is not a reptant form.

3. *Semimultelea cenomana* (d'Orbigny). Judging from d'Orbigny's figure,[3] this is a Cheilostome.

The synonymy of the group is given in full in the British Museum Catalogue.

II. British Specimens of the 'genus' *Semimultelea*.

Semimultelea irregularis, d'Orbigny.

A specimen (D 7274) in the British Museum collection, with no information attached, exhibits the zoœcial characters of *Semimultelea irregularis*, d'Orbigny. The zoarium is a multilamellar incrustation whose upper surface is locally raised into knobs. These suggest

[1] Von Hagenow, 1846: Geinitz, "Grundriss der Versteinerungs kunde," pl. xxiii *b*, fig. 7.

[2] D'Orbigny, 1853–1854: Paléontologie Française, Terrains Crétacés, vol. v, pl. 787, figs. 17–20.

[3] D'Orbigny: loc. cit., pl. 788, fig. 3.

the beginnings of cylindrical branches which, if present, would link this form with the 'genus' *Nodelea.*

The pieces of matrix adhering to the fossil are a greensand resembling that of Warminster, and the state of preservation of the fossil resembles that of specimens of polyzoa from that place. The probability, then, of the specimen being of Cenomanian age from the Upper Greensand of Warminster is sufficient to warrant the record of its occurrence.

Semimultelea Dixoni,[1] sp. nov. (Figs. 4, 12.)

A specimen of an Eleid (B.M. D 7845), found by Messrs. C. P. Chatwin and T. H. Withers, and presented by them to the British Museum in October, 1905, exhibits the zoarial characters of the 'genus' *Semimultelea.* It is an incrustation of two or three superimposed laminæ; there are no avicularia. It differs from all the

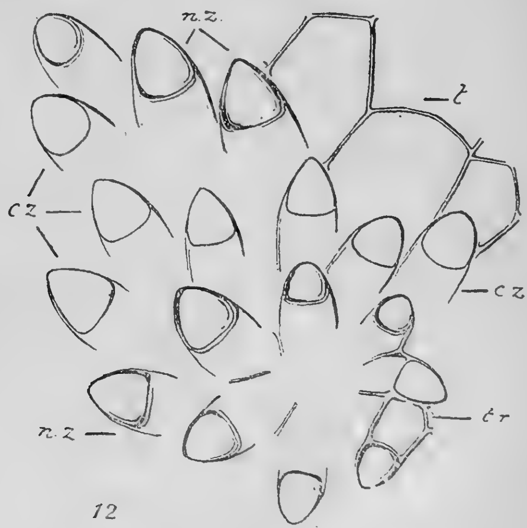


Fig. 12.—Part of the zoarium of the type-specimen of *Semimultelea Dixoni,* sp. nov. (See explanation of figure at the end of the text, p. 68.)

other species of *Semimultelea* in the great size of its apertures, which are about ·33 mm. in diameter. The apertures are subtriangular to nearly circular, resembling in this respect those of *S. irregularis,* d'Orbigny. The aperture is surrounded by a low, rather thin rim, which is not (as in the species just mentioned) thickened distally. Numerous closed zoœcia occur. The apertures are very irregularly distributed, being generally frequent, but rarer in some places. In some parts of the zoarium the zoœcia are

[1] After Frederic Dixon, author of "The Geology of Sussex." Dixon's collection, acquired by the British Museum in 1850, contains many type-specimens of Chalk Polyzoa.

separated by thin, low ridges. They are immersed in the zoarium. Occasionally parts of the zoarium occur, free from apertures, but divided into irregular polygonal areas by thin, low ridges (see Fig. 12).

That species of reptant Eleid which this form most resembles is *Reptoceritites Rowei*, Gregory, from the Lower Senonian of Chatham. The three obvious points of difference are: (1) *R. Rowei* has an unilaminar zoarium; (2) it has avicularia; (3) it has no closed zooecia. The systematic value of these points will be discussed later. On the strength of the first two it is placed in the genus *Reptoceritites*. The chief zooecial difference between the two species lies in the fact that the zooecia of *Semimultelea Dixoni* are immersed, while those of *Reptoceritites Rowei* are very emergent. The specimen was obtained from the Lower Senonian, zone of *Micraster cor-testudinarium*, from the chalk-pit opposite the Rose and Crown Inn, Kenley, south of Croydon, Surrey. The pit is No. 32 of Dibley [1] and No. 113 of Young.[2]

III. The Validity of the 'Genera.'

The table given on pp. 62–3 shows the principles on which the Eleid genera are at present based. Nor are those principles confined to the Eleidæ; they are fundamental in all the families of Cyclostomata. If the systematic arrangement of forms is to be finally established on an evolutionary basis, and the term 'genus' to be used to include those species whose nearest common ancestor differed from that of another group of species, the 'genera' as at present established in the Cyclostomes and Eleids are obviously artificial, for they represent groups of species of various genera in the same stage of phylogeny, and are such as would be the case if, for instance, a given genus of Ammonites included all forms with a keel. Gregory [3] has realised how artificial are the 'genera' in the Cyclostomes, but advocates their retention on the plea that they are "convenient" though "artificial groups of species." But he evidently did not allow that the phylogeny of the group could be found in the astogeny [4] of the colony, for he claims that the Bradford Clay Bereniceas were the direct descendants of the Great Oolite Diastoporas. If once the astogenetic principle is granted the task of establishing new genera, though one requiring much material collected rigidly according to exact horizon, is not as hopeless as he describes; still less in the Eleids where more zooecial characters are available than in the Cyclostomes.

On reference to the table on pp. 62–3, which gives the specific distinctions in this family, it will be noticed that in regard to

[1] G. E. Dibley, "Zonal Features of the Chalk Pits": Geol. Assoc. Proc., vol. xvi, pt. 9 (1900), pp. 490–491.

[2] G. W. Young, "The Chalk Area of North-East Surrey": Geol. Assoc. Proc. (1905), p. 206.

[3] J. W. Gregory: British Museum Catalogue of Jurassic Polyzoa, 1896, pp. 14–22.

[4] Cumings' term for the ontogeny of a colony. See E. R. Cumings, "Development of *Fenestella*": Amer. Journ. Sci., vol. xx (1905), footnote to p. 169. In a colonial organism like a Polyzoan, three developments have to be considered: (1) ontogeny, the development of the individual; (2) astogeny, the development of the colony; (3) phylogeny, the development of the race.

zoœcial characters the two species *Semimultelea irregularis*, d'Orbigny, and *Reptelea pulchella*, d'Orbigny, appear inseparable. This conclusion has been reached after the examination of specimens in the British Museum collection referred by Gregory to these two species. Nor can they be distinguished zoœcially by the diagnoses given in the British Museum Catalogue. It seems, therefore, that here are two species of one genus—the more primitive possessing a zoarium which, when adult, consists of an encrusting unilaminar sheet of zoœcia; the other, whose adult zoarium is in a more advanced stage, namely, bi- or paucilaminar, passing through an immature unilaminar stage corresponding with that of the adult of the more primitive species.

Reptomultelea Rowei, Gregory, and *Semimultelea Dixoni*, Lang, are another pair of species approximating in zoœcial characters, and differing chiefly from the two preceding species in the size of the apertures. These four species appear to be more nearly related to each other than to any other reptant forms, and possibly form a single genus. Similarly, the species or groups of species marked A, B, C, and E possibly indicate so many different genera. But before more certain conclusions can be formed the erect forms will have to be considered, more specimens must be forthcoming, and especially must the various stages in the life-history of the zoaria of different species be examined. As the facts stand it seems probable that zoœcial characters rather bear generic and zoarial specific significance. Such a general law, however, must not be applied blindly, but always with regard to its bearing upon evolutionary series; and the test for a common genus among several species exhibiting similar zoœcial characters must be the identity of developmental stages in zoarial growth.

IV. Topomorphs.[1]

In the discussion above on generic and specific determination, two characters have been disregarded — the presence or absence of avicularia and of closed zoœcia.

Scattered irregularly among the normal zoœcia of the reptant 'genera' *Reptoceritites* and *Reptomultelea* are individuals of extraordinary shape, generally having the distal portions of the aperture drawn out to form a long tongue. Such individuals have been considered the homologues of avicularia in Cheilostomes, whose function is regarded as protective. The nature of the Eleid avicularia is fully discussed in the British Museum Catalogue.[2] Whatever their physiological significance, the morphological fact remains that their distribution is irregular. Never very frequent, they are often so rare that large portions of the zoarium are free from them. For instance, from the large zoarium of the figured specimen of

[1] ὁ τόπος, 'the place,' and ἡ μορφή, 'the form.'

[2] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899), pp. 287–288, where references to other writings are given, of which that by A. W. Waters, "Chilostomatous Characters in Melicertitidæ" (Ann. Mag. Nat. Hist., ser. VI, vol. viii, 1891, pp. 48–53), should be read in this connection.

Reptomultelea tuberosa, d'Orbigny (B.M. 36,746), pieces of some size containing no avicularia might be broken, which, if found in the first instance, would have been placed in the 'genus' *Semimultelea*. Unless, therefore, a given zoarium is known to be complete, which is not often the case, there is no means of knowing whether, although no avicularia are seen, they did not occur in the lost portions, because their distribution is rare and irregular, and their presence or absence has not been discovered to be correlated with any other structure.

The distribution of closed zoœcia is not generally sporadic like that of avicularia, but when one occurs others are associated with it, often in the same numbers as the normal zoœcia, generally more frequently, and often forming an area composed of closed zoœcia only. Like the avicularia their physiological significance is a matter of conjecture,[1] nor does the study of the rest of the zoœcia interpret their apparently irregular distribution.

In his diagnosis of *Semimultelea irregularis*, d'Orbigny, Gregory remarks that the zoœcia are "separated by ridges." This is very clearly shown in most of the zoarium of the specimen B.M. D 4867, but not so clearly, if at all, in other parts, and not at all in specimens B.M. D 4818 and D 4843. Again, Gregory cites this character as sometimes occurring in *Reptelea pulchella*, d'Orbigny. Forms possessing it he calls var. *plana*. The character again occurs in parts of the zoarium of the type-specimen of *Semimultelea Dixoni*, Lang (B.M. D 7845). It may be said, therefore, that ridges between the zoœcia occur as a character in various forms of reptant Eleids, in scattered parts of the zoarium; and that the distribution of these areas is determined by unknown conditions.

Parts of the zoarium containing abnormal zoœcia may be found outside the Eleids. The linear arrangement of apertures is specifically distinctive of *Proboscina radiolitorum* (d'Orbigny). But parts of the zoarium are liable to occur in which the arrangement of apertures is irregular. A case of this (specimen D 975) is figured in the British Museum Catalogue.[2]

In the Cretaceous forms of the genus *Membranipora*, a Cheilostome, the shape of the aperture is seen to vary in the same species. In some instances this variation is clearly connected with Astogeny; the different shapes are growth stages. For example, a very general sequence is as follows:—The first formed zoœcia have circular apertures, and approaching the distal parts of the zoarium the shape of the aperture changes to oval, to ovate to very long oval, nearly elliptical[3]; and katagenetic stages are shown. But besides this zoœcia are often found whose apertures are of a shape differing from those in their immediate neighbourhood.

Instances might be multiplied, but enough have been cited to

[1] J. W. Gregory: British Museum Catalogue of Cretaceous Bryozoa, vol. i (1899), p. 290.

[2] British Museum Catalogue of Cretaceous Polyzoa, vol. i (1899), p. 50, text-fig. 1.

[3] These terms are used with their botanical significance, as defined, for instance, by Asa Gray, "Structural Botany," 1879, p. 95.

show that this phenomenon of isolated patches of abnormal zoœcia occurs commonly among Polyzoa. And for these local forms I propose the name *Topomorph*, a purely morphological term, describing any part of the zoarium in which the zoœcia differ from those of the rest of the zoarium. Thus it includes, for instance, growth stages, "localised stages,"[1] peculiar forms due to external conditions such as overcrowding or a different food supply, to possible intermittent or seasonal causes such as reproductive activity. The characteristic of the term is its freedom from physiological implication, and herein lies its value, for it can be used in morphological descriptions before the origin or use of the described parts is known. Whereas the terms variety (as in the case of var. *plana* above), stage, etc., imply systematic or developmental relations which on further investigation may or may not be found to hold; and the term 'form' (as, for instance, *Sparsicavea carantina*, d'Orbigny, form *franquana*) is far too useful and too widely used as a general term applicable to zoœcium, zoarium, or parts of a zoarium, and to members of other groups of organisms, to be limited by a technical and special significance. To describe a part of a zoarium of a species of *Membranipora* in which the apertures were ovate as a topomorph of species *x*, and to describe it again as a growth stage of the species, because it has been discovered that a stage with circular apertures always precedes and one with elliptical apertures always succeeds it, implies no incongruity nor contradiction, because the first is a morphological term describing structure, and the second a physiological term describing the behaviour of the species.

It is hoped that this paper, though adding little to what is already known about the Eleids, may be of some use to the collector in helping him determine the species by presenting them in a tabular arrangement, that the occurrence of forms new to England may stimulate further collecting, and that the suggestions concerning generic distinctions may place in a more hopeful light the ultimate discovery of the evolution within the group and of the true relations of its members among themselves.

EXPLANATION OF FIGURES IN TEXT.

FIGS. 1–11.—Diagrammatic representations of apertures of Eleids.

All the figures are very much enlarged, but their sizes are not comparative.

FIG. 1. Aperture of *Reptelea ligeriensis* (d'Orbigny). After d'Orbigny.
,, 2. Aperture of *Reptelea pyriformis* (Michelin). After Michelin.
,, 3. Aperture of *Reptelea actæon* (d'Orbigny). After d'Orbigny.
,, 4. Aperture of *Semimultelea Dixoni*, n.sp. From the type-specimen (B.M. D 7845).
,, 5. Aperture of *Reptoceritites Rowei*, Gregory. From the type-specimen (B.M. D 4244).
,, 6. Aperture of *Semimultelea irregularis*, d'Orbigny. From the specimen B.M. D 4867.

[1] I.e. local recapitulations. See R. T. Jackson, "Localised Stages in Development": Mem. Boston Soc. Nat. Hist., vol. v, No. 4 (1899), pp. 92, 139, 141. See also W. D. Lang, "*Stomatopora antiqua*, Haime": GEOL. MAG., 1905, pp. 259, 260.

FIG. 7. Aperture of *Semimultelea acupunctata* (Novak). After Novak.
,, 8. Ditto.
,, 9. Aperture of *Reptomultelea sarissata*, Gregory. From the type-specimen (B.M. D 7106).
,, 10. Aperture of *Reptomultelea Reussi* (Pergens). After Pergens. Other zoœcia in Pergens' figure have a much more rounded distal angle.
,, 11. Aperture of *Reptomultelea tuberosa*, d'Orbigny. From the specimen B.M. 36,746.
,, 12. Part of the zoarium of the type-specimen of *Semimultelea Dixoni*, n.sp. (B.M. D 7845), showing normal zoœcia (*n.z.*); closed zoœcia (*c.z.*); a topomorph with ridges between the zoœcia (*t.r.*); and a topomorph composed of areas marked out on the zoarium by raised ridges, but with no closed or open apertures (*t.*). × about 24. Somewhat diagrammatic.

V.—MACHINE-MADE IMPLEMENTS.

By F. J. BENNETT, F.G.S.

ATTENTION has lately been called by M. Marcellin Boule to the production in cement-mills in the Commune of Guerville, near Mantes, of all the more characteristic forms of Eoliths, and of these he has given photographic reproductions. The evidence for the necessarily artificial shaping of Eoliths had for many years been questioned by him, because he had found chipped flints of this character in the midst of Oligocene or Miocene beds in Auvergne and in the Velay; and it seemed imprudent to infer the existence of man in those early stages of the Tertiary period in the absence of osteological evidence.

In speaking here of machine-made implements I do so advisedly, because all stone implements were once referred to natural or supernatural causes; the obvious arrow-head, for instance, being termed an 'elf-bolt.'

M. Boule, however, seeks only to show that stones shaped like Eoliths may be produced by Nature, because he finds that they are produced by certain pseudo-natural, machine-made torrents, and so considers that Eoliths are due to such torrential action. Yet the Eolithic deposits known to the writer do not seem to indicate torrential action.

The first objection is that M. Boule compares known and unnatural agencies with natural ones, and the analogue of his machine-made torrent would be hard to find in Nature and would be most exceptional there, and yet to this he would refer all Eoliths.[1] The Mantes wash-mill apparently deals only with flints fresh from the chalk, while the flints from which the Kent plateau Eoliths were made were mostly tough and much weathered, and not as a rule such flints from which good chipping can be obtained; and that may account a good deal for their rough execution, and for their non-acceptance by some observers.

Anyone who is a flint-knapper knows that the results obtained from the one kind of flint are very different from those obtained from the other, that the fracture varies with the flint, and that in

[1] *Nature*, Aug. 31, 1905, p. 438; Sept. 28, p. 538; and Oct. 26, p. 635; see also *L'Anthropologie*, vol. xvi, p. 257, in which the detailed observations of M. Boule are published.

some flints the human fracture is not distinguishable from the natural fracture.

The mill also rotates at a definite speed for a definite time, and so cannot compare with Nature. In order to get any results of value, the flints should be examined first, and samples taken out from time to time and compared, and yet the flints in question are only taken out after about 29 hours' interval.

There is another complication, which also seems to introduce a human element, if we may say so, in the case of the harrows with chain attachments, and these harrows in one of the mills visited by the writer were also weighted with old gear wheels, etc. So that, added to the impact of flint against flint, there is also a possible knapping action due to the teeth of the harrows and to the links of the chains, and these, in shape and possibly in effect, would compare with the pebbles used in knapping; the teeth, too, of the old gear wheels may also be chipping agents. Hence it becomes more difficult to say by which of these agencies, or by their combination, the fractures are produced. Thus any quasi-human results may be due to these quasi-human agencies introduced.

It is also possible, if the area contains worked flints, that these may be introduced. And in the cases we have investigated such flints do occur in the area. The analogy also with Nature would be closer if the harrows, etc., could be removed and the flints subjected only to the torrential action of the water.

So much for some of the objections. I will now give some account of the observations I have just made at certain wash-mills in Kent. These mills are confined to brickyards. The results are found to vary with the kind of flint, with that of the matrix, and with the proportion of this to the flints and to their size. I will take the mills as I observed them, but the washing process was not then in operation in any one of them.

The first was that at Pascall's Kiln, at Platt, near Wrotham, Kent. There, resting irregularly on the Gault, is an angular white flint gravel much weathered, together with some much worn flints. At another part of the brickyard is a sandy loam with some blocks of sandstone and a few small scattered flints, and this seemed to be washed together with the Gault, as the wash-heap also contained sand and rounded lumps of sandstone.

The small angular flints were not affected at all by the milling action, and the other flints only slightly so. Samples of all those that were at all like implements were taken, and most of those were Eolithic in form merely, and photographs of these would pass as good Eoliths, but some of rude palæolithic form were also found. The flint being of a coarse and cherty nature, the 'work' was rough in accordance with this material.

On two of the specimens the writer, who can knap so that he can deceive an expert, and can treat the chipped flint so as to remove the new look, tried his hand, and chipped and bruised and 'treated' (the work of a few minutes only) one side of each specimen, so successfully that there was no real difference between his side and the milled side. So that one side was possibly mill-made and the other certainly hand-made. This would seem to leave the case of the mill, in this instance, as non-proven, or rather in favour of man.

The other place visited was Temple Farm Brickyard, near Strood, Rochester. Here there are two wash-mills, a lower and an upper one, each with its refuse heap. Here the conditions in the one differed from those in the other, and so did the 'work' on the flints. At the lower brickyard is a long extended section of brickearth across the wide trumpet-mouthed opening of the valley. This shows 20 feet of clean sandy loam, laminated in places, and with occasional small seams of pellety chalk and very small angular flints and small pebbles. This loam is thinly capped by stony loam with some scattered flints, some angular and others more or less worn. The lower refuse heap was composed mostly of a mixture of fine flinty gravel with many small pebbles, and much pellety chalk and many lumps of 'ginger,' and very few large flints. Some of these, which were like those fresh from the chalk, were very little rolled or chipped, and the reason was plain, as they were contained in a matrix that kept them from contact with each other, and so their original condition was little affected.

The upper mill is higher up the valley; there the brickearth was dug in two places, one in a terrace on the valley side and the other in the bottom of the valley. That in the terrace showed six feet of stony loam resting on a marly, pellety chalk, with many large and mostly angular flints, little worn and like those fresh from the chalk; the other flints were much worn and weathered, with a few pebbles. The second section had fewer flints and was mostly in the pellety chalk. Thus this brickearth seems due to the decalcification of the chalky waste formed during the denudation of the stiffer and more stony loam in the upper, and the finer washed loam in the lower part of that valley. One great refuse heap at the upper mill was mostly composed of large flints, some of Eolithic form, but evidently shaped, as the old patina showed, before they entered the mill, while one or two were of palæolithic form and one neolithic. Here the chipping, rolling, and bruising due to the mill apparently, though slight, was much more noticeable than at the lower mill, as here there were so many more and larger flints to act on each other and to be acted on by the harrows, etc. A very good imitation of beach action was seen in the many rounded lumps of chalk, etc., from the loam in the large refuse heap.

All that the mill then seemed to have done was to round and bruise and re-chip in an irregular manner the sharper original edges, as offering the least resistance. Where old indentations occurred, it would seem that the teeth of the harrows had found these out, as they were re-touched in some cases and the old patina removed in places. Thus it would appear that the mill, like the sea, in the writer's opinion, rounds rather than shapes, and so deforms any flints that had been previously chipped into a definite shape.

Though he has not visited any chalk wash-mills, the writer has seen some flints from one near Sevenoaks, and these were thin pieces of flint irregularly chipped at the edges, but not apparently 'formed' in any definite way.

In chalk wash-mills, as in the examples mentioned, much must depend on the proportion of the flints to the mass of the chalk and on their size, as the more numerous and the larger the flints, the more will they be affected, and *vice versâ*. Thus the power of the mill, as able to shape Eolithic flints, must, in the cases observed by me, be considered as non-proven.

The difficulty of the whole question consists in this, that we are trying to decide where no final decision seems possible. For those who hold that certain flints are due to natural causes have never seen, or can see, Nature doing what they would refer to Nature, and those who uphold the human origin of the flints could never, of course, have seen them actually made by man. But we have actual proof that man has and does fashion certain stone tools, and therefore have good reason for asserting that man did make some of these early tools, and we also know that man improves on his early work, so that the best forms of these cannot be man's earliest efforts. The difficulty always will lie in fixing the starting-point of his 'prentice hand.

The stages in the progression from the ruder to the more perfect forms were probably these. As soon as man found that some adjunct to the hand was needed in his conflict with Nature and the beasts, sticks, bones, shells, and stones were used. Of these, only stones, for the most part, have remained.

The stones, in the first instance, would be those best adapted to his needs, and were so selected. Next it might occur to him that he might imitate those *natural* forms: hence the difficulty to distinguish between the apparently natural forms and the possible artificial ones, both having only one sharp or sharpened edge. Then he would gradually learn so to adjust the angle of incidence as to extend the chipping all over the flint, and at last to select the kind of flint that gave the best results. The process must have been a gradual one, with intermediate stages, with reversions perhaps to older and ruder forms, and the difficulty will always lie in fixing the starting-point of the undoubted artificial stage, and I do not think that the wash-mill evidence will help to do this. But it may cause those who have been too ready to accept worked flints to be more careful in the future.

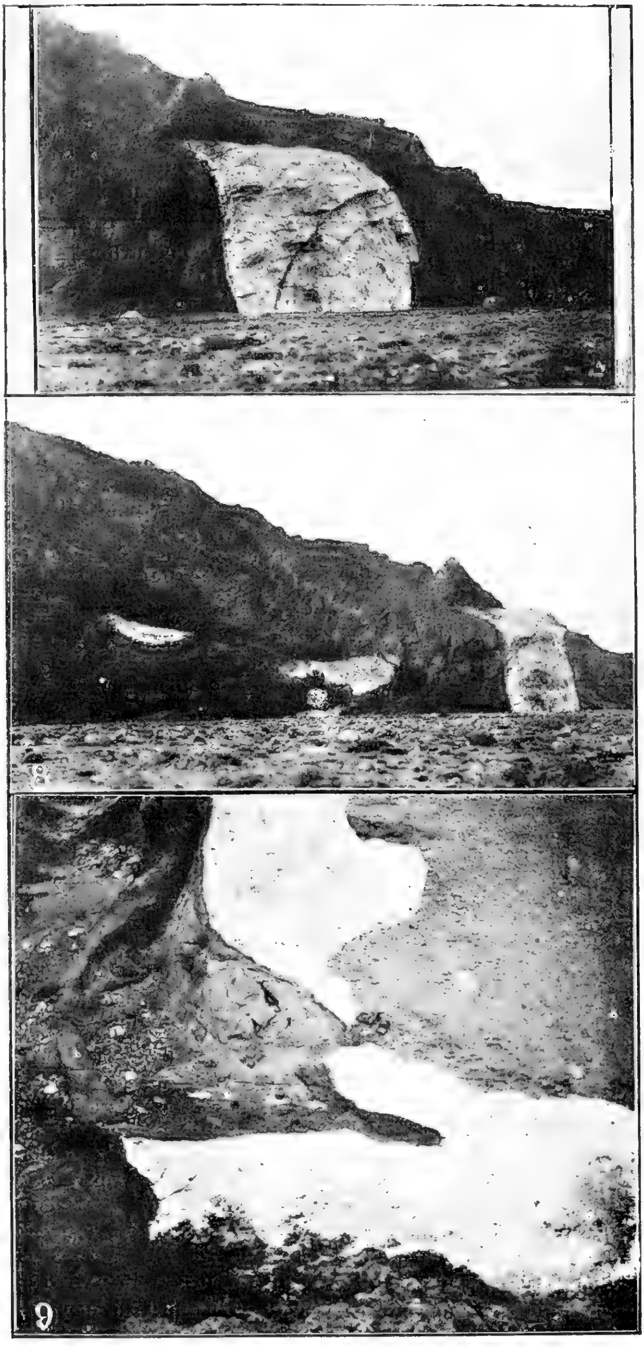
VI.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

By R. M. Brydone, F.G.S.

(PLATES IV AND V.)

(*Continued from the January Number, p. 22.*)

DOWNWASHED sand and mud much obscured the section, but the clay appeared to be definitely continuous, while the chalk might be continuous under the mask of mud, but did not seem likely to be so. The section suggested very strongly a flat sheet of clay



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.
(To illustrate Mr. R. M. Brydone's paper.)

pushed at a level some way below the beach against a backward sloping and then overarching surface (e.g. the side of a cave), which it had followed until doubled back upon itself.

The masses of chalk in the bay, where accessible, all showed *Ostrea lunata* chalk, except the stringer from the bluff. This was accessible from above, and was then composed solely of the grey chalk.

It was quite clear that the landward face of the bluff was not parallel to the coastline, but ran about east and west, the bluff being therefore a rude triangle with its apex towards the north. The landward face was covered by what appeared to be crushed blisters of finely laminated clay apparently formed round projections in the surface of the chalk.

In the Autumn of 1904 I got desperate at my inability to satisfactorily sketch the constant changes which were taking place, and borrowed a camera, and since that time I have a fairly continuous series of photographs, some of which are reproduced as Figs. 6 to 18 in the plates illustrating this article. Unfortunately I had had no previous experience of photography, and I have always chanced upon dull and cloudy weather, so that I may be forgiven for the imperfection of the photographs. As it is, they show far more than I ever dared to hope for. They are all, I think, self-explanatory except Fig. 9, which was taken from the summit of the bluff, and in which the boundaries between the grey chalk above and below and the *O. lunata* chalk between is traceable in the 'slope' (the nearer piece of chalk) by a slight variation in shade.

During the period covered by these photographs erosion has been very rapid at this point (the clay seen on the left hand of the bluff in Fig. 13 was faced with chalk of fair thickness six months previously) (Fig. 8), and several further points of interest have been disclosed. The most important is perhaps that shown in Figs. 10, 11, and 15. The cutting back of the main cliff has provided a section across what appears to be an erratic mass of rudely stratified flint shingle, varying from very coarse to fairly fine, with a bed of sand in the middle and a long thin slice of chalk at its left hand, the stratification being vertical. The slice of chalk, though nowhere more than two feet thick, contains both *O. lunata* chalk and grey chalk with an occasional grit seam at the base throughout the whole length I have been able to examine, the *O. lunata* chalk being next the clay which forms as it were the backing of the mass. The lower end of the chalk slice was recently exposed, and the clay was seen to run down beside it and then turn at right angles in under it (Fig. 15), with the banding parallel to the surface of the chalk, which seems inseparable from the junction of clay and chalk here. The whole thing very strongly suggests a piece of shingly beach set on end, the chalk representing the basement bed on which the shingle was heaped up. The rude stratification of the shingle is what might be expected from the sifting together of the pebbles of similar size which takes place in every beach, the coarsest part being that next the chalk. This huge mass of shingle, which can hardly have been transported from any distance, as it would not have held together, forms an interesting parallel to the masses of coarse shingle which lie on the top of the northern part of the south bluff as recorded in my previous pamphlet (see also Fig. 1 hereto).

Another point of interest is the behaviour of the grey bed in the seaward face of the bluff. As this was cut back the grey bed developed a deep pocket, shown just beginning in Fig. 7 and complete in Figs. 13 and 17, at the bottom of which the gritty basal seam thickened considerably and became exceptionally coarse. (It will be noticed in these figures that the two upper flint beds shown in fig. 1 of my previous pamphlet have become comparatively indistinct, while the third has become very marked. At the moment of writing the second is regaining its importance.) On the left-hand side of this pocket the base of the grey chalk rises very sharply, so that the chalk which strings out into the clay, thin as it is, becomes, as on the other side of the bluff, composed of a layer of *O. lunata* chalk below and a layer of grey chalk above. There is clearly at this point a very strongly marked unconformity between the two beds of chalk.

Another point is that *O. lunata* chalk has come in between the grey chalk and the clay in the cross section at the end of the north side of the grey chalk bay and at several other points in this mass where the grey chalk and clay were previously in contact, so that it seems fair to assume that the distance by which the grey chalk overlaps the *O. lunata* chalk is slight everywhere. Whenever the grey chalk has been removed from off the *O. lunata* chalk beneath it the latter has always presented a decidedly wave-worn and smoothed appearance.

This grey chalk, as before stated, presents some remarkable peculiarities besides its basement bed of grit with flint and chalk pebbles. It is very soft, but contains a great abundance of hardish lumps of varying shades of grey which are not clearly rolled, but have very smooth and suspicious outlines. These lumps are very similar in texture, and, so far as I know, identical in fossil contents with their grey matrix. The flints present two facies. One, which is generally small, is dark grey throughout and very soft, being often little more than a central mass of spongy texture, but no definite shape, surrounded by a very thin skin, very imperfectly silicified and easily cut with a knife on slight pressure. The other type appears to be confined to the base of this chalk, and includes nearly all the large flints. It is very thoroughly silicified and black inside with little or no cortex, and light bluish grey outside. These, like the included lumps, suggest gentle rolling, but contain only the same fossils as those of the grey matrix, including the peculiarly characteristic ones, and certainly no specimen of *O. lunata*, which occurs in profusion in the flints of its own horizons. The bed as a whole is certainly not reconstructed, for the grey matrix abounds in fragile fossils in absolute perfection, the most striking being *Ostrea inæquicostata*, bivalved *Ostrea ungulata*, and numerous branches of *Vincularia* and other Polyzoa. The fossils show the unconformity between the grey chalk and *O. lunata* chalk as clearly as the stratigraphy. *Ostrea lunata* and the bun-shaped *Echinoconus* are unknown in the grey chalk, which is full of *Ostrea inæquicostata, O. canaliculata*, and *Terebratula obesa,* none of which have ever yet been found in the *O. lunata* chalk. There are very similar grey beds on the foreshore underlying white chalk without *O. lunata,* which passes up into *O. lunata* chalk, but below they are cut off by a fault, and until we know either what overlies the grey chalk of the bluff or underlies the grey chalk of the foreshore it is not safe to identify the two sets of grey beds, though it is very tempting, the similarity being very striking, especially in the fossils.

At the beginning of October, 1905, the clay behind the bluff was broken through by the waves, and by the middle of the month the bluff had been completely isolated and a secondary bluff formed behind it out of the seaward face of the *O. lunata* chalk underlying the 'slope' of grey chalk, which had by this time become mainly a slope of *O. lunata* chalk showing several lines of flint dipping gently seaward. The cross section of this secondary bluff showed gently arched lines of flint, from which it was clear that this secondary bluff was the top of a gentle anticlinal fold rising towards the land, exactly like the ridge forming the southern part of the south bluff. It was, however, underlain where its base was clear of sand by clay visibly continuous in the south bay with the clay underlying the chalk masses. The same waves that had breached the clay pinnacle had also cleaned the section in the south bay, which is recorded by Fig. 17. The clay appeared to have pressed upwards from under the mass of chalk nearer the bluff and carried up with it on its surface the mass high up in the cliff, for the two were connected by a very thin but unbroken line of chalk which kept the clay above the masses of chalk from quite touching the clay which emerged from beneath them. A similar but more partial appearance was presented in the north bay by the clay which emerged from under the 'slope' and passed up into the cliff, only to arch over and, as before stated, pass down beside and in under the erratic slice of chalk. Both the masses in the south bay, i.e. the lateral section of the 'secondary bluff' and the mass seen high up in the cliff, were composed of *O. lunata* chalk with about a foot of grey chalk above separated by the regulation grit seam with pebbles, and above the grey chalk came about six inches of very regularly bedded sharp grey sand with one interlaminated seam of black clay, and above the sand about 2 feet of dark bluish grey clay. Between the two masses of chalk the sand was cut out by the clay above it, but over the masses themselves it was very regular. Above the bluff it passes into a coarse gravel.

The most recent exposures of the north side of the bluff itself appear to show an actual inversion of all the chalk below the thick flint. These flint lines are not clearly marked on this side, but their appearance is quite consistent with and indeed suggestive of their being actually inverted, and the hypothesis that they are actually inverted is made very probable by the fact that the seams of *O. lunata* up to and including that immediately below the thick flint follow the same inverted course, a fact pointed out to me by Mr. Bidder. Now it will be remembered that the *O. lunata* chalk was continuous across the gap, and that the gap was quite recently fairly narrow, and though no bed of flint happened to occur in the arch of *O. lunata* chalk crossing the gap, I am convinced (and Mr. Bidder is equally positive) that the thick flint in the bluff was identical with the flint line at a corresponding height in the 'secondary bluff' (Fig. 14). If we are right, then the thick flint was not involved in the inversion. That being so, we should expect to find filling the gap which would otherwise be left between the thick flint which continues more or less horizontal, and the beds below which break away from it, an area of reconstructed chalk, and this is exactly what does occur there. The sketch below will show what is meant:—

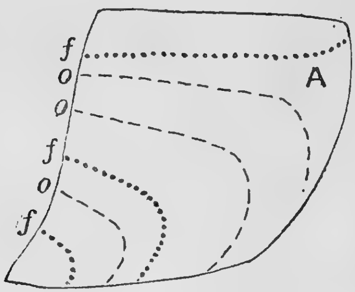


Diagram-sketch of the north-west face of bluff.
f, f, f, flint bands; *o, o, o,* seams of perfect *O. lunata* in section.
A, area composed of chalk crowded with comminuted *O. lunata* and no other fossils.

Now I think we are entitled to assume (until the contrary is shown) that the inversion is a result of the same, or practically the same, force which has so greatly tilted the beds which are not actually involved in the inversion, for both the tilting and the inversion must have been produced before the deposition of the grey chalk on the upturned ends of the tilted strata, since neither the tilting nor the inversion has affected the grey chalk, and that fixes the tilting and the inversion as of late Cretaceous age. Evidently all the beds now appearing in the bluff were tilted together, but by the time the angle had been reached at which the uninverted beds now stand, these beds must have been raised above the plane at which the thrust was operating, and the lower beds, being still in that plane, must have been forced to part company with the uninverted beds, no great matter, as the whole could by that time have only been lightly consolidated, and turn under themselves. This view conforms very well with Lyell's figure of the bluff when it was about twenty times its present length. This figure shows at the north corner a small area of chalk with a steep dip which flattens out southward to quite a gentle dip over a comparatively very extensive area, showing the steep dip to be very local. Probably we have in the bluff of to-day a remnant of the steeply dipping area only of Lyell's bluff, but whether that is so or not Lyell's figure is a very strong argument against assuming the general prevalence of a steep dip at this point.

The only possible explanation of these local phenomena seems to be one on the lines of the original and ingenious theory of Mr. Clement Reid, varied by postulating the lateral thrust as of Cretaceous age, directed almost due south and very local, and leaving the thrusting agent altogether indefinite. Except at this very point the thrusting force only created a gentle anticline. This anticline of greatly varying sharpness must have been exposed to denudation, which planed off the upper part and more or less flattened the sides, and the surface so formed was then resubmerged and the grey chalk deposited on it to a minimum thickness of three feet. At some date shortly before the formation of the glacial beds, the chalk must have been again raised and exposed to a south-westerly sea, which formed caves in it which were filled by the first inflow of boulder-clay. The bottoms of these caves are probably well below the present beach level, and we only see horizontal sections through the roofs and the upper surface of the infilling clay, which of course then appears to be underlying the thin edge of the broken-through roof by natural deposition. The detached masses of chalk seen in the cliff behind the bluff have clearly been carried up by a mass of clay from below, and represent parts of the roofs of these caves, which were too weak to resist the upward pressure of the clay. Possibly this upward pressure was applied at a much later date than the infilling of the caves, for the thin line of chalk recorded as connecting two masses of chalk is strongly suggestive of chalk, so to speak, rolled out between the upper and lower clay, and this could only take place by a fresh movement of the lower clay after the upper clay had taken up its present position. It is also suggested by the regular blending of the deposits immediately overlying the chalk just at this point that after the first influx of clay had filled up the sea bed to the level of about the top of the chalk there was an interval, during which the above-mentioned regular deposits were formed on the new sea floor so created, before this sea floor was covered by the upper clay, and then broken up by renewed motion in the lower clay.

5. *Other Exposures.*

A new feature of interest is the exposure for a short time of a patch of *O. lunata* chalk, about 30 yards by 12, some 340 yards to the south of the south bluff, i.e. roughly, intermediate between it and the short ridge exposed some years ago at the foot of the cliff under the brickfield (which latter I will call for convenience the brickfield chalk). This new patch of chalk was practically touching the base of a great mass of firm clay which forms at present the first headland to the south of the south bluff, and appeared to pass under this clay in the cliff and also under clay to the northward, its other boundaries being formed by sand. It appeared to represent the top (or rather a section across the upper part) of a flat ridge running and sinking in the usual direction about 30° south of east. Its southern and eastern ends were capped by a practically continuous sheet of flint, identical in appearance with a sheet of flint which I had previously observed on the foreshore close by coating one side of a ridge of *O. lunata* chalk heading in this very direction. The brickfield chalk recorded in my previous pamphlet I have never seen again, but once or twice in 1900–1904 there just showed through the sand some way further down the beach a narrow ridge of *O. lunata* chalk once visible for as much as 30 yards, and apparently running out to sea in much the usual direction, and in a line with the first recorded brickfield chalk. This ridge has been frequently just visible during 1905, and in October, 1905, it was gradually exposed to a length of over 66 yards. It was nowhere more than 4 feet and rarely more than 2 feet thick, and dipped very steeply to the north. It seemed very remarkable that such a long thin ridge should have been preserved on a foreshore, though there were strong indications that it increased greatly in width at a very short distance deeper down. But a still more remarkable thing was revealed on close examination, i.e. that throughout practically its whole length it was composed of a layer of *O. lunata* below and a layer of grey to white chalk above, separated by a grit bed full of rolled flints and chalk, and agreeing most exactly, except for its greater thickness (maximum at least 6 inches) and the greater size of the flint pebbles, with the grit bed at the base of the grey chalk in the north bluff over a mile away. I have little hesitation in identifying the two grit beds, for though the brickfield chalk above the grit bed was not uniformly grey, it contained many hardened and apparently rolled lumps of chalk. I could not find there any of the characteristic grey chalk fossils, but the total amount of chalk exposed was very small, and the physical identity is very pronounced.

EXPLANATION OF PLATES.

Views of Trimmingham Chalk Bluffs, Norfolk Coast.
Various views of the North Bluff and the exposures in the bays on either side of it.

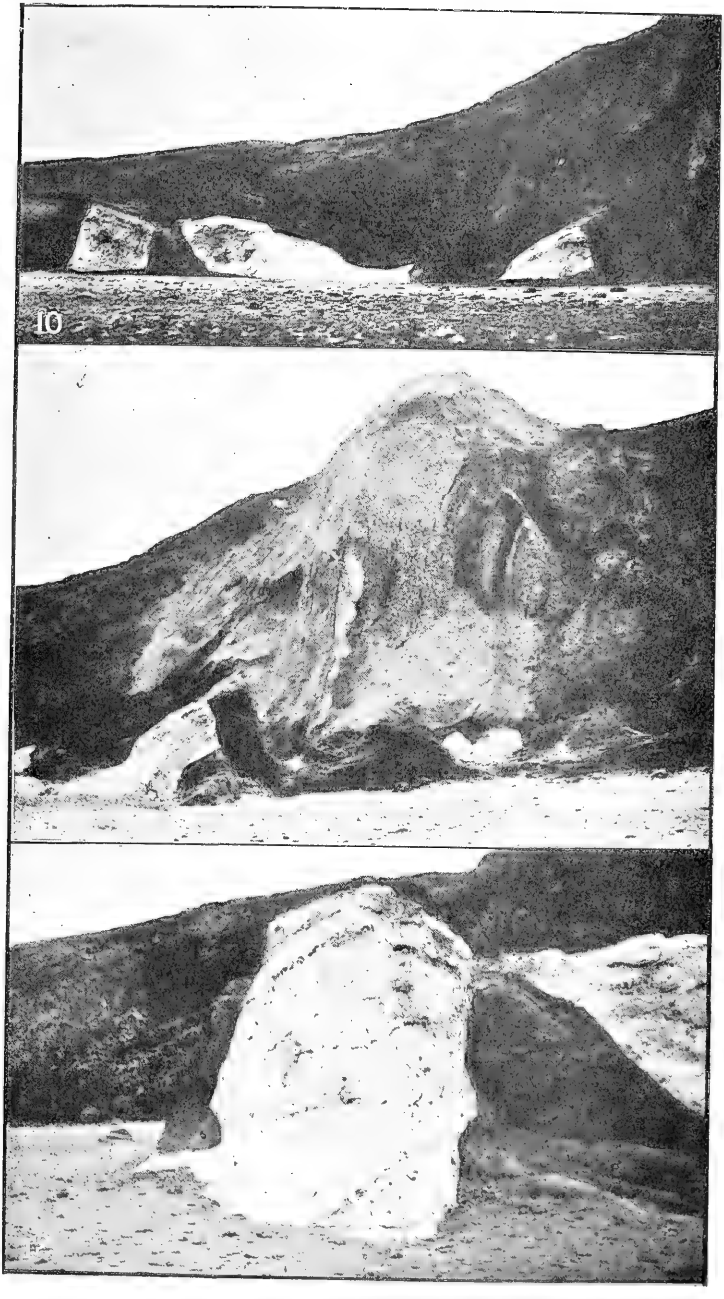
Plate IV.

Fig. 7.—Photograph taken November, 1904.
,, 8.—South bay; November, 1904.
,, 9.—Head of north bay from top of bluff; May, 1905.

Plate V.

Fig. 10.—North bay, showing slab of chalk on end in cliff; April, 1905.
,, 11.—Showing slab of chalk and mass of stratified shingle on end; May, 1905.
,, 12.—North Bluff, seaward aspect; May, 1905.

(To be concluded in our next number.)



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

VII.—Radium and the Radial Shrinkage of the Earth.

By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E.

IN his Presidential Address to the British Association, South African Meeting, 1905, Professor G. H. Darwin points out that the presence of radio-active materials in small proportion in the sun would serve to explain the present radiation, and "that concentration of matter is not the only source from which the sun may draw its heat." Professor Darwin goes on to explain how this enables us to extend the possibilities of geological time beyond that to which some physicists would limit us.

My object in writing this is to point out that if the sun's heat is kept up by the presence of radio-active materials the same must follow with regard to the earth. The rate of cooling of the earth must consequently be slower in proportion to the quantity of heat generated by the radio-active matter present in its substance.

It further follows from these premises that if the generation of heat by these radio-active matters in the earth equals the dissipation of it at the earth's surface the globe will be kept at the same *average* temperature. If this be the condition of the earth at the present time there can be no radial contraction taking place unless due to some other cause than loss of heat, and the same may be predicated of any previous period.

This is no doubt stating an extreme case, but if, on the other hand, we assume that only a portion of the heat lost by the earth by conduction and radiation is replaced by that generated by radio-active bodies, by so much will the radial shrinkage be reduced and the mountain-making activities on the contraction hypothesis rendered less efficient.

It has been shown by Osmond Fisher and myself that the gradual dissipation of the initial heat of the earth, considered simply as a cooling body, that has taken place in the past is quite insufficient to provide the radial contraction demanded by the contraction hypothesis.[1] If any of this lost heat is renewed this inefficiency is proportionately intensified.

Our ideas of the constitution of matter are undergoing serious changes, and it becomes increasingly important that geologists should keep themselves abreast of the times. The bugbear of a narrow physical limit to geological time being got rid of, we are free to move in our own field of science. The methods of geology have this advantage over those of pure physics, we can more readily appeal to nature for confirmation or disproof.

May I be permitted to point out that while the discovery of radium has shaken the foundations of what may be designated the mathematical theory of the earth, it strongly supports those who like myself have long contended that the forces which create mountain ranges, raise continents, and give external form to the

[1] Fisher: "Physics of the Earth's Crust." Reade: "Origin of Mountain Ranges"; "Evolution of Earth Structure."

earth reside in the earth itself, and that "the earth is not merely an inert mass cooling in space." [1]

Our conception of the geologic potentialities of matter has been marvellously widened by the recent discoveries. How these discoveries may affect our views of the interaction of matters as explaining geological changes remains to be decided when the new methods are established on a firm basis, of which there seems to be an early prospect.

NOTICES OF MEMOIRS, ETC.

Abstracts of Papers read before Section C (Geology), British Association: South Africa, 1905.

I.—On the Marginal Phenomena of Granite Domes. By Professor Grenville A. J. Cole.

In examining the gneisses of the counties of Donegal and Tyrone, which have been in part regarded as sheared Archæan masses, the author was led to conclude that the main structures are due to igneous flow, and that the most marked gneissic structure occurs where previously foliated sedimentary and igneous material has been incorporated with an invading granite. The patches of foliated gneiss in the granites of Donegal are thus remnants of considerable masses of older rock that have been absorbed; and the phenomenon of banded gneiss arises characteristically as a marginal feature of granite domes. Foliation is found in surrounding masses parallel to that in the granite, and at the same time parallel to the surface of junction, for the simple reason that the granite has picked off, leaf by leaf, the layers of foliated rock against which it rose. The author thus ranges himself with those who ascribe the most profound metamorphism to igneous rather than to dynamic action, and ventures to suggest that similar conclusions may be drawn from the rocks of the Malmesbury series in the west of Cape Colony, where a commingling of rocks appears to have taken place during a period of subterranean flow.

II.—Magmatic Segregation of Sulphide Ores. By Dr. A. P. Coleman.

The formation of ore bodies by magmatic segregation in eruptive rocks has long been admitted as regards magnetite and titaniferous iron ores, but the formation of sulphide ore bodies in this way has been disputed by many geologists. The pyrrhotite ores of nickel in Norway were first recognised by Professor Vogt as having this origin; and his theory has been applied to the Sudbury nickel ores by various geologists, and opposed by others. The recent complete mapping of the eruptive sheet, with which the Sudbury ore bodies are all connected, proves that they are really

[1] "Evolution of Earth Structure," p. 28.

segregated from the eruptive rock and form an integral part of it, with every gradation between ore and rock. It is believed that gravitation played a large part in the segregation, since the ore bodies are regularly found at the lowest points in the lower edge of the norite-micropegmatite sheet with which they are connected.

III.—On the Geology of South Victoria Land. By H. T. Ferrar, M.A.

I. The knowledge we had of South Victoria Land previous to the departure of the "Discovery" was mainly acquired by the expedition under Sir James Clarke Ross in H.M.S. "Erebus" and H.M.S. "Terror," in the years 1839–1843. His discoveries may be briefly summed up thus:—

(*a*) A great range of mountains, which rise occasionally to heights of 15,000 feet, and extend in a north and south direction for at least 500 miles.

(*b*) The presence of volcanic and plutonic rocks in this area.

(*c*) An open shallow sea south of the Antarctic circle.

(*d*) An active volcano, Mount Erebus, over 12,000 feet high, emitting flame and smoke in great profusion.

(*e*) A wall of ice, the Great Ice Barrier, on an average 150 feet high and about 470 miles long.

In 1899 the "Southern Cross" expedition brought home from Cape Adare specimens of granites, basalts, and quartz slates, but unfortunately the latter proved to be unfossiliferous.

II. This section deals with the *volcanic islands* off the coast, commencing with the Balleny Group, in latitude 66° S., and passes on to the rocks of the mainland in latitude 77° S. The rocks from the islands are chiefly basalts and tuffs, though intrusions of trachyte are fairly common. Edward VII Land and the volcanoes on the mainland are included in this section, as the latter, at any rate, belong to the recent volcanic eruptions of the area. All the volcanoes are undenuded cones, and are usually situated in isolated positions, and contrast strongly in outline with the rugged scenery of the main mountain range.

III. *The Continental Range.* The great range of mountains discovered by Sir James Ross has been proved to be at least 800 miles long, and to have some remarkable features common to the whole length. This great mountain range is divided into smaller ranges, to which distinguishing names have been given; but only one, the Royal Society Range, has been examined in detail by the expedition. The rocks that compose the range are conveniently separated into four distinct groups—namely, gneisses, granites, sandstones, and dolerites. The sandstone, to which I propose to give the name Beacon Sandstone Formation, provides a convenient stratigraphical datum-line, with reference to which the other phenomena may be considered.

(i) *The Gneissic Rocks* occur at sea-level and below a sequence of rocks which is at least 12,000 feet thick, and may be safely regarded as forming the ancient platform on which the central part of South Victoria Land is built. The foot-hills of the Royal Society Range and the lower portions of the Cathedral Rocks are composed of this class of rock.

(ii) *The Granites* have been encountered at the north end of the Royal Society Range, where they rest upon gneisses, and dykes of granite pierce the gneissic series. At Granite Harbour this type of rock is found as a huge boss, and is probably covered by a sheet of dolerite. Where the Ferrar Glacier forks, a junction of dolerite and granite proves that there are two distinct developments of granite, one older and one younger than a certain sheet of dolerite.

(iii) *The Beacon Sandstone Formation* is met with at a height of 4,000 feet above sea-level, and about 40 miles from the sea. It appears to be nearly 3,000 feet thick, and near the top indeterminable fossil plants were found. The bedding is practically horizontal, and the rock is remarkably uniform in texture. The surface upon which it rests has not yet been discovered.

(iv) *The Dolerite Sheets* produce the plateau features characteristic of that rock, and cap the sandstone over a very large area. Dykes, sills, and pipes of the dolerite occur in the sandstone, and prove the former to be intrusive. The original dolerite plateaux have been dissected by water action, apparently prior to the faulting which has dislocated the Beacon Sandstone.

IV. *The Ice.* Sea-ice, produced by the freezing of the sea during the Winter, is on an average 8½ feet thick, but during the Summer the sea-water melts the lower surface of the ice. Shore-ice, a fringe of glacier ice attached to the land, shows the conservative action of ice in this latitude. Inland ice, local ice-caps, piedmonts, and other types of glaciers may be recognised in South Victoria Land. The term 'floating piedmont' has been suggested as descriptive of the Great Ice Barrier, or Ice Sheet, of Ross, and there are at least three examples in our area.

The moraines high on the slopes of Mount Erebus, and other moraines stranded at various spots, are considered in their relation to the past and present distribution of the ice, and the conclusion arrived at is that the glaciation is approaching a minimum.

IV.—Evidences of Glacial Conditions in Permo-Carboniferous Times in the Transvaal. By Edward T. Mellor, B.Sc.

[Communicated by permission of the Director of the Geological Survey of the Transvaal.]

THE present paper gives a brief account of recent work in connection with the rocks at the base of the Karroo System in the Transvaal, including some additions to the evidence of extensive glacial action in early Karroo times. The description given of the character and mode of occurrence of the glacial conglomerate is based mainly upon observations made in the course of mapping a district lying between the Elands and Wilge Rivers, east of Pretoria. The Karroo System does not here attain so complete a development as in the more eastern and southern portions of South Africa. The whole thickness of the formation rarely exceeds 400–500 feet, and it is not possible as yet to recognise the many divisions which it presents in those parts of South Africa where it attains a much greater thickness. Outliers along the margin of the main area occupied by the Karroo System afford good opportunities for the study of the glacial conglomerate which forms its base. They are occasionally entirely composed of this conglomerate owing to the complete denudation of the overlying sandstones and grits.

The upper and well stratified portion of the formation lies everywhere horizontally, and its base maintains a very constant elevation of about 4,900 to 5,000 feet. The glacial beds of the lower portion of the formation rarely show distinct stratification, and outliers consisting of these alone closely resemble, both in appearance and mode of distribution, patches of glacial drift of comparatively recent origin. There is abundant evidence that they were laid down upon an old land surface possessing considerable variety of surface feature, and some of the thickest deposits of glacial conglomerate occur in valleys or below escarpments which were in existence before its deposition.

Owing to the abundant sandy drift arising both from the conglomerate itself and from the grits and sandstones which usually overlie it, the solid conglomerate is rarely exposed at the surface. Where seen, it is of a light yellow or cream colour, and usually consists of a sandy-looking matrix containing abundant boulders and pebbles distributed without definite arrangement through the mass. The pebbles and boulders vary in size from 2 to 3 inches up to as much as 10 feet in diameter. The materials of which the boulders are composed vary much in character. There is always a great preponderance of local rocks, with an admixture of others which can be shown to be derived from comparatively distant sources, which are to the north of the present position of the boulders. In the district here specially referred to, the majority of the boulders consist of hard red quartzites and conglomerates derived from the Waterberg Formation, which underlies the glacial conglomerate over a large part of the area. Almost equally numerous are boulders of the Red Granite, which occurs extensively further to the north.

The boulders are always highly polished and usually facetted. When composed of fine-grained rocks, such as felsites and shales, they frequently show striations on the facets. The matrix of the glacial conglomerate consists of sharply angular fragments of quartz and of rocks similar to those of which the boulders are composed, varying in size from mere grains upwards. It differs to some extent from the matrix of the typical Dwyka conglomerate of the more southern portions of South Africa in presenting an appearance much less suggestive of an igneous origin. By weathering, the matrix of the conglomerate usually gives rise to sandy products; in some localities, however, it produces a yellowish clay, in which the boulders remain embedded. In specimens from a depth, the matrix is occasionally greenish in colour. Locally there occur in the conglomerate lenticular patches of fine-grained, massive, white or cream-coloured sandstones, and white, finely laminated shales and mudstones.

The progressive denudation of the glacial conglomerate exposes at its margin the glaciated surfaces of the underlying rocks, which frequently show very clear striation. The best examples yet met with are those occurring to the north of the Douglas Colliery near Balmoral. In a number of examples distributed over an area of 300 square miles the striæ exhibit great constancy of direction, and point to the existence of an extensive ice-sheet with a movement from N.N.W. to S.S.E.

It is very probable that the glacial conglomerate extends very much further north than the localities at present known. During the past year outliers of the conglomerate were found ninety miles north of the latitude of Johannesburg.

V.—The Plutonic Rocks and their Relations with the Crystalline Schists and other Formations. By F. P. Mennell.

IT has been pointed out by Teall that the final solution of the problems arising in connection with the origin of igneous magmas is possibly to be looked for where the plutonic rocks are seen in their relations with the crystalline schists. The writer dealt with observations made in such an area and the inferences to be drawn therefrom. He concluded that the average igneous rock has practically the composition of the average granite, and that plutonic rocks are immensely more important than the other classes, even when the term plutonic is used in a much more restricted sense than by many authors. The causes of variation were discussed, and segregation, except as a phenomenon of limited importance, was dismissed as an untenable theory. The origin of the magmas must be considered in order to account for subsequent variation. 'Refusion' seems the only possible mode of formation. Granite appears to result from the effective mixing of the heterogeneous materials melted down, other igneous rocks being the result of the cooling of different parts before mixture is complete, basic material having also the best chance of reaching the surface as lava, owing to its superior liquidity. There is circulation of material between the igneous and sedimentary rocks, the material analysed in the latter being subjected to synthesis in the making of the former.

VI.—Baviaan's Kloof: A Contribution to the Theory of Mountain Folds. By Ernest H. L. Schwarz, A.R.C.S.

BAVIAAN'S KLOOF is a narrow valley lying between mountains belonging to the Triassic period. The geological history may be summarised thus:—

(*a*) First base-level. Deposition of Enon Conglomerate, derived from the disintegration of the newly-formed mountains, on a plain eroded between the two mountain chains.

(*b*) Period of cross-folding. The area traversed by two sets of folds in directions W.N.W.–E.N.E. and S.W.–N.E.; these let down portions of the surface in deep pits, bounded by circular faults and sharp folds.

(*c*) Second base-level. The Enon Conglomerate removed, except that in the fold-basins, and the surface of the valley again reduced to a double level of erosion.

(*d*) Rising of the land. Deep erosion of the river channels; immense gorges cut in the floor of the plain and most of the loose contents of the Enon Conglomerate in the fold-basins removed.

Cross-folding is the interpretation of the two sets of mountain folds, and the sinking of areas in the meshes between is contrary to what would happen if the folds were produced by direct tangential thrust. The direct thrust theory also has to explain how a force could act at a distance when the material through which it is transmitted is so heavy in proportion to its strength and has such immense friction to overcome.

The resemblance of these Baviaan's Kloof fold-basins to pits found between two sets of crossing ripple-marks has suggested that certain mountain folds are produced by earth-shaking waves which become retarded when approaching an immovable buffer, such as masses of granite anchored to the deep substructure of the earth's crust. This theory is further illustrated experimentally by what happens in a lead sink where hot and cold water is let in at one end from a tap; the disturbance produced by this gradually causes ridges to form at the further end of the sink, though the lead is too pliant to allow a direct thrust thus to act at a distance.

'Shearing' and 'fold arc' structure may also be explained on the wave theory, whereas 'block up-lift' structure is rather a problem in isostasy.

REVIEWS.

I.—An Introduction to Geology. By J. E. Marr, Sc.D., F.R.S. 8vo; pp. viii, 229, with 33 illustrations. (Cambridge: at the University Press, 1905. Price 3*s*.)

THAT geology flourishes as a recreative science is manifest to all who read their Quarterly Journal, Geological Magazine, or Proceedings of the Geologists' Association; while the good work that is being done and may be done by amateurs as well as professionals, especially in the study of fossils, formed the text last year of Dr. Smith Woodward's interesting address to the Geologists' Association. Most excellent work is being achieved by those who concentrate their attention on certain formations, or fossils, or districts; and it is necessary that the supply of such workers be maintained.

The little book before us, by the President of the Geological Society, is well calculated to promote this object; indeed, it was written as an introduction for those who will subsequently proceed to more advanced treatises and as a guide to those general readers who simply desire to obtain some idea of the science. As far as possible in a limited space the author has provided good and stimulating material for both classes of enquirers, a task always difficult, and if, as will surely be the case, the student finds that the information on this or that point is too meagre, he will, we trust, be induced to turn to other guides and philosophers, if not to the classroom where Dr. Marr has so long and successfully expounded the principles of geology and the methods of research.

The book is illustrated by many diagrams and by several beautiful photographs, notably those of a glacier, glaciated rocks, graptolites, a trilobite, and nummulites.

We are doubtful whether the diagram of fan-structure, fig. 15, p. 93, would be easily intelligible to the student. It rather represents an anticlinorium than the *structure en éventail* where the bands of rock in a doubly inverted anticline spread out in fan-like form, as figured in Sir A. Geikie's Textbook, vol. i (1903), p. 678, or in Chamberlin & Salisbury's Geology, p. 484. In saying this we admit that a figure somewhat similar to that in the book before us was given by Lapworth in his "Secret of the Highlands," Geological Magazine for 1883, Plate V, but we think that the true fan-structure of A. Favre, Heim, and others is represented in Plate VIII, Figs. 6 and 7, accompanying the same article. Such a handy book is certain to be taken up by many readers.

II.—Memoirs of the Geological Survey.

The Geology of Mid-Argyll. By J. B. Hill, R.N., with the collaboration of B. N. Peach, LL.D., F.R.S., C. T. Clough, M.A., and H. Kynaston, B.A. With Petrological Notes by J. J. H. Teall, D.Sc., F.R.S., and J. S. Flett, M.B., D.Sc. pp. vi, 166. (1905. Price 3*s*.)

THE area embraced in this memoir, very lucidly described by Mr. Hill in the Introductory Chapter, extends from the borders of Upper Loch Fyne into the district of Lorne on the north-west and to Cowal on the south-east. The capital of Argyllshire stands near the centre, and there is an excellent photographic frontispiece showing Inveraray Castle and the raised-beach platform that fringes Loch Fyne. A great part of the district is formed of metamorphic schists, including slates, quartzites, schistose grits, and limestones, together with mica schists, graphite schists, and the problematical "Green Beds," which may have originated as clastic rocks derived from basic igneous rocks. Lower Old Red Sandstone and conglomerate with andesites, etc., occur in the north-western region. The most mountainous portion is that in the north-east, on the borders of which the ancient schistose rocks of Beinn Buidhe rise 3,106 feet. Rather full particulars are given of all the metamorphic and older igneous rocks, the latter comprising epidiorite and serpentine; there is a chapter on the effects of folding and progressive regional metamorphism; while the later intrusive rocks, granite, hyperite, diorite, and kentallenite, various sills and dykes, and the Tertiary intrusions furnish ample material for those interested in petrography. Matter perhaps of more popular interest is contained in the chapter on the Glacial and Recent deposits. It is pointed out that the gathering-ground of the ice-cap, which in the period of maximum glaciation completely overrode this mountainous district, was situated in the Grampian range to the north-east, the ice issuing in a south-westerly direction along the parallel basins of Loch Fyne and Loch Awe; the major rock-basins coincide with the direction of this ice-flow, and the evidence generally obtained in the area favours the connection of the rock-basins with glacial phenomena. Of the various glacial drifts and fluvio-glacial gravels, of the raised beaches and the story they tell of changes of level, and of the economic deposits of the area we find many interesting and useful particulars. A bibliographical list is given in the appendix, but perhaps further references in the text might have been given to the observations of other geologists who have written on Argyllshire.

III.—The Geology of the Country around Cork and Cork Harbour. By G. W. Lamplugh, F.G.S., J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., W. B. Wright, B.A., and H. B. Muff, B.A. pp. vii, 135. (1905. Price 3*s.*)

THIS memoir is descriptive of a specially prepared and colour-printed map of the country around the city of Cork, including the whole of Cork Harbour; the area having been re-surveyed with the object only of mapping the glacial drifts and other superficial deposits.

The older geological formations include the Lower and Upper Old Red Sandstone (termed on the previous Geological Survey map the Dingle and Kiltorcan Beds) and the Carboniferous Limestone Series. The boundaries that mark the exposed limits of these older rocks are reproduced from that Survey; and the only notable change is the abolition of the term "Coal-measures?" which strangely enough was used for beds now grouped as "Upper Shale or *Posidonomya Becheri* Beds." So much interest attaches to the relations of these Old Red and Carboniferous beds to the equivalent strata in the west of England and South Wales, that it is a matter of regret that the attention of Mr. Lamplugh and his associates was confined (officially) to the mapping of the superficial deposits. In consequence we have to be content with a good deal of information gathered more than fifty years ago, as the district was surveyed by Jukes and his staff in 1851–2; while the explanatory memoir on Sheets 187, 195, and 196, owing to "the inadequate means afforded us to carry out our work to completion," was not issued until 1864.

Needless to say, there is much of interest in the remarks of Jukes on the Old Red Sandstone, Devonian, and Carboniferous rocks in that old memoir, which deals with a large part of the area described in the work before us.

Until the new survey was carried out our knowledge of the Glacial Drifts of the district was meagre, and the greater part of the present memoir is occupied with a general and detailed description of the raised beaches, 'head,' boulder-clay, glacial sands and gravels, old river gravels and deltas, and other superficial deposits. The story told by these complex accumulations has been most ably and skilfully disentangled; and we commend its perusal to our readers. The pre-glacial or early glacial shore-line discovered by Messrs. Muff & Wright near the mouth of Cork Harbour consists of a rock-shelf, on which there rests in succession raised beach, blown sand, 'head' or talus, boulder-clay, and an upper 'head.' The ancient shore-line is distinctly older than the glaciation of any part of the south or south-east of Ireland. The present river valleys, the origin of which was discussed in a classic paper by Jukes, were mainly of pre-glacial age. The valley system of the interior has been only slightly modified, and the present sea-inlets have been brought about by depression whereby the lower parts of the valleys were submerged. The memoir is well illustrated with photographic plates and other figures, and it contains a useful chapter on economic geology.

IV.—Geological Survey of Canada. By Robert Bell, I.S.O., M.D., F.R.S., Acting Director. Part O, Annual Report, vol. xiv. The Artesian and other Deep Wells on the Island of Montreal. By Frank D. Adams, D.Sc., F.G.S., and Osmond E. Leroy, M.Sc. 8vo; 74 pp. (Ottawa: S. E. Dawson, 1904.)

THE objects kept in view by the authors of this able report were, in the first place, to describe as completely as possible all the borings put down in the Island of Montreal up to the close of the year 1903, and secondly, to ascertain, if possible, whether any definite water-bearing horizons existed in the underlying rocks, and by a study of the geology of the district to learn the character and origin of the subterranean water supplies and the prospect of obtaining water by further borings.

Eighty-nine boreholes were found to have been made during the period covered by the report. Only six of these were, however, actually flowing, that is artesian wells, most of the Montreal wells requiring to be pumped. A tabulated list specifies the depth in feet of the borings, the diameter of the holes in inches, the capacity per diem in gallons (much higher than that usually required), the character of the water, hard, soft, saline, etc., together with the names of the owners, location of the borings, and other details. A careful description of each boring follows this list, from which it is seen that most of the wells yield potable waters, while some of them are hard, owing to the presence of a considerable quantity of lime or magnesia salts, thus rendering them unsuitable for use in steam boilers. Others, being impregnated with sulphurous compounds, or possessing a saline character, are only of use for cooling purposes. Analyses of the waters have been made from time to time, but these having been prepared merely for technical purposes are in most cases incomplete. A comparative examination of them, however, brings out some interesting points bearing upon their chemical composition in relation to the rocks from which they were derived.

Regarding the course of the underground waters supplying the numerous wells sunk in the thickly-bedded (Ordovician) limestones in the Island of Montreal, the authors conclude that the channels through which the waters flow have the form of irregular fissures, and that "there is no distinct water-bearing horizon in the form of interstratified permeable beds." The proof of this is to be found in the circumstance that both the supply and the character of the water differ in borings in comparatively close proximity to each other. The irregular course of the waters is partly influenced by the presence of abundant dykes and sheets of impervious igneous rocks traversing the limestone strata in every direction.

A very moderate estimate shows that the wells already bored would yield, if pumped to their full capacity, 2,500,000 gallons per diem, which is nearly one-tenth of the daily average pumped by the Montreal Water Works for the use of the city.

The source of the underground water is considered to be in all probability the higher portion of the plains along the flanks of the Laurentian country in the north-western part of the Island of Montreal.

This valuable report is illustrated by diagrams in the text, and by (1) a geologically coloured map of the Island of Montreal and its vicinity, (2) a topographical map of the city of Montreal with the positions of the borings, (3) graphic diagrams showing the relations of certain groups of wells in the city of Montreal and its vicinity.

Arthur H. Foord.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 20th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Highest Silurian Rocks of the Ludlow District." By Miss Gertrude L. Elles, D.Sc., and Miss I. L. Slater, Newnham College, Cambridge. (Communicated by Professor T. McKenny Hughes, M.A., F.R.S., F.G.S.)

After an introduction dealing with previous work in the district, the authoresses adopt the following classification of the beds:—

		Feet.	
III. Temeside Group.	B. Temeside or *Eurypterus* Shales	110 to 120	Zone of *Lingula cornea* and *Eurypterus*.
	A. Downton Castle or Yellow Sandstone	30 to 50	Zone of *Lingula minima*.
II. Upper Ludlow Group.	B. Upper Whitcliffe or *Chonetes* Flags	150 to 160	Zone of *Chonetes striatella*.
	A. Lower Whitcliffe or *Rhynchonella* Flags	110 to 120	Zone of *Rhynchonella nucula*
I. Aymestry Group.	B. Mocktree or *Dayia* Shales	40 to 150	Zone of *Dayia navicula*.
	A. Aymestry or *Conchidium* Limestones	75 to 250	Zone of *Conchidium Knightii*.
		515 to 850	

A brief outline description of the main subdivisions is first given, as they appear when followed from Ludlow southward to Overton, eastward to Caynham Camp, westward to Downton-on-the-Rock, and northward to Bromfield, and also near Onibury and Norton. The main tectonic features of the district appear to be due to the superposition of Armorican movements in rocks with a Caledonian trend, held by some rigid mass to the north, presumably the Longmynd massif. A detailed description is then given of the succession, as seen at the following localities: River Teme, Wigmore Road, Deerhouse Bank, Caynham inlier, the Teme and north-east of the Castle at Downton, Downton Castle inlier, Mocktree, and near Onibury on the Craven Arms Road, the Onibury Norton Lane, and at Norton. The paper closes with a detailed list of fossils obtained by the authoresses, supplemented by the collection in the Ludlow Museum.

2. "The Carboniferous Rocks at Rush (County Dublin)." By Charles Alfred Matley, D.Sc., F.G.S. With an Account of the Faunal Succession and Correlation. By Arthur Vaughan, B.A., D.Sc., F.G.S.

Rocks of the Carboniferous Limestone Series are exposed along 5 miles of coast near Rush, Loughshinny, and Skerries, in county Dublin. The present paper deals only with the beds near Rush, in the southern portion of this tract, where about 2,500 feet of the series are exposed, without allowing for gaps in the succession. The upward sequence is (on the whole) from south to north, and the range is from the Upper *Zaphrentis* to the Upper *Dibunophyllum* Zone.

The Rush Slates are the lowest beds, 1,380 feet thick, but their base is not visible. They consist of black and dark-grey, well-cleaved argillaceous, and less perfectly cleaved calcareous, slates; and they contain bands and nodules of limestone. The peculiar outcrop of some of the limestone bands is described, and instances of cataclastic structure are noticed. The characteristic fossil is *Zaphrentis* aff. *Phillipsii*.

The Rush Conglomerate Group succeeds the Rush Slates, after a short interval of passage-beds. It is 500 feet thick, and consists of well-bedded alternations of conglomeratic, pebbly, and sandy limestones, with shales and calcareous flaggy beds. Ordovician and Silurian rock-fragments abound in them, together with many inclusions of Carboniferous Limestone. The group is shown to be of the same age as the Pendine *Syringothyris* conglomerate and the volcanic rocks of Weston-super-Mare, and its existence indicates that the movement and disturbance in Mid-Avonian times extended over a considerable area.

The beds above the conglomerates are mainly limestones and calcareous shales. They are thrown into numerous sharp folds, and are occasionally inverted. The highest beds seen (*Cyathaxonia* Beds) are correlated with the Eastern Gower or Oystermouth Limestone of the South-Western Province; but the fauna agrees still more closely, and is identical, with that of the highest Avonian beds of the Midlands of England, at Parkhill, Wetton, Thorpe Cloud, etc. The disappearance by solution of a considerable thickness of limestone is described.

A list is given of the fossils from a large number of horizons in the Rush Series (which is divided into the *Zaphrentis*, *Megastoma*, and *Cyathaxonia* Beds), as well as of the fauna of the Curkeen Hill Limestone, near Loughshinny, the horizon of which is assigned to the Upper *Dibunophyllum* Zone, probably below the *Cyathaxonia* Beds.

The palæontological section deals only with Brachiopods and Corals. In that part which deals with the Brachiopods the interrelationship of the various members of the more important gentes is discussed in considerable detail. In the part which is devoted to the Corals a new subgenus is suggested, and four new species are described.

Professor G. F. Wright, in exhibiting a map of the Lebanon district, gave an interesting description of the evidence which he found, in a recent journey to that district, as to the height and extent of the terminal moraine. He remarked also that the water-level in the Jordan Valley stood, in comparatively recent times, 750 feet higher than at present, and this he connected with the glaciation of the area. Very small climatic changes would be sufficient to start the Lebanon Glacier again.

II.—January 10th, 1906.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Clay-with-Flints: its Origin and Distribution." By Alfred John Jukes-Browne, B.A., F.G.S.

Until recently the Clay-with-Flints has been regarded as being, in the main, a residue from the slow solution of the Chalk. This was the explanation proposed by Mr. W. Whitaker in 1864, although he admitted that the deposit included some material derived from the Eocene. Writing in 1865, Mr. T. Codrington thought that an overlying stratum of clay or loam was essential to the formation of Clay-with-Flints. Lastly, Charles Darwin in 1881 seems to have taken it for granted that it was solely a residue from the Chalk. Of late years the opinion has been growing that it consists very largely of material derived from the Eocene.

The present paper is devoted to an examination of the facts, with the view of ascertaining whether the Clay-with-Flints could possibly be derived from the Chalk, or whether the theory of its derivation from the Eocene is confirmed by more detailed enquiry. The author first describes its composition, noting that unbroken flints are not everywhere abundant, that broken angular flints are common, and green-coated flints are not rare; finally, that if the clay is washed it always yields a residue of sand, composed chiefly of rounded quartz-grains with some of iron-oxide, and both apparently derived from the Eocene sands.

The thickness of the accumulation is next discussed, especially with reference to sheets of it that lie on fairly even floors. In such positions it varies from 2 to 12 feet in depth, and large areas occur where it must have an average depth of 3 or 4 feet. The products resulting from artificial solution of chalk are then considered, and a series of analyses is given, from which the average amount of insoluble residue existing in the four lower zones of the Upper Chalk is deduced. Experiments have been made by Mr. William Hill to determine the related weights of a cubic foot of Upper Chalk and a cubic foot of Clay-with-Flints, in order that allowance might be made for the difference in calculating the quantity of clay which would be left by the solution of a given quantity of chalk. The result shows that 100 cubic feet of the *Micraster coranguinum* Chalk will produce only 1·2 cubic feet of clay, and the solution of the *Marsupites* and *Micraster coranguinum* Zones to the extent of 200 feet over any part of the area would only yield clay enough to make a layer 2 feet deep. Lastly, it is shown that the quantity of flints in the Upper Chalk is so much greater than the quantity of clay that the natural residue could not form a Clay-with-Flints. Thus, solution of 100 feet of *Micraster coranguinum* Chalk would yield a bed of flints about 7 feet thick, and only enough clay to fill up the interstices between the nodules.

The next section is devoted to the distribution of the Clay-with-Flints, and its stratigraphical relations to the Chalk on the one hand and to the Eocene on the other. In dealing with this part of the subject, details are restricted to the areas lying west and north-west of the London Basin and to the wide area between the London and Hampshire Basins.

From these several lines of investigation the author concludes:—(1) That the Clay-with-Flints cannot have been formed from mere solution of the Upper Chalk; (2) that all its components, except the unbroken and angular flints, could have been furnished by the Reading Beds; (3) that the positions occupied by it are such that no great thickness of Chalk can have been destroyed to form it, the tracts being seldom more than 30 or 40 feet below the local plane of the Eocene base, or the presumed level of that plane.

Finally, an attempt is made to explain the manner in which the Clay-with-Flints was formed, and the theory adopted is that the outlying Eocene tracts, which were in existence during late Pliocene time, were broken up and spread out by the severe climatic conditions of the Glacial Period. In post-Glacial time little has been added, but much removed by erosion.

2. "On Footprints from the Permian of Mansfield (Nottinghamshire)." By George Hickling, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.G.S.)

These fossils were discovered in 1897 by Mr. Francis Holmes in the Rock Valley Quarry, Mansfield, in a local lenticular mass of sandstone intercalated in the Magnesian Limestone. The impressions formed two double rows, approximately parallel, and 7 and 2 feet long respectively. Nearly the whole of the longer series is in the Nottingham Museum, and part of the shorter series in the Manchester Museum. Both sets were made by the same species of animal, the stride in one case being 8 and in the other $8\frac{3}{4}$ inches. The prints show a well-marked heel and comparatively slender digits, and there is evidence of a membrane between the toes. There is wide separation between the right and left sides, this separation being more marked in the fore than in the hinder footprints. The prints present some resemblance to those named *Ichnium acrodactylum*, from the Upper Permian of Thuringia. Recently the author has found other prints in the same quarry.

CORRESPONDENCE.

THE ZONE OF *OSTREA LUNATA*.

Sir,—I am very gla l that Mr. Brydone is publishing his further observations on the Chalk bluffs of Trimmingham, and it is clear they will throw valuable light on the much disputed question of the manner in which these masses were brought into their present positions.

I am sorry, however, that he should object to my choice of *Ostrea lunata* as the index-fossil for the zone which his previous observations enabled me to establish on a firm basis; the more so as his reason for objecting to the choice seems to me to have little force. He admits that *O. lunata* "has two characteristics of an ideal name-fossil in that it is, as far as we know, almost confined to the Trimmingham Chalk, and that in that chalk it always occurs abundantly if at all." He thinks, however, that "it fails to fulfil the most important requirement for a good zone-fossil in that it is not distributed all through its so-called zone."

Moreover, Mr. Brydone seems so sure that *O. lunata* will not do as an index that he proposes to rename the beds as the "zone of *Terebratulina gracilis* and *T. Gisei*," in spite of the most obvious objections. I am therefore compelled to defend my choice of a zone-name from his attack upon it.

In the first place I must ask Mr. Brydone why he asserts that the index-fossil of a zone must be distributed "all through its zone," and what he means by this expression. I am sure that he does not expect to find the chosen fossil in every foot of the chalk which makes up the zone. I suppose, therefore, he means that it ought to occur at frequent intervals throughout the zone, and that the total thickness of beds in which it does occur should be greater than that of those in which it does not.

I greatly wish that fossils would occur in such a well-regulated manner, but unfortunately their behaviour often falls sadly short of what we should like it to be. Mr. Brydone must surely have forgotten that *Marsupites* is not a common fossil throughout the zone of which it is accepted as the index. In fact, it is common only in the *Marsupites* band or subzone, and is rare or absent in the *Uintacrinus* band. Yet I am not aware that anyone has objected to its being used as the index-fossil of the zone, and I sincerely hope that no such objection will ever be taken.

Again, has Mr. Brydone considered the case of the zone of *Act. quadratus,* where that species (as now restricted) only occurs rarely, especially in the higher part of the zone. It is true that Mr. Rowe has proposed to take *Offaster pilula* as the index-fossil, because it is common throughout, but this generally occurs at intervals only, being common in spots or in bands and rare or absent in the intermediate beds, just as *Ostrea lunata* seems to be absent from certain beds in the Trimmingham Chalk.

From the succession of beds given by Mr. Brydone on p. 14 of this Magazine, and assuming his group 3 to be identical with part of his group 4, it is seen that *O. lunata* occurs abundantly at four horizons in the series, and that it occurs in all three divisions. This is quite sufficient to satisfy all reasonable demands on any fossil for qualification as the index of a zone; consequently I must maintain the propriety of my choice, and must object to any other species being substituted for *Ostrea lunata*, unless a much better reason can be given than that advanced by Mr. Brydone.

A. J. Jukes-Browne.

Floriston, Torquay.

DISCOVERY OF *EXOGYRA SINUATA* IN THE LOWER GREENSAND OF CULHAM, NEAR OXFORD.

Sir,—It might interest your readers to hear of the finding of a specimen of *Exogyra sinuata* by Mr. W. D. Hutchinson and myself in the Lower Greensand of Culham, near Oxford.

The specimen is a large one, and was found in a bed of coarse laminated sandstone, in a neighbourhood where the Greensand has been considered unfossiliferous.

Clinton G. E. Dawkins
(Balliol College, Oxford).

6, Larkstone Terrace, Ilfracombe.

OBITUARY.

CHARLES TOOKEY, F.I.C., F.C.S.

Born May 13, 1828. Died January 3, 1906.

We regret to record the death of Charles Tookey. He was born at Oddingley Rectory in Worcestershire, and educated at Bromsgrove School; he became a student at the Royal College of Chemistry in 1851, and was an assistant in the following year. In 1854–5 he was assistant to Dr. Stenhouse at St. Bartholomew's Hospital, and from 1856 to 1865 assistant to Dr. Percy at the Royal School of Mines. During this period he analysed examples of iron-ore from South Staffordshire for part 2 of "The Iron Ores of Great Britain," 1858 (Mem. Geological Survey).

In 1865 he was appointed Assayer in H.M. Mint at Hong Kong, a post which he relinquished in 1868. From 1870 to 1874 he was Assayer, Chemist, Superintendent of Refinery, and Temporary Director at the Japanese Imperial Mint at Osaka. On his return to this country he served 1874–8 as Chemist on the Admiralty Boiler Committee. He was author of papers "On the Separation of Tin from Antimony, and on the analysis of alloys containing Lead, Tin, Antimony, and Copper" (1862) and "On the Manipulation of Assays of Gold and Silver Bullion" (1870), Journ. Chem. Soc.

We are indebted for most of the above particulars to the "Register of the Associates and Old Students of the Royal College of Chemistry, the Royal School of Mines," etc., by T. G. Chambers, 1897.

MISCELLANEOUS.

Retirement of Dr. B. N. Peach, F.R.S.

In September last Dr. B. N. Peach, F.R.S., retired from the Geological Survey after a period of 43 years service. Joining the staff in 1862 as assistant geologist, after a distinguished career at the Royal School of Mines, he was engaged for the first few months in determining Carboniferous fossils from the county of Fife under Salter's supervision in the London office. When favourable opportunities presented themselves during his subsequent career, he pursued this branch of research with keen fascination, impelled by the instinct of the naturalist, which he inherited from his gifted father. In the same year he was attached to the field staff in Scotland, then under the direction of Sir Andrew Ramsay, and in 1867 he was appointed geologist when a separate staff was organised for the northern part of the kingdom under the Directorship of Sir A. Geikie. Throughout his long career it has fallen to his lot to take a prominent part in mapping all the Palæozoic formations in Scotland, together with large areas of crystalline schists of the

Highlands. In particular, the detailed work in the complicated region in the west of Sutherland and Ross was carried out under his immediate supervision. It is within the mark to state that no geologist has acquired such a thorough mastery of the details of Scottish geology, exclusive of the rocks of Secondary and Tertiary age.

In 1879, after Mr. Etheridge, jun., had joined the geological department of the British Museum under Dr. H. Woodward, F.R.S., Dr. Peach, in addition to his field duties, was appointed Acting Palæontologist on the Scottish staff. He was thus furnished with opportunities which he long had in view. He devoted special attention to the Palæozoic Arthropoda, and in addition to his purely official work he published papers in the Transactions of the Royal Society, Edinburgh, the Geological Society, London, and the Royal Physical Society, Edinburgh. Among these papers we may particularly mention those dealing with the fossil Scorpions of the Carboniferous and Silurian rocks of Scotland, and with the fauna of the Olenellus-zone of the North-West Highlands. But the incessant demands of field work prevented him from carrying out his investigations as fully as he had hoped. At present there are about 2,000 specimens of the higher Crustacea of the Carboniferous rocks of Scotland in the Geological Survey collections, some of which have been figured and described by Dr. Peach. But many new forms are still undescribed, and in the interests of Scottish geology it is to be hoped that an arrangement will be made whereby he will be enabled to complete this research.

In recognition of his eminent services to Scottish geology, of the assistance which he has generously rendered to other investigators, of his inspiring influence on the younger members of the Survey staff with whom he came in contact, his many friends have resolved to present him with a substantial testimonial, towards which about £100 has been already subscribed. This testimonial will be presented to Dr. Peach at a public dinner to be held in Edinburgh on March 30th, 1906.

Corrigenda.—We have been requested to state that, in the article on Professor T. McKenny Hughes in the January number, in the list of distinguished students, Miss Elles should have been described as "Assistant Demonstrator in the Geological Museum," instead of "Assistant to the Woodwardian Professor," Mr. F. R. C. Reed having held the latter post since 1892. The degree of D.Sc. held by Miss Elles was conferred upon her by the University of Dublin in July last, and upon Miss Wood by the University of Birmingham at the same date. No doubt the University of Cambridge will, in time, become equally liberal in conferring degrees upon women.—Edit. Geol. Mag.

Erratum. — Mr. C. Davies Sherborn writes: — Please correct a misprint in Geol. Mag., January, 1906, p. 34, nine lines from bottom; I refer there to *Nereitopsis* (the worm), after *Nereis*, not to *Neritopsis* (the mollusc).

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ASSISTED BY

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THE

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No. III.—MARCH, 1906.

ORIGINAL ARTICLES.

I.—The Geological History of South Africa.[1]

By Dr. F. H. Hatch, F.G.S., M.I.C.E.,
President of the Geological Society of South Africa.

THE subject of this address is a brief account of the succession, thickness, and geological history of the South African, and more especially of the Transvaal, formations. The information necessary for such an account is of course very incomplete, but in broad outline the succession is now known, and some speculation as to the physical conditions that prevailed during the building up of the region may perhaps be permitted. I propose to deal with the period of the geological history of this country that came to an end with the close of Karroo times. The Karroo period ends with the Stormberg rocks (Rhætic), and since that time South Africa has, with the exception of a small coastal area, been a land surface, and the rocks have consequently been exposed uninterruptedly to the forces of denudation.

1. *Order of Superposition of the Stratified Rocks.*

As is well known, no determinable remains of organisms have been found in the Transvaal below the Karroo Beds, and none below the Bokkeveld Beds in the Cape Colony. In the absence of fossil evidence, the succession can only be established by a careful observation of the order of superposition and the lithological character of the strata. The succession has already to a great extent been determined by various workers, and the main dividing-lines placed at the great breaks or unconformities that have been found to exist. Thus we have, as natural dividing-lines, five great unconformities, namely, that below the Dwyka Conglomerate (which for future reference we will call Unconformity No. V), that below the Waterberg Sandstone (Unconformity No. IV), that below

[1] Presidential Address delivered by Dr. F. H. Hatch to the Geological Society of South Africa, 29th January, 1906.

the Black Reef Series (Unconformity No. III), that below the Ventersdorp System (Unconformity No. II), and that below the Witwatersrand System (Unconformity No. I). In regard to Unconformity No. V, we have the exception that in Southern Cape Colony the Table Mountain Sandstone, which some of us regard as the representative of the Waterberg Sandstone, is followed successively and in strict conformity by the Bokkeveld, the Witteberg, and the lower shales of the Dwyka Series.

The following order of superposition of the South African stratified rocks may be regarded as now fairly established:—

European Equivalents.	Southern Cape Colony.			Transvaal.	
Rhætic.	Karroo System.	Stormberg	Volcanic Group. Cave Sandstone. Red Beds. Molteno Beds.	Missing.	
		Beaufort		Missing.	
Permo-Carboniferous.	...	Ecca and Dwyka		= Ecca and Dwyka.	
					(No. V.)
Devonian.	Cape System.	Witteberg		Missing.	
		Bokkeveld		Missing.	
		Table Mountain Sandstone		= Waterberg Sandstone.	
					(No. IV.)
	... ...			Potchefstroom System.	Pretoria Beds. Dolomite Series. Black Reef Series.
					(No. III.)
				Ventersdorp System.	Boulder Beds, Volcanic Breccias, Klipriversberg Amygdaloid, etc. Elsburg Conglomerates.
					(No. II.)
				Witwatersrand System.	Upper Witwatersrand Beds. Lower Witwatersrand Beds.
					(No. I.)
Archæan.	Malmesbury Series			= Swaziland System.	

With the exception of one or two points, which I shall proceed to deal with, the above succession has found general acceptance. One of the points about which there is some considerable difference of opinion is as to how much or how little of the Karroo System above the Dwyka Conglomerate is represented in the Transvaal. The view originally put forward was that the coal-bearing beds of the Transvaal were a continuation of the Stormberg Beds of the Cape. This was adopted by Molengraaff in his first geological reports; but later, in the course of a discussion as to the age of the coal beds which took place in the Society some two years ago, he came to the conclusion that our coal beds corresponded to the Beaufort Beds.[1] Since then the conviction has grown amongst

[1] Molengraaff, Discussion on Dr. Corstorphine's paper "The Age of the Central South African Coalfield": Trans. Geol. Soc. S. Afr., vol. vi (1903), p. 45.

some of us that the Transvaal coal horizon corresponds rather to the Ecca Beds.

The present Director of the Transvaal Survey, however, has adopted Dr. Molengraaff's view that the Ecca Series is not represented at Vereeniging, the Dwyka Conglomerate being immediately followed by the Beaufort Series or Upper Karroo, as he terms it.[1] But, as militating against this view, I would point out that the Transvaal Coal-measures, while containing plant remains that are common both to the Ecca and to the Beaufort Series (such as *Glossopteris, Schizoneura,* and *Phyllotheca*), have also yielded abundant specimens of two species which at the Cape have only been found in the Ecca Beds. I refer to *Noeggerathiopsis Hislopi,* which occurs both in the Middelburg Coalfield (Boschfontein)[2] and at Vereeniging, and to *Gangamopteris cyclopteroides,* which occurs at Vereeniging.[3] *Cardiocarpus,*[4] which is associated with *Gangamopteris* and *Glossopteris* in Ecca Sandstone near Worcester, also occurs at Vereeniging. Moreover, to regard the Vereeniging Beds as of Beaufort (Upper Karroo of the Survey) age must involve the assumption of a considerable unconformity between the Dwyka Conglomerate and these beds, unless indeed we are to believe that the deposition of the glacial conglomerate took place at a much later date in the Transvaal than in the Cape Colony.

A minor matter to which the attention of the Survey might be drawn is the nomenclature to be adopted for the Karroo System, for if the coal sandstones are to be regarded as corresponding to the Beaufort Beds of the Cape, then it will be much preferable to retain the name of Middle Karroo Series for them, since the term Upper Karroo is applied only to the Stormberg Beds at the Cape.

Another difference of opinion between the Survey and some of us exists as to the unconformity beneath the Witwatersrand Beds; and whether the latter form an independent system, or are but a portion of a more comprehensive system in which the granite is intrusive. The Director of the Survey is apparently not prepared at present to admit that there is in the Transvaal an older system than the Witwatersrand. He is not satisfied with the evidence that has been advanced that the Mont Maré schists are older than the Witwatersrand, nor that the Witwatersrand Beds are younger than the granite on which they rest.[5] In taking up this position he ignores the evidence as to the relative age of the granite and the Witwatersrand Beds furnished by Dr. Corstorphine[6] and the late

[1] Kynaston, "Geology of the Transvaal and Orange River Colony": Science in South Africa (1905), p. 298.

[2] Seward: Q.J.G.S., 1897, p. 322.

[3] Feistmantel, "Uebersichtliche Darstellung der geologisch-palæontologischen Verhältnisse Süd-afrikas": Abhandlungen d. königl. böhm. Ges. d. Wiss., Folge vii, Band 3; Prague, 1889.

[4] Seward: Q.J.G.S., 1897, p. 322.

[5] Transvaal Geological Survey Report, 1904, p. 18.

[6] G. S. Corstorphine, "The Geological Relation of the Old Granite to the Witwatersrand Series": Trans. Geol. Soc. S. Afr., vol. vii (1904), pp. 9–12.

Mr. Dörffel.[1] But what is the nature of the evidence that he would deem satisfactory to establish the relation of the Witwatersrand Beds to the granite? They are seen in contact at numerous places, but nowhere is the latter found penetrating or sending off apophyses into the former. Neither do the sediments show anywhere any sign of contact metamorphism. On the contrary, they appear to have been accumulated on an ancient granite floor. If the granite were later than and intrusive into the Witwatersrand Beds, surely some evidence of this would be forthcoming. It is true that Mr. Kynaston does not deny the possibility of an unconformable relation, but he records the evidence as insufficient.

Now this is a question which affects the mapping of thousands of square miles of country; it is besides important to the public from a mining point of view. I will give an instance — boreholes put down by exploration companies through the overlying covering of Karroo rocks or Dolomite are invariably stopped if they should reach the Granite. Is the doubt as to the usually accepted relation of the Granite to the Witwatersrand Beds so strong in Mr. Kynaston's mind that he would advise the continuation of such boreholes? We unfortunate geologists and mining engineers, who have to take practical views of such matters, are not allowed the luxury of academic doubt. Further, the important question is involved as to the relation of the Witwatersrand Banket to the conglomerates and quartzites that occur in association with schistose rocks in the Barberton and Pietersburg districts, and in Swaziland and Mashonaland, a question which has recently been much discussed, owing to the prominence given to the so-called banket occurrence at Lomagunda in Rhodesia, and its correlation with the Witwatersrand rock.[2] I maintain that instead of shelving questions like these, the Survey should investigate the facts, and establish definitely the relation of the Witwatersrand Beds to the Old Granite, and the existence or non-existence of an older system of sedimentary rocks. These are questions of vast importance to the mining industry, and call for as early a settlement as possible.

While the maps produced by the Survey are a fit subject for congratulation there is room for a difference of opinion as to the line on which the survey work should be carried out. Personally I am of the opinion that in the present stage of the development of the country the most good would be done, not by giving us detailed maps (however excellent in themselves) of outside districts, but by settling the large questions which its Director holds still require solution.

While on the subject of the Survey I will touch on another question, of the importance of which Mr. Kynaston is as fully cognisant as we are. The maps issued by the Survey since its reorganisation in 1902 cover an area of about 4,100 square miles.

[1] D. Dörffel, "Note on the Geological Position of the Basement Granite": Trans. Geol. Soc. S. Afr., vol. vi (1903), pp. 104–105.

[2] F. P. Mennell, "The Banket Formation of Rhodesia": Trans. Geol. Soc. S. Afr., vol. viii (1905), p. 82.

This is a very creditable performance considering the smallness of the staff. But a simple computation will show that at this rate of progress some 30 years will be required to finish the work unless the staff be augmented. The importance of rapidly completing the geological survey of a country, dependent as this is for its future welfare on the development of its mineral resources, cannot be too strongly impressed on the authorities; and to accomplish it the staff must be largely increased. I am glad that we can welcome an additional field geologist in the person of Dr. W. A. Humphrey, who has had part of his training in South Africa, and we may trust that this is an augury of the Government's recognition of the importance of the work, and of its intention to carry it out with the least possible delay.

I will pass on now to a consideration of the data available for deducing the thickness of the South African formations.

2. *Thickness of the Strata.*

Since we know neither the base nor the summit of the Swaziland system no estimate can be made of the thickness of these ancient rocks, which are partly of sedimentary, partly of igneous origin, but have in both cases been profoundly modified. There can be no doubt, however, that they are very thick, and that an immense quantity of material has been removed by erosion since their first upheaval. Recently, in a paper read before this Society, Dr. Voit[1] has expressed the opinion that certain banded gneisses of the Northern Transvaal should be separated from the Swaziland system as an older fundamental gneiss, corresponding, say, for instance, to the Laurentian rocks of Canada and the Lewisian gneiss of Scotland. As, however, he describes no section from which the relation of these gneisses to the remainder of the Swaziland system can be inferred, and since it is by no means certain that these gneisses are anything else than a sheared or metamorphic portion of the granite, which in other places is found intrusive in the Swaziland Beds, it must be premature in the present state of our knowledge to attempt any such subdivision.

With regard to the Witwatersrand System, the shales and quartzites of the lower division have on the Rand a thickness of 12,000 feet; the upper division, if we exclude the Elsburg Series, about 7,000 feet; in all about 19,000 feet. The necessity of separating the Elsburg Series from the Witwatersrand Beds, which was advocated by Dr. Corstorphine and myself in a paper on the Geology of the Bezuidenhout Valley, read before this Society, is again shown by fresh evidence from the Klerksdorp district, which will be made the subject of a paper by Mr. Torissen. This series of conglomerates and quartzites has on the Rand a thickness of from 3,000 to 4,000 feet. I include it with the Ventersdorp System.

The thickness of the latter system, which includes boulder beds, coarse conglomerates, volcanic breccias and lavas, is very difficult

[1] F. W. Voit, "Gneiss Formation on the Limpopo": Trans. Geol. Soc. S. Afr., vol. viii (1905).

to compute. South of the Rand the Klipriversberg Amygdaloid has a thickness of at least 4,000 feet, and adding this to the thickness of the Elsburg Series, we get a total of 7,000 to 8,000 feet for the thickness of the Ventersdorp System as developed on the Rand.[1]

The Potchefstroom System presents difficulties of another kind, owing to the very variable thickness of its lower members, the Black Reef and the Dolomite Series. In the Pretoria and Witwatersrand districts the Black Reef Series is under 100 feet, even sinking to as little as 10 to 20 feet, as has been proved by boreholes on the East Rand[2]; whereas at Pilgrims' Rest Mr. Thord-Gray[3] has recently estimated its thickness at 1,800 feet, while Mr. Sawyer[4] gives it as 1,200 feet at Chunies Poort. The Dolomite Series has been estimated in the Pretoria district at 5,000 feet by Molengraaff,[5] although Mr. Kynaston considers it probable that its thickness does not exceed 3,000 feet in that district. In the Makapan Mountains Molengraaff puts it at 4,000 feet, near Godwan at 1,650 feet, in the vicinity of Lydenburg at 2,600 feet, and south of the Witwatersrand at 2,600 feet. Mr. Thord-Gray gives its thickness at Elandsfontein in the Lydenburg district as 3,000 feet, while Mr. Holmes informs me that from careful measurements he has made in the Marico district, where the series exists in very regular order in the Dwarsberg, he estimates the thickness of the Dolomite at as much as 7,500 feet, the Black Reef Series being very thin there, not more than 75 feet. Taking the thicknesses given above, it would appear as if where the basal quartzites are largely developed, as in the Lydenburg district, the Dolomite suffers a corresponding diminution, and where the Dolomite is thick the Black Reef is poorly developed. Together, the maximum thickness of the two formations probably does not exceed 8,000 feet. In Griqualand West Messrs. Rogers and Schwarz have found the limestone series, "measured from the quartzites, below which no limestone is seen, to the lowest jaspers or magnetite quartzites of the Griquatown Beds (Pretoria Series)," to have a thickness of 5,000 feet, while the underlying quartzite (Black Reef Series) varies from 200 to 2,000 feet.[6]

The Pretoria Series is estimated by the Transvaal Geological Survey to have a thickness of not less than 10,000 feet.[7] Mr. Holmes has measured this series in the Dwarsberg (Lotteringskop), and

[1] F. H. Hatch & G. S. Corstorphine, "The Geology of the Bezuidenhout Valley and the District East of Johannesburg": Trans. Geol. Soc. S. Afr., vol. vii (1904), pp. 97–109.

[2] F. H. Hatch, "The Extension of the Witwatersrand Beds eastward under the Dolomite and the Ecca Series of the Southern Transvaal": Trans. Geol. Soc. S. Afr., vol. vii (1904), p. 63.

[3] I. Thord-Gray, "Notes on the Geology of the Lydenburg Goldfields": Trans. Geol. Soc. S. Afr., vol. viii (1905), p. 66.

[4] A. R. Sawyer, "The Geology of the Transvaal": North of England Inst. Min. Engineers, 1905.

[5] G. A. F. Molengraaff, "Geology of the Transvaal": Johannesburg, 1904.

[6] A. W. Rogers & E. H. L. Schwarz, "Geology of the Orange River Valley in the Hopetown and Prieska Districts": Ann. Rep. Geol. Comm. Cape Colony, 1899, p. 80.

[7] Transvaal Geol. Surv. Rep., 1903, p. 40.

informs me that his figures work out to 9,900 feet, which is in very close agreement with the estimate of the Survey. We have, therefore, a maximum aggregate thickness for the three members of the Potchefstroom System of about 18,000 feet.

The thickness of the Waterberg Sandstone has not been measured in any place where there is anything approaching a complete section. The lower beds, however, have been carefully examined by Mr. Mellor in the Rhenosterkop area, and were found by him to have a thickness of 3,150 feet.[1] The Table Mountain Sandstone, which appears to be the Cape representative of the Waterberg,[2] is estimated by the Cape Survey to have a thickness of 5,000 feet, and there can be very little doubt that the Waterberg formation is at least as thick.

The Bokkeveld Beds, which succeed the Table Mountain Sandstone at the Cape, are estimated by the Cape Survey at 2,500 feet, and the same thickness is given to the Witteberg Beds, making a total thickness for the Cape System of 10,000 feet. The Bokkeveld and Witteberg Series are, however, absent in the Transvaal.

According to Mr. Rogers,[3] the Karroo System has a thickness of 18,000 feet, of which 4,900 feet is apportioned to the Dwyka and Ecca Series, 5,000 feet to the Beaufort Beds, and 8,200 feet to the Stormberg, 4,000 feet of the latter being occupied by the volcanic group which forms the summit of the system.

Summarising, we have the following maximum thickness for the South African stratified rocks:—

Karroo System	18,000 feet.
Cape System (in which is included the Waterberg formations, as correlative with the Table Mountain Sandstone)	10,000 ,,
Potchefstroom System ... ... about	18,000 ,,
Ventersdorp System ... ... about	8,000 ,,
Witwatersrand System	19,000 ,,

Excluding the Karroo Beds, there remain some 55,000 feet of beds (say 10 miles) lying below the base of that system and above the Swaziland Beds, or, in other words, below the Permo-Carboniferous of Europe. When we take into consideration the gaps represented by four great unconformities, we see that the 'geological column' must necessarily be much greater than this total, since no allowance is made for the losses due to denudation. It probably embraces the period of time covered by the Devonian, Silurian, Ordovician, and Cambrian Systems of the European classification.

Unfortunately, no correlation with the European formations is at present possible, on account of the complete absence of fossils in all the South African formations below the Bokkeveld (Devonian) Beds.[4] But we need not despair of finding organic remains in some

[1] Transvaal Geol. Surv. Rep., 1904.

[2] F. H. Hatch & G. S. Corstorphine: "The Geology of South Africa," p. 309; London, 1905.

[3] A. W. Rogers: "The Geology of Cape Colony," p. 147; London, 1905.

[4] Quite recently some lamellibranch remains have been found by the Cape Survey in the Table Mountain Sandstone, but have not yet been determined.

of these formations, when we remember the patient search that has been necessary in Europe in order to obtain fossil evidence for the age of important formations. Rogers[1] instances the work done in the north of Devonshire by two generations of geologists before the Morte slates were found to be fossiliferous. We may still hope that some of our more promising shales and limestones will yet yield palæontological evidence which will enable them to be correlated with the classic systems of Europe.

(To be concluded in our next number.)

II.—The Physical History of the Great Pleistocene Lake of Portugal.[2]

By Professor Edward Hull, LL.D., F.R.S., F.G.S.

A RECENT visit to Portugal has given me an opportunity of seeing the geological features of the neighbourhood of Lisbon and the Lower Tagus; and though of a somewhat cursory nature I venture to bring them before the Society, being supplemented by reference to the investigations of previous observers, and a study of the excellent geological maps which are in the library of this Society. I make no pretension to be an original explorer, but I hope to be able to show that there is a very interesting physical history, not hitherto written so far as I am able to discover, bringing down the account of the changes which have taken place from the Cretaceous period to the Recent, or Quaternary, epoch.

In addition to my own observations I have relied for the necessary data for this paper on the geological maps of Portugal,[3] together with the papers of the late Mr. Daniel Sharpe[4] and of Mr. Smith[5] of Jordan Hill, which sufficiently put us in possession of the materials for an historical sketch of the remarkable physical changes which the Iberian Peninsula has undergone, at least along its western margin, in Tertiary and still more recent times.

Geological Formations.

The formations bordering the lower banks of the Tagus near Lisbon are arranged by Sharpe in the following order of succession:—

Mr. D. Sharpe's Classification.

1. Upper Tertiary Sands, etc.
2. Almada Beds (Marine).
3. Lower Tertiary Conglomerate.
4. Hippurite Limestone (Cretaceous).

[1] "Geology of Cape Colony," p. 114; London, 1905.
[2] Read before the Geological Society, December 6th, 1905.
[3] "Carta Geologica de Portugal," ed. by Carlos Riberio & J. F. N. Delgado (1876); "Mapa Geologico de España y Portugal," by D. F. de Botella (1879).
[4] "On the Geology of Lisbon": Trans. Geol. Soc., ser. II (1839), and Q.J.G.S., vol. vi, p. 134 (1850).
[5] "On the Age of the Tertiary Beds of the Tagus": Q.J.G.S., vol. iii, p. 410 (1847).

In the *Legenda* of the Geological Map of Portugal the succession does not materially differ from the above, and is as follows :—

Terciario	Moderno e quaternario (alluvial). Lacustre superior. Marino (Almada Beds). Lacustre inferior.
Cretaceo	Superior (Hippurite Limestone). Inferior.

Description.

The Upper Tertiary (Lacustre superior) consists of fine white, yellow, and red sands, with thin layers of rolled pebbles, nearly horizontal and 100 feet in thickness, resting on 150 feet of coarse ferruginous sands and gravel; no organic remains have been observed in these beds; but at a locality 15 miles from Verdelha, on the north bank of the Tagus, the hills rising about 200 feet above the sea consist of brown marl and soft rubbly limestone containing *Lymnæa longiscata* (Sow.), and have been traced from Cartaxo to Santarem. These are probably the uppermost beds of the lacustrine series, and overlie the sands and gravels previously described.

At Villa Franca a bed of marl occurs 50 feet above the Tagus with *Lutraria compressa,* and near Villa Nova da Rainha the same shell occurs with *Cardium edule,* both now living in the estuary of the Tagus near Lisbon; so that, as Sharpe observes, it is evident that this part of the country has been upheaved at least 50 feet within a comparatively recent period.[1] The occurrence of these shells indicates, as it seems to the writer, a local intrusion of the sea-waters at an early stage of the "Lacustrine" period.

The Almada Beds (Miocene).

These beds are so named by Sharpe from the promontory on the south bank of the Tagus, opposite the city of Lisbon, where they are well shown in the sea cliff. They consist of marls and limestones rich in marine fossils, and are considered by Smith to be of Older Miocene age. Of the 124 species determined, 20 are new and peculiar, and are figured and described by G. B. Sowerby,[2] 51 occur in the Older Miocene beds of Bordeaux, 17 in the Falunes of Touraine, 15 in the sub-Apennine beds, 8 in the Eocene of the London and Paris Basins, and 35 are recent. Their claim to be referable to the Miocene stage is thus clearly established. At Lisbon they rest unconformably on the Cretaceous Limestone.[3]

Pliocene Beds not represented.

It will be observed that the "Almada Beds" of Miocene age are immediately succeeded by those denoted on the Geological Map of Portugal as "Lacustre superior," and by Sharpe called "Upper Tertiary Sands, etc." The relative position of these sands to the

[1] Sharpe, ibid., p. 138.
[2] James Smith, supra cit., pp. 410–423.
[3] The Almada Beds rest on the sands and gravels called "Lacustre inferior," but as they are unfossiliferous their geological age is obscure or unknown.

underlying "Almada Beds" in the neighbourhood of Lisbon is very clearly shown in the sections accompanying Mr. Sharpe's paper; for, while the Almada Beds are inclined at angles varying from 10° to 15°, the Upper Sands are well-nigh horizontal. In addition to this the Almada Beds have been faulted and denuded, and subjected to disturbances which do not affect the Upper Lacustrine Sands. All these phenomena go to indicate absolute disconnection between the two formations, a disconnection which in time would in other districts have been filled up by the Pliocene beds, but which are here altogether absent from their place in the geological series. The cause of this *lacuna* I hope to be able to explain further on.

The Sub-Oceanic Extension of the Tagus.

When a few years since I was endeavouring to determine by the aid of the soundings on the Admiralty Charts the physical features of the land areas now covered by the waters of the Eastern Atlantic, I was enabled to show that the principal rivers of Western Europe, and partly of Africa, were continued across the continental platform to great depths and various distances under the ocean from their present outlets. Amongst these the sub-oceanic Tagus was one of the best developed, and can be well delineated owing to the large number of soundings off the coast of Portugal. The isobathic contours are perfectly clear, as will be seen from the photographic slides, together with those of the Adour in the north of Spain and the Congo on the coast of Africa.[1] In reference to the sub-oceanic cañon of the Adour, I may mention that Dr. Nansen, who in northern latitudes has studied these physical features, has stated that it is impossible to suppose that it can be anything else than a drowned river valley.[2]

I do not intend to go farther into the question of these submerged valleys, except as they are connected with the geological history of the Tagus valley. Their existence is clearly due to river erosion, inasmuch as they could not have been formed under the ocean-waters themselves. The question we are here concerned with is the determination of the geological period of their formation. The conditions must have been those of great land elevation affecting the ocean-bed and adjoining lands. That they are not of great geological antiquity is shown by the fact that the rivers with which they were continuous are geologically modern, more modern indeed than the Chalk, and, in this district, than the Miocene, which, as shown above, is a marine deposit.

Pliocene Elevation.

It is to the Pliocene and post-Pliocene epochs that we must therefore refer that great land-uprise which would be necessary for the erosion

[1] These photographic pictures were then exhibited, but have already been described in the Trans. Vict. Inst., vols. xxxi and xxxii.

[2] Nansen, "Bathymetrical Features of the North Polar Seas, etc.," p. 95 (1893–5).

of these river-valleys, and owing to which there was no deposition of strata under the ocean. To this cause I venture to attribute the absence of representatives of the Pliocene formation in Portugal; as, indeed, is the case with other parts of the Continent and the western areas of the British Isles.

From the above considerations it will be seen that between the "Upper Tertiary Sands" of Sharpe (or the "Lacustre superior" of the Geological Survey) and the marine "Almada Beds" there is no physical connection. As regards periods of formation, they are separated by the whole of the Pliocene and probably post-Pliocene periods, as already stated. It is therefore necessary to revise the classification of the post-Cretaceous series of the authors above quoted, and I therefore venture to substitute for these the following arrangement of the beds.

Revised Classification.

Quaternary	1. Recent and Quaternary.	Alluvia of the valley and estuary of the Tagus.
	2. Lacustrine.	Marls with *Lymnæa*, sands and gravel.
	3. Post-Pliocene and Pliocene.	Not represented unless by some land-glacial beds due to elevation.
Tertiary	4. Miocene.	Almada Beds, calcareous marls and limestones with marine fossils.
	5. Eocene (?).	Unfossiliferous sands and gravels (Lacustre inferior) of doubtful age.
Cretaceous	6. Upper.	Hippurite Limestone.

Personal.

When observing the sections of strata, along the line of the railway for several miles between Carlaxo and Abrantes, consisting of white, yellow, and red laminated sands, with lines of rolled pebbles, horizontally stratified, and extending to a height of 150 to 200 feet above the river, it became evident that these beds could not have been deposited by the river itself; and I arrived at the conclusion that they must have formed the bed of an extensive lake. I was therefore anxious to ascertain whether my conclusion was borne out by the Geological Survey Map of Portugal. It was therefore with great satisfaction that on consulting the maps I found that these beds were included under the term "Lacustre superior." They are specially coloured, and, according to Sharpe, cover an area of "2,000 to 3,000 square miles."[1] On crossing the Tagus at Praia we find the country formed of extensive plains of gravel, from which at Das Vargans and Cunheira the bed-rock of granite emerges and the gravel and sand cease; this limit of the lacustrine beds probably corresponds very nearly with that of the original waters of the lake itself. To this point of the limit of the lake it is now necessary to direct our attention for a brief space.

[1] Supra cit., p. 138.

The Limits of the Pleistocene Lake of Portugal.

In dealing with this question I have to be guided by the Geological Map of Portugal, on which is represented the area of the "Lacustre superior" beds by a light-yellowish tint. Thus guided, the margin of the lake stretched along the banks of the Tagus from Cartaxo to Abrantes; then turning southwards it stretched to Alvallade, and thence to the Atlantic coast and the mouth of the Tagus. Over this area the lacustrine beds rest directly on the granitic rocks, or on the supposed "Lower Lacustrine" beds (Lacustre inferior), the Miocene beds being absent; they have therefore no connection with the upper lacustrine deposits with which we are dealing. The margin of these deposits is, according to the map, much indented along the river-valleys flowing towards the west, and showing that they have been considerably denuded during the rising of the land which took place subsequently, and to which is owing the drainage of the lake itself.

During the period of depression in which the waters of the lake accumulated, it would appear that the general level of its bed was nearly that of the outer sea, and that the sea-waters gained access occasionally during the earlier stage of its formation, owing to which (as already stated) some marine molluscs gained access. The magnificent harbour of Lisbon doubtless formed a portion of the lake, and the narrow channel by which it is connected with the ocean may be regarded as the unsubmerged portion of the great sub-oceanic cañon which carried the waters for about fifty miles beyond its present outlet. On the final uprise of the land to its present level the channel of the river was deepened, and the waters of the lake were drained off; and thus the great river which filled the basin afterwards became the agent by which it was ultimately drained.

Such appears to have been the physical changes coming down into recent times which have brought about the present conditions of land and sea in the western part of the Iberian Peninsula.

Glacial Conditions in Pliocene Times in Portugal.

In connection with the Pliocene elevation here postulated, it is interesting to observe that it was concurrent with extensive glacial conditions in the western portion of the Iberian Peninsula. It has long been known that the glaciers of the Pyrenees, like those of the Alps, extended far beyond their present limits in the Glacial period, but it is not so generally known that Portugal was the seat of extensive glacial conditions. This, however, was the case; and according to the views of Sgr. Delgado, the Director of the Portuguese Geological Survey, than whom there is no higher authority, these conditions commenced with the Pliocene epoch, gradually giving way to one of progressive refrigeration of the climate, accompanied by an invasion of glacial ice descending from the mountain chain of the Serra d'Estrella. This chain, commencing at Garda, ranges in a south-west direction through the centre of Portugal, attaining a height of 6,539 feet, and was, in all probability, the most important axis of glacial dispersion during the post-Pliocene period. Of the great extent of glacier-ice both to the north of the Serra, where it invaded the affluents of the Mondégo, as well as the regions to the south towards the valley of the Tagus, there can be no doubt since the publication of M. Delgado's elaborate memoir,[1] following on that of his late colleague, M. Frederico A. de Vasconcellos,[2] both beautifully illustrated by photographic plates, recalling all the familiar phenomena of mountainous regions from which the glaciers have disappeared. According to Delgado there were two glacial stages separated by an interglacial one ("La phase interglaciaire"), corresponding to those which, in company with some British geologists, I have long held as having occurred in the British Isles. The most important point to be noticed is the occurrence of these glacial phenomena at an epoch corresponding to that of the elevation of the land and the erosion of the now submerged valley of the Tagus. If there are any geologists who regard this concurrence of events as accidental I am unable to agree with them. To the mind of myself, and a goodly number of other physicists both in Britain and America,[3] the glacial conditions are the direct result of the land elevation, for the simple reason that altitude above the sea-level is the governing factor, though not the only one, in the occurrence of warm and cold temperatures in all parts of the globe, even in equatorial regions. If the surface of Portugal was sufficiently elevated to allow of the erosion of the Tagus out to a distance from the coast of 55 miles, and to a depth of over 7,000 feet from the surface of the ocean,[4] we have the measure of the elevation of the land at the Glacial period. Adding, therefore, the depth of the submerged cañon (7,200 feet) to the present elevation of the Serra d'Estrella (6,539 feet), we have as the result a mountain 13,739 feet high, a height sufficient, notwithstanding its latitude, to give rise to a system of glacial dispersion and erosion, to some degree, comparable with that of the Alps at the present day. I now feel satisfied that, on observing the forms of the granite masses as they emerged from beneath the lacustrine gravels towards the Portuguese frontier, I was not mistaken in recognising them as ice-worn surfaces.

[1] "Note sur l'Existence d'anciens Glaciers dans la Vallée du Mondego," par J. F. Nery Delgado, extr. des Communicadões da Direc. dos Tratalhos Geologicos, tome iii (1895).

[2] Ibid., tome i, p. 189 (1887).

[3] See Professor J. W. Spencer on "Professor Hull's Sub-oceanic Terraces, etc.," a review, *American Geologist*, vol. xxxv (March, 1905).

[4] Trans. Vict. Inst., vol. xxxi, p. 284, footnote.

III.—On a Collection of Fossil Corals from Eastern Egypt, Abu Roash, and Sinai.

By J. W. Gregory, D.Sc., F.R.S., F.G.S.,
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(PLATES VI and VII.[1])

(*Concluded from the February Number, p.* 58.)

III. PLEISTOCENE.

SYMPHYLLIA, Edwards & Haime, 1848.

Symphyllia erythracea (Klunz.), 1879.

Isophyllia erythracea, Klunzinger, 1879: Korallth. roth. Meer., pt. iii, p. 10, pl. i, fig. 10; pl. ix, fig. 9.
Symphyllia erythracea, Gregory, 1898, Egypt. Foss. Madreporaria: Geol. Mag., Dec. IV, Vol. V, p. 242.

Distribution.—Recent: Red Sea (Klunzinger). Pleistocene, fossil: ? Jebel Zeit (Gregory, 1898); also Old Beach, Camp 7; Wadi Barud, Eastern Egypt. No. J 1789.

STYLOPHORA, Schweigger, 1819.

1. Stylophora elongata (Lamarck), 1816.

Porites elongata, Lamarck, 1816: Hist. nat. Anim. sans Vert., vol. ii, p. 271.
Stylophora elongata, Klunzinger, 1879: Korallenth. roth. Meer., pt. ii, p. 64, pl. vii, fig. 14; pl. viii, fig. 19.

Six fragments and a slide cut from one of them (No. J 2153), collected by Mr. Barron on the coastal plain between Ras Jemsa and Jebel Zeit, agree in all characters with this species, which is clearly very closely allied to *S. pistillata* (Esper), the common Red Sea form.

Eight worn fragments, J 2186, from the raised beach, east of Jebel Esh, belong to the same species.

2. Stylophora cf. palmata (Blainville), 1830.

Sideropora palmata, Blainville, 1830: Dict. Sci. nat., vol. lx, p. 360.
Stylophora palmata, Edwards & Haime, 1850: Ann. Sci. nat., ser. iii, vol. xiii, p. 103.

Distribution. — Recent: Red Sea and Indian Ocean. Fossil, Pleistocene: 380 feet above sea-level, near Camp 8 in Wadi Shigeli.

There are two limestone specimens, which bear surface casts of a *Stylophora*, which are probably *S. palmata*, but they are not sufficiently well preserved for certain identification. They were collected by Mr. Barron, 380 feet above the sea, near Camp 7 in Wadi Abu Shigeli. J 1667.

CŒLORIA, Edwards & Haime, 1848.

Cœloria lamellina (Ehrenberg), 1834.

Platygyra lamellina, Ehrenberg, 1834, Beit. Corallenth. roth. Meer.: Abh. k. Akad. Wiss. Berlin für 1832, p. 323.
Cœloria lamellina, Edwards & Haime, 1851: Pol. foss. Terr. palæoz., p. 93; 1857, Hist. nat. Cor., vol. ii, p. 415.

[1] [By an error of the binder, *both* Plates VI and VII appeared in the February Number with the first part of this paper.—Edit. Geol. Mag.]

Cœloria ehrenbergiana, Edwards & Haime, 1849: Ann. Sci. nat., ser. III, vol. xi, p. 296.
Platygyra labyrinthica, var. *leptochila*, Ehrenberg, 1834: op. cit., p. 323.
Cœloria labyrinthiformis, Haeckel, 1876: Arab. Korall., pl. ii, fig. 4.
Cœloria forskaliana, Edwards & Haime, 1849: op. cit., p. 296.
Cœloria forskalana, Edwards & Haime, 1851: op. cit., p. 93; 1857, op. cit., p. 414.
Cœloria bottæ, Edwards & Haime, 1849: op. cit., p. 295; 1851, op. cit., p. 93; 1857, op. cit., p. 414.
Cœloria subdentata, Edwards & Haime, 1849: op. cit., p. 296; 1857, op. cit., p. 413.
Cœloria arabica, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 17, pl. ii, figs. 1, 2, 3, 8; pl. ix, figs. 10*a–c*.

The best specimen in the collection is a large, massive block (J 1578), which I refer to var. *triangularis*, Klunz., but it is so eroded that the calices are destroyed, and the depth of the calicular furrows gives it some resemblance to var. *leptochila*, Ehr.

Klunzinger renamed the common Red Sea Cœloria *C. arabica*, though there are several names with prior right, and I have, therefore, adopted the oldest of them.

The specimens referable to *C. lamellina* are:—

J 1578, a large specimen of var. *triangularis*, Klunz.: raised beach, Camp 4, 80 feet above the sea, Wadi Hamrawein, near Qosseir.

J 2115, a specimen of var. *triangularis*, Klunz.: lower raised beach, north of Qosseir.

J 2234, a specimen of var. *subdentata*, Ed. & H.: raised beach, east of Gharib.

J 2231, a specimen of var. *leptochila* (Ehr.): raised beach, east of Gharib.

K 1630, a specimen of the typical form: raised beach, 80 feet above sea-level, Wadi Gueh, Qosseir.

FAVIA, Oken, 1815.

1. Favia lobata (Edwards & Haime), 1850.

Parastræa lobata, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 171.
Favia lobata, Edwards & Haime, 1857: Hist. nat. Cor., vol. ii, p. 434, pl. D 8, fig. 3.
Favia lobata, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 31, pl. iii, fig. 9; pl. x, fig. 8.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: raised beach, Camp 4, Wadi Hamrawein, near Qosseir, K 1633; lower raised beach, north of Qosseir, J 2143.

2. Favia ehrenbergi, Klunzinger, 1879, var. sulcata, Klunz.

Korallenth. roth. Meer., pt. iii, p. 29, pl. iii, figs. 5, 8.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: raised beach, Camp 6, northern Wadi Queh, K 1577.

Some corallites of the *Favia ehrenbergi* type in a corallum of *Goniastræa pectinata*, J 1819 (see Pl. VII, Fig. 14).

GONIASTRÆA, Edwards & Haime, 1848.

1. Goniastræa retiformis (Lamarck, 1816).

Astræa retiformis, Lamarck, 1816: Anim. sans Vert., vol. ii, p. 265.
Goniastræa retiformis, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 161.

Goniastræa retiformis, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 36, pl. iv, fig. 5.

Distribution. — Recent: Red Sea, Indian and Pacific Oceans. Fossil, Egypt: raised beach, 50 feet above sea-level, Jemsa, J 2032; lower raised beach, north of Qosseir, J 2118; raised beach, east of Gharib, J 2232.

2. Goniastræa pectinata (Ehrenberg), 1834.

Astræa pectinata, Ehrenberg, 1834, Beitr. Corallenth: Abh. k. Akad. Wiss. Berlin für 1832, p. 320.
Goniastræa pectinata, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 34, pl. iv, fig. 6.

Distribution. — Recent: Red Sea. Fossil, Pleistocene: lower raised beach on coast plain, north of Qosseir, J 2119; raised 50 feet beach, Jemsa, south of Jebel Zeit, J 1819.

The specimen (J 1819) is of interest, as it shows one of these cases in which some of the corallites of the same specimen would, if found dissociated, be assigned to distinct genera. Part of the surface is shown on Pl. VII, Fig. 14. The narrow walled corallites on the left side of the figure agree with *G. pectinata*; but those in which the calices are separated by wide valleys, so that even the costæ of the adjacent corallites do not unite, have the form of *Favia ehrenbergi.*

Such occurrences show that the plasticity of the corals is such that occasional abnormal polypes may suddenly acquire the characters of another genus.

3. Goniastræa favus (Forskal), 1775.

Madrepora favus, Forskal, 1775: Descr. Anim. Itin. Orient, p. 132.
Goniastræa favus, Klunzinger, 1879:, Korallenth. roth. Meer., pt. iii, p. 35, pl. iv, fig. 4; pl. x, fig. 7.

Distribution.—Recent: Red Sea, Indian Ocean. Fossil, Pleistocene: raised beach, 50 feet above sea-level, Jemsa, J 2032.

SOLENASTRÆA, Edwards & Haime, 1848.

1. Solenastræa chalcidicum (Forskal), 1775. (Pl. VII, Fig. 12.)

Madrepora chalcidicum, Forskal, 1775: Descr. Anim. Itin. Orient., p. 136.
Cyphastræa chalcidicum, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 53, pl. v, fig. 8; pl. x, fig. 11.

Distribution. — Recent: Red Sea. Fossil, Pleistocene: raised beaches near Qosseir.

Figures.—Pl. VII, Fig. 12, part of the surface of a worn corallum of J 2140, from near Qosseir, by 2 diam.

J 1633, a very altered specimen, but judging by the cellular exotheca and rudimentary columella it is *S. chalcidicum* rather than *S. serailia*, the alternative identification: Camp 4, Wadi Hamrawein, north-west of Qosseir, Eastern Egypt.

H 1633*b*: Camp 4, Wadi Hamrawein.

H 1633*e*, a very weathered specimen, bored by Lithodomi: Camp 4, Wadi Hamrawein.

H 1633*f*: Camp 4, Wadi Hamrawein.

J 2122, 2138, two young coralla, one 27 mm. diam.: lower raised beach, north of Qosseir.

J 2136, a well-preserved specimen: lower raised beach, north of Qosseir.

J 2140, two specimens with dense walls: lower raised beach, north of Qosseir.

J 2149: lower raised beach, north of Qosseir.

1623, a much altered specimen, which, however, retains some of the original surface, showing the extent of projection of the calicinal edges: raised beach, Camp 4, Wadi Hamrawein, near Qosseir.

1628, a well-preserved specimen: 80 feet above sea-level, Wadi Queh, near Qosseir.

2. Solenastræa serailia (Forskal), 1775.

Madrepora serailia, Forskal, 1775: Descr. Anim. Itin. Orient., p. 135.
Cyphastræa serailia, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 52, pl. v, fig. 4; pl. x, fig. 12.
Solenastræa forskalana, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 123; 1857, Hist. nat. Cor., vol. ii, p. 497.

Distribution. — Recent: Red Sea. Fossil, Pleistocene: raised beach, east of Jebel Esh, J 2177.

This specimen has the more compact exotheca and the equality of the septa of the first and second cycles, which are two of the chief distinctions of this species as compared with *S. chalcidicum* (Forsk.).

3. ? Solenastræa savignyi (Ed. & H.), 1850.

Cyphastræa savignyi, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 115.
Cyphastræa savignyi, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 51, pl. v, fig. 7.

This specimen (J 1826) is a large block with long, thin corallites, about $2\frac{1}{2}$–3 mm. in diameter. It agrees with this species by its compact endotheca, and the marked inequality of the primary and secondary septa. But the specimen has been so altered that its identification is not free from doubt.

ORBICELLA, Dana, 1848.

1. Orbicella forskali (Edwards & Haime), 1849.

Astræa forskaliana, Edwards & Haime, 1849, Mon. Astr.: Ann. Sci. nat., Zool., ser. III, vol. xii, p. 100.

For Egyptian references and synonyms, see Gregory, 1898, Egypt. Foss. Madrep., Geol. Mag., Dec. IV, Vol. V, p. 242.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: low-level and high-level raised reefs, near Jebel Zeit; also near Qosseir, Wadi Abu Shigeli, and Wadi Barud.

H 1633*c*; this specimen is much weathered, and has no trace of the surface, but the available characters are the same as those of J 2138: Camp 4, Wadi Hamrawein, near Qosseir.

J 1669, a specimen with the calices 6–8 mm. in diam.; the corallites are circular and not elliptical as in *O. mammillosa*: raised beach, 80 feet above sea-level, Wadi Abu Shigeli.

J 1789, a block with corallites 7 mm. in diam.: old beach, Camp 7, Wadi Barud.

J 2138, a small specimen but with well-preserved characters: lower raised beach, north of Qosseir.

2. Orbicella mammillosa, Klunzinger, 1879.

Korallenth. roth. Meer., pt. iii, p. 49, pl. v, fig. 5; pl. x, fig. 10.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt and Gulf of Tadjura (Faurot), lower raised beach, north of Qosseir, No. J 2145.

This specimen is worn and is fragmentary; it has three cycles of septa, a large columella, and some of the corallites are oval in section. In a previous paper (Geol. Mag., 1898, p. 242) I included this *Orbicella* in *O. forskali*, and I still think that it may well be merged in that species. But as it is necessary to contrast these fossils as closely as possible with the recent Red Sea fauna, I am, for this purpose, recording the specimen under Klunzinger's name. The following species is provisionally accepted for the same reason.

3. Orbicella laxa, Klunzinger, 1879.

Op. cit., pt. iii, p. 49, pl. v, fig. 3; pl. x, fig. 9.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt.

H 1633, a large block with thin walls, thickened by some secondary calcification: Camp 4, Wadi Hamrawein, near Qosseir.

H 1633*d*, a specimen with corallites varying from 8 to 10 mm. in diam.: Camp 4, Wadi Hamrawein, near Qosseir.

K 1663, a specimen with somewhat smaller calices, 7 mm. in diam. The corallites are close, and have very little exotheca; the walls are thin, and the septa number 27 to 30. None of the surface is shown. This is the coral which differs most from the central type of *O. laxa*, but I do not see any adequate reason for excluding it from that species: 380 feet above sea-level, near Camp 7, Wadi Shigeli.

ECHINOPORA, Lamarck, 1816.

1. Echinopora fruticulosa (Ehrenberg), 1834.

Stephanocora hemprichii, forma *fruticulosa*, Ehrenberg, 1834, Beitr. Korallenth.: Abh. k. Akad. Wiss. Berlin für 1832, p. 301.

Echinopora fruticulosa, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 55, pl. vi, fig. 4.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt, 380 feet above sea-level, near Camp 7, Wadi Shigeli, K 1660.

This specimen is the irregular nodular base of a coral with calices 5–5·5 mm. in diameter, so they are somewhat smaller than in the recent corals, and the paliform processes are perhaps less distinct. It is, moreover, not raised in definite branches, but would probably have developed thus had it grown larger. In other respects it appears to be the same as the recent forms.

K 1665, from the same locality, is a fragment of *Echinopora*, but is specifically indeterminable.

GALAXEA, Oken, 1815.

Galaxea fascicularis (Linnæus), 1767.

Madrepora fascicularis, Linnæus, 1767: Syst. Nat., 12th ed., vol. i, pt. 2, p. 1278.
Madrepora fascicularis, Ellis & Solander, 1786: Nat. Hist. Zooph., p. 151, pl. xxx.
Galaxea fascicularis, Oken, 1815: Lehrb. Naturgesch., Th. iii, Zool., Abt. 1, p. 73.
Galaxea fascicularis, Klunzinger, 1879: Korallenth. roth. Meer., pt. ii, p. 78.

Distribution. — Recent: Red Sea. Fossil, Pleistocene: raised beach, 80 feet above sea-level, Wadi Queh, near Qosseir, K 1629; Camp 6, Wadi Queh, K 1631.

These are two excellent specimens. The septa of the primary and secondary cycles are subequal, and the corallites are from 6·5 by 9 mm. or 6·5 by 10 mm. in diameter, and they are not gyrose or so compressed as in *G. irregularis*, Ed. & H.

LEPTASTRÆA, Edwards & Haime, 1848.

Leptastræa ehrenbergana, Edwards & Haime, 1850.

Ann. Sci. nat., ser. iii, vol. xii, p. 120; and Hist. nat. Cor., vol. ii (1857), p. 494, pl. d 7, fig. 4.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: the raised beach between Jebel Mellaha and Jebel Zeit, J 2160; raised beach, 80 feet above sea-level, Wadi Queh, K 1586.

This species has polygonal calices, a well-developed papillary columella, and 24 to 30 septa. In No. J 2160 the calices are 4–7 mm. in diameter.

PRIONASTRÆA.

1. Prionastræa pentagona (Esper), 1795.

Madrepora pentagona, Esper, 1795: 'Pflanzenth.' Forsetz., p. 23, pl. xxxix.
Prionastræa pentagona, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 41, pl. iv, fig. 11; pl. x, figs. 6, *a*, *b*.

Distribution.—Recent: Red Sea, Egypt. Fossil, Pleistocene: lower raised beach, north of Qosseir, J 2142 and J 2150.

2. Prionastræa tesserifera, Ehrenberg, 1834.

Astræa tesserifera, Ehrenberg, 1834, Beitr. Corallenth.: Abh. k. Akad. Wiss. Berlin für 1832, p. 321.
Prionastræa tesserifera, Edwards & Haime, 1851: Pol. Terr. palæoz., p. 102.
Prionastræa tesserifera, Klunzinger, 1897: Korallenth. roth. Meer., pt. iii, p. 37, pl. iv, fig. 9.

Distribution.—Recent: Red Sea. Pleistocene: Sinai, north end of the Quarantine Enclosure, El Tor, L 4193. Egypt, raised beach east of Jebel Esh, J 2177 (two specimens).

3. Prionastræa vasta, Klunzinger, 1879.

Korallenth. roth. Meer., pt. iii, p. 38, pl. iv, figs. 8, 12; pl. x, figs. 4, *a*, *b*.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt, raised beach, east of Gharib, J 2226.

Klunzinger has founded this species, which he admits as a very near ally of *Prionastræa tesserifera*, owing to the greater size of its calices; in *P. tesserifera* he records them as from 10 to 12 mm. wide and from 10 to 15 mm. long, while those of *P. vasta* he records as 10–15 mm. wide and 10–20 mm. long; but in his own photograph of *P. tesserifera* one of the calices is 20 mm. long, and they vary so much in different parts of the colony that *P. vasta* seems to me only a variety of *P. tesserifera* with large corallites. But for the sake of precise comparison between the recent and fossil faunas the species may be provisionally accepted.

SIDERASTRÆA, Blainville, 1830.

1. Siderastræa savignyi, Edwards & Haime, 1850.

Siderastræa savignyana, Edwards & Haime, 1850: Ann. Sci. nat., ser. III, vol. xii, p. 140.
Siderastræa savignyana, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 77.
Astræa savignyana, Edwards & Haime, 1857: Hist. nat. Cor., vol. ii, p. 508.

Distribution. — Recent: Red Sea. Fossil, Pleistocene: Egypt (*fide* Edwards & Haime); also at raised beach, east of Jebel Esh, J 2172–2190.

2. Siderastræa lilacea, Klunzinger, 1879.

Korallenth. roth. Meer., pt. iii, p. 77, pl. ix, fig. 6; pl. x, figs. 16, *a*, *b*.

Distribution.—Recent: Egypt, near Qosseir (Klunzinger). Fossil, Pleistocene: lower raised beach, north of Qosseir, J 2122–2138; raised beach, east of Jebel Esh, J 2186.

The specimens, Nos. J 2122–2138, include three nodular coralla, of which the two more perfect ones are 56 by 42 mm. in diameter and 25 mm. high, and 29 by 27 mm. in diameter and 13·5 mm. high.

FUNGIA, Lamarck, 1801.

I have previously called attention to the variability of the Fungiæ found in the Pleistocene deposits of Egypt.[1] Klunzinger accepts four previously described species as found in the Red Sea, and founded three more. He divided them primarily according to the septal teeth, and his secondary division is based on the circular or elliptical form of the corallum. The specimens included in the present collection do not seem to me to agree with Klunzinger's scheme, as they represent a union of characters. But accepting Klunzinger's arrangement for the sake of convenience, the Fungias in this collection can be named as follows:—

1. Fungia patella (Ellis & Solander), 1786.

Madrepora patella, Ellis & Solander, 1786: Nat. Hist. Zooph., pl. xxviii, figs. 1–4.
Fungia patellaris, Lamarck, 1801: Syst. Anim. sans Vert., p. 370.
Fungia patella, Klunzinger, 1879: Korallenth. roth. Meer., pt. iii, p. 61, pl. vii, fig. 4; pl. viii, fig. 2.

Distribution. — Recent. Fossil, Pleistocene: Egypt, R 1308, Brit. Mus. (Gregory, op. cit.), Sinai, Lower Terrace, south of Hedemia Bay, L 3498.

2. Fungia valida, Verrill. (Pl. VII, Fig. 13.)

Bull. Mus. Comp. Zool., No. 1, p. 51.

Distribution.—Recent: Indian Ocean (Zanzibar). Fossil, Pleistocene: Egypt, Wadi Queh; Sinai, Lower Terrace, south of Hedemia Bay.

[1] Geol. Mag., Dec. IV, Vol. V (1898), p. 244.

Figures.—Pl. VII, Fig. 13, part of a young corallum from the side, nat. size.

K 1560, a set of five specimens ranging from 20 by 21·5 mm. in diameter and 5·5 mm. thick to 60 by 58 mm. in diameter and 11 mm. thick. One specimen figured on Pl. VII, Fig. 13, retains the anthoagathus: raised beach, Camp 6, Northern Wadi Queh.

K 1589, one well-preserved specimen from the Wadi Queh.

L 3498, two specimens, the larger of which is 73 by 67·5 mm. in diameter, and about 11 mm. thick: Sinai, Lower Terrace, south of Hedemia Bay.

L 3498, three smaller specimens, of which the largest is 57 by 52·5 mm. in diameter and 11 mm. high, and its costæ resembles *F. placunaria*, Klunz.: same locality.

PORITES, Edwards & Haime, 1860.

1. Porites solida (Forskal), 1775.

Madrepora solida, Forskal, 1775: Descr. Anim. Itin. Orient., p. 131.
Porites solida, Klunzinger, 1879: Korallenth. roth. Meer., pt. ii, p. 42, pl. vi, fig. 14; pl. v, fig. 21.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt, lower raised beach, north of Qosseir, Nos. J 2116 and J 2134.

These specimens closely resemble *P. lutea*, Edwards & Haime,[1] but their pali are less distinct, and so I record them under Klunzinger's name. The depth of the calices cannot be determined in these specimens.

2. Porites nodifera, Klunzinger, 1879.

Korallenth. roth. Meer., pt. ii, p. 41, pl. vi, fig. 13; pl. v, fig. 17.

Distribution.—Recent: Red Sea. Fossil, Pleistocene: Egypt, raised beach, 80 feet above sea-level, Camp 8, Wadi Abu Shigeli, Coast Plain, north of Qosseir.

This specimen is 70 mm. high, and above the base the transverse section is elliptical, being 47 mm. wide by 28 mm. thick. The corallum divides above into short, thick branches. The walls are very thin and trabecular; the pali are fairly distinct, but the columella is not very apparent; but these structures are not well defined in the irregularly trabecular skeleton of this genus.

MONTIPORA, Quoy & Gaimard, 1833.

Montipora sp.

No. J 1826, old beach, Camp 17, Wadi Barud. The collection made by Mr. Barron from this locality includes a worn fragment of a *Montipora*. But it is too imperfect for determination as to its position in a genus, which, according to Mr. Bernard's Catalogue, includes 140 recent species.

The collection includes some indeterminable specimens as follows:

K 1656, cast probably not a coral: raised beach, 300 feet high, Wadi Hamrawein.

[1] Edwards & Haime: Hist. nat. Cor., vol. iii, p. 180.

K 1632, cast of a *Lithodomus*: raised beach, No. 1, north of Qosseir.
H 1633*a*, ? *Favia*: Camp 4, Hamrawein, near Qosseir.
K 1640, (*a*) Prionastræoid, indet., (*b*) *Acanthastræa* sp., (*c*) indet.: raised beach, No. 1, 520 feet high, north of Qosseir.
K 1664, an Orbicelloid: raised beach, 380 feet above sea-level, Wadi Shigeli.
H 1776, ? *Mussa* sp.: Abu Sha'ar Plateau.
H 1866*a*, ? *Orbicella*: Wadi Belih.
J 1826, *Acanthastræa* sp.: old beach, Camp 17, Wadi Barud.

DESCRIPTION OF PLATES.

Plate VI.

Fig. 1.—*Smilotrochus* sp. Abu Roash. No. 3795. *a*, seen from the side; *b*, outline as seen from above. Nat. size.
,, 2.—*Favia humei*, n.sp. Miocene: Wadi Belih, Abu Sha'ar. No. H 1780. Part of surface of the corallum. × 1½ diam.
,, 3.—*Orbicella mellahica*, n.sp. Miocene: west flank of Jebel Mellaha. Part of the surface of H 1862. × 1½ diam.
,, 4.—The same. Some corallites of 1818*b*. × 2 diam.
,, 5.—*Orbicella schweinfurthi* (Felix). Miocene: west flank of Jebel Mellaha. Part of the surface of H 1862 (duplicate). Nat. size.
,, 6.—*O. defrancei* (Edwards & Haime). Miocene: west flank of Jebel Mallaha. H 1862. A few corallites from a transverse section. × 1½ diam.
,, 7.—*Stylina tetramera*, n.sp. Miocene: Abu Sha'ar. H 1818. Part of the surface of corallum. × 2 diam.
,, 8.—*Leptastræa barroni*, n.sp. Miocene: surface of Abu Sha'ar Plateau. H 1864. *a*, part of surface; *b*, another part of surface of same specimen; *c*, part of internal section. × 2 diam.

Plate VII.

Fig. 9.—*Stylocœnia tuberculata*, n.sp. Miocene: Wadi Belik. H 1814. *a*, the coral, seen from side; nat. size. *b*, part of the surface; × 2 diam.
,, 10.—*Prionastræa lyonsi*, n.sp. Miocene: Wadi Belih. H 1814*a*. *a*, part of worn surface; *b*, part of transverse section. Nat. size.
,, 11.—*Solenastræa elliptica*, n.sp. Miocene: Abu Sha'ar. H 1818*a*. *a*, part of the surface; × 2 diam. *b*, part of a transverse section; × 4 diam.
,, 12.—*Solenastræa chalcidicum* (Forsk.). Pleistocene: raised beach near Qosseir. J 2140. Part of the surface of a worn corallum. × 2 diam.
,, 13.—*Fungia valida*, Verrill. Pleistocene: Wadi Queh. K 1560. Corallum from side. Nat. size.
,, 14.—*Goniastræa pectinata* (Ehr.). Pleistocene: Jemsa, south of Jebel Zeit. J 1819. Part of the surface of the corallum. Nat. size.

IV.—Allotropic Forms of Silica and their Significance as Constituents of Igneous Rocks.

By Cosmo Johns, M.I.Mech.E., F.G.S.

That silica appears as a constituent mineral of igneous rocks in two distinct phases, viz. quartz and tridymite, has been known for some time. The writer is not aware that any explanation has been offered which would indicate the conditions determining the appearance of one or the other in a cooling fused rock-mass. He now proposes to describe certain experiments made with a view to explain why it is that though the free silica generally appears as quartz, yet occasionally, as in certain trachytes, it crystallizes out as tridymite.

He was also desirous of clearing up, if possible, the difficulty caused by the conflicting values given to the fusion-point of silica by different investigators. Joly,[1] using the meldometer, found quartz to fuse at 1200° C., and, with prolonged heating, even at much lower temperatures. Boudouard,[2] in the course of his observations on calcic and alumino-calcic silicates, used Seger cones and determined the fusion-point of silica to be 1830° C. Other experimenters have given values varying from 1450° to 1550° C. It is very evident that the differences are too great to be explained by suggesting experimental errors as the cause.

Advantage was taken of the fact that a regenerative gas furnace, whose temperature could be regulated and only limited theoretically by the dissociation point of carbon dioxide, was available to make a series of experiments with quartz sand of a high degree of purity.

After its specific gravity had been determined, a quantity was introduced into the furnace, rapidly heated to 1500° C., and maintained at that temperature for 48 hours. When withdrawn the material was quite pulverent, and did not show the slightest signs of fusion. It had, however, increased in volume and become milk-white in appearance. Selecting the hottest part of the furnace, where the temperature was determined to be above 1800° C., another portion of similar sand was introduced and withdrawn after 30 minutes exposure to that high temperature. On examination the surface of the mass was found to be fused to a depth of 7 or 8 mm., but the remainder was in the same pulverent state as that found after the first experiment.

Both experiments were repeated, but it was found that quartz sand could only be fused with great difficulty, and only by selecting the hottest part of the furnace. Yet at the same time the temperature of the furnace was such that steel was being maintained in a fluid state with ease. It would seem that Boudouard's determination is confirmed, and the fusion-point of silica lies above 1800° C.

Reference has been made to the fact that the unfused sand had increased in volume during both experiments. This was confirmed when the specific gravity was determined, for the results were as follows :—

Original quartz sand	2·645 sp. gr.
After prolonged exposure to 1500° C.	2·309 ,,

The specific gravity of the original quartz sand is that of a very pure quartz, and this only confirms the analysis, which showed it to be practically pure silica. The specific gravity of the altered and unfused mass is the average of tridymite. The quartz had, in fact, been transformed into another phase, and later experiments indicated the transformation point to be about 1300° C. It is hoped to make further experiments and determine the point more accurately.

It becomes apparent that silica may exist in two solid phases, viz. quartz and tridymite. Also that the former is only stable

[1] Rep. Brit. Assoc., 1900, p. 730.
[2] Journ. I. and S. Inst., vol. i (1905), p. 350.

below 1300°, and, from Joly's experiments, fuses at 1200° or even lower. But tridymite is stable below 1800°, and only fuses when that temperature is exceeded. Those familiar with the phase rule will remember instances of a substance having two solid phases each with a different fusion-point. It should also be noted that it was by rapidly heating the quartz up to and beyond the transformation point that the higher fusion-point was realized.

The vapour pressure would have some effect in modifying the temperature of fusion of these two phases of silica, and though, owing to the absence of data, this could not be profitably discussed here, yet it is a factor that should be considered when dealing with a cooling fused rock-mass.

The significance of the possibility of silica appearing in either of its two solid phases cannot be overlooked owing to its obvious bearing on the question of the thermal conditions attending the consolidation of the igneous rocks. Treating the cooling mass as a case of reciprocal solution, it would appear that the temperature at which silica may be thrown out of solution is a critical point of some importance. If it happens to be above 1300° C., and neglecting for the present the effect of vapour pressure, then the silica would appear in the form of tridymite. If the temperature of the mass happened to be below 1300° C. when silica was thrown out of solution, then quartz would appear.

Quartz is generally one of the later minerals to appear in a cooling rock-mass, therefore its predominance in igneous rocks as a phase of silica is not surprising. The comparative rarity of the tridymite phase would also be explained. If the correctness of the writer's conclusions be admitted, then we are able to fix within moderate limits the temperature of certain critical points in the cooling curves of the igneous rocks.

There is, of course, just a possibility that tridymite is really metastable below the transformation point, but that it requires a long period of time before passing into the more stable form. In that case the geological age of the tridymite-bearing rocks becomes a factor of some importance.

V.—The Thickness of the Ice-Cap in the various Glacial Periods.

By Ernst H. L. Schwarz, A.R.C.S., F.G.S.,
Rhodes University College, Grahamstown, South Africa.

In estimating the maximum load which pressed upon the northern type of Glacial (Dwyka) Conglomerate in Prieska, Cape Colony, I assumed that the calculations of Sir Wyville Thomson and Bernacci were correct, and that the greatest column of ice that could exist on the earth's surface was from 1,400 to 1,600 feet high.[1] This limit, however, is by no means accepted by European glacialists, who, though they do not go as far as Dr. Croll in assuming

[1] "An Unrecognized Agent in the Deformation of Rocks": Trans. S. African Phil. Soc., vol. xiv (1903), p. 400.

thicknesses of 120,000 feet, yet see no reason why there could not have been ice-sheets 5,000 feet thick. The publication of Captain Scott's narrative of the voyage of the "Discovery" has given us certain definite data from the Antarctic which enable the case for the 1,600 feet maximum to be put with more confidence, and I will endeavour in the present paper to state the main lines of the argument. The question is of importance not only to us in South Africa with our two Palæozoic ice-ages, but to all geologists, as it affects the problem of the earth's equilibrium. To give a recent example, Professor Penck, in describing the Bodensee, discusses whether the weight of ice pouring down from the Alps in a sheet 3,600 feet thick may not have had some effect in producing a sinking in the earth's crust.[1]

To begin with, it is necessary to enquire into the thickness of the ice-sheet at the present day, and in no case where there has been direct measurement has the ice been found to exist in sheets surpassing the 1,600 feet limit. The estimates of the thickness of the Greenland ice-cap rest on assumptions which it is impossible to prove or disprove, but if they are examined closely they will be found to be as favourable to the lesser limit as to the greater one of 6,000 feet. Dr. Nansen's argument is that the coastline of Greenland is very like that of Scandinavia, and therefore it is permissible to assume that the internal relief of the island continent is the same as that of Norway and Sweden; if the latter were covered with an ice-sheet up to the tops of the mountains the valleys would be filled with ice to depths of 6,000 to 7,000 feet; consequently, in Greenland, allowing for the land surface being somewhat higher than in Scandinavia, the valleys would have accumulations of ice 5,000 to 6,000 feet thick. As confirmatory evidence Dr. Nansen quotes instances of the enormous erosion which has gone on along the coast of Greenland, which he states was produced by glaciers excavating their valleys while filled with ice and giving at the foot pressures of not less than 160 atmospheres.[2]

Von Drygalski, as the result of two expeditions to Greenland, has given elaborate measurements of the glaciers that now end in the sea, and concludes that an iceberg rises higher than the glacier front from which it has calved only when it turns over on its side;[3] as the glacier front, where it is floating, rarely rises to 300 feet, icebergs of more than 300 feet high must be ones that have turned over, and are consequently of no use in measuring the height of the original ice-sheet from which they have issued. If we take Steenstrup's figures for the proportion of the parts of an iceberg above and below water, namely, 1 : 7·4 to 1 : 8·2,[4] a height of 300 feet would make an iceberg have a base over 2,000 feet deep. Von Drygalski, however, found that soundings off the edge of

[1] Vorträge d. Vereins z. Verbr. Naturwiss. Kennt., xlii (Vienna, 1902), Heft 6, p. 11.
[2] "The First Crossing of Greenland," Appendix, p. 472; London, 1890.
[3] "Gronland Expedition," p. 387; Berlin, 1897.
[4] "Meddeleser om Gronland," p. 97; Copenhagen, 1879.

floating glaciers gave only a depth of four times the height of the glacier front, and a 300 feet iceberg would therefore be 1,500 feet thick in all. Scott says the same thing for the Antarctic, where 120 to 150 feet icebergs do not touch bottom in more than 100 to 120 fathoms of water, giving a proportion of something like 1 : 5 for the portions above and below water.[1] The discrepancy between the estimated and observed proportions is explained by the experiment performed by the "Challenger" in firing cannon-balls into an iceberg: while some layers reacted like solid rock, others were so soft that the balls imbedded themselves, proving that a large proportion of the berg was soft, spongy, and filled with air, thus making it buoyant.

Scott found that the Great Barrier ice rose at one point to 240 feet above sea-level, but as some portions sank to nearly sea-level, these greater elevations may safely be put down to pressure ridges; the average height was under 200 feet. The height of the ice-column in the Great Barrier may give too low a figure for the mass of ice as it leaves the land, whereas that of the Greenland glaciers, coming steeply off the land, probably gives too high a one. The point I wish to emphasize is that the whole resources of the Greenland ice-cap and the great snow-fields of the Antarctic, can only produce a sheet of ice in the valleys or places of greatest accumulation of heights that are near the estimated possible maximum, namely, 1,600 feet.

These estimations depend on the ice being 0° C. at the junction of the sheet with the earth, and doubt has been thrown on this. Ice only becomes colder than its melting-point by reason of radiation of heat into space, and where this is stopped by great thickness of ice —ice being a bad conductor of heat—the temperature of the ice will rise from any degree below zero at the surface to 0° C., where the heating effect due to pressure comes into play. V. Drygalski has given a large series of observations bearing on this question, and the same rise of temperature is observed as in the case of the earth's crust, only on a more exaggerated scale. The following are a few extracts, temperatures in degrees Centigrade (Celsius in the original):—[2]

Temperature in the Ice on the Great Karajak Glacier,
175 m. above sea-level.

	6 in. (·15 m.)	17·5 ft. (5·4 m.)	28·9 ft. (8·9 m.)
30th October, 1892	−13·7	−3·7	−2·9
19th November, 1892	−13·7	−10·1	−7·2
29th November, 1892	−19·2	−5·5	−5·2
2nd February, 1893	−32·9	−6·1	−5·0
14th April, 1893	−15·0	−9·0	−9·2

The last figure in the third column is the greatest cold found at this depth; it was taken on April 14th, and denotes the lag in the temperature of the interior of the ice-sheet when the surface was becoming warmer. These figures demonstrate sufficiently clearly

[1] "Voyage of the 'Discovery,'" p. 410; London, 1905.
[2] "Greenland Expedition," pp. 451–2.

that the lowering of the melting-point of ice due to pressure is not materially affected by the intense cold at the surface, and that therefore we may take the physicists' estimate of the maximum thickness as approximately correct.

Scott found the Antarctic ice-cap to be flat on the surface of the land with an edge of rock which, from the sea, appeared to consist of lofty mountains, but the highest points of these sank below the horizon directly the level of the ice-cap was reached. Peary and Nansen have found the same thing in Greenland. The tops of the mountains look as if they once were part of a peneplain, but Nansen maintains that it is not likely that a great land-mass like Greenland should be all on a level beneath the ice. In his later researches, however, Nansen has demonstrated the existence of a vast submarine plateau in the Arctic Ocean, and if the plateau here rose above the sea by block-uplift it would be covered by ice and protected from denudation by ice. Douglas Freshfield, in his address to the British Association at Cambridge, stated that it is at the face of the glacier that denudation begins, and the configuration of the coastline in Greenland and in the Antarctic regions bears this out; the valleys go but a short way inland, and are ended abruptly. If, then, there is some reason to suppose that the polar ice-caps lie on level land, the argument for estimating the thickness of ice above the limit which physicists say is the maximum is shown to be of doubtful value.

The only way by which a sheet of ice over the 1,600 feet limit can exist is when the surface of the ground on which it rests is below the temperature of the melting-point of ice, and to obtain such a condition of things there must be a cause of abstraction of heat from within the earth, as the ice-sheet forms a blanket to protect the surface of the ground from radiation from above. The heat of the earth's interior is always creeping outwards, and instead of abstracting heat from the ice it is the ice that is abstracting heat from the earth. Not only is this true for the existing ice-caps, but it must have been true for the ice in the Glacial periods of the northern hemisphere and the Palæozoic ice-ages of the southern, and I cannot, therefore, see how it is possible, in the light of physical experiment, supplemented by actual observation, to obtain the great thickness of ice that glacialists ordinarily call in to explain the phenomena which they have described.

Finally, there is one observation of Commander Scott's[1] which perhaps explains the enormous apparent thickness of glacier ice in past ages as seen in the evidence afforded by ice-scorings on the sides of the valleys. In the Ferrar glacier the ice had once been from 3,000 to 4,000 feet higher than it is at present. There is also reason to suppose that the climate was milder at the period of maximum glaciation, because it is physically impossible for cold air to contain much moisture and consequently to feed the glacier streams. With a milder climate the ice must have melted more easily, and yet even

[1] "Voyage of the 'Discovery,'" p. 416.

now within the Arctic circle glaciers have streams of running water issuing from their fronts; there must have been, therefore, very great erosion in the glacier valleys by running water during the maximum glaciation, and the valleys became rapidly deepened. When the climate became severer and the glaciers became smaller owing to insufficiency of supply, they no longer flowed down the valley as it originally existed, but in the narrower gorges excavated by the sub-glacial streams in earlier times. This fact, that during maximum glaciation there was necessarily a milder climate and consequent greater melting and erosion, may perhaps explain how glacier valleys in Europe and America have been scored by ice from their bottoms to heights of 3,000 and 4,000 feet above. To maintain that such valleys at one time were filled from top to bottom with ice is, to my mind, equivalent to saying that in an ordinary river valley, with terraces high up the sides, the valley was once filled with water from the present level to the topmost water-mark.

VI.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

By R. M. Brydone, F.G.S.

(PLATES VIII AND IX.)

(*Concluded from the February Number, p.* 78.)

THE very uniform trend of all these ridges will have been noted, but my previous remarks on the general strike of the foreshore chalk require considerable modification. The whole of the chalk so far exposed may be divided into four sections. Each of these comprises an exposure in or close to the cliff of what appears to be the highest part of a ridge running down the beach in a direction from 10° to 30° south of east (and sinking as it goes) to about the half-tide level. Here three of them (the exception being the brickfield chalk) turn and run for some way roughly parallel to the shoreline, and then resume their original direction and run out to sea. The brickfield chalk only varies from this plan by running out to sea with practically no change of direction on the way. Except where a ridge is running up to the cliff, the substratum of the beach is invariably glacial clay down to about half-tide level. Here it is either banked against what appear to be vertical faces of chalk or else (*between* the foreshore exposures) disappears under the sand. It has never been seen to run out to sea, and every time a fresh bit of the foreshore below the half-tide level is cleared of sand it is chalk that is revealed. In the case of the section attached to the north bluff there is below the half-tide level a continuous mass of chalk with perfectly regular bedding exposed for at least 1,000 yards along the shore, and directly opposite the north bluff I have myself seen chalk continuous from the foot of the bluff for over 200 yards straight out to sea (except about 20 yards close up to the bluff, which, however, are covered by Mr. B. B. Woodward's letter in the October (1905) number of the Geological Magazine), the regular sequence of the beds being only broken by one fault. The section attached to the ridge coated with a sheet of flint is a good second in size, showing chalk in regular sequence for a length of over 400 yards, and maximum (exposed) breadth of about 45 yards.

There seem to be only two possible theories as to the nature of these chalk masses, as Mr. Reid's theory is quite impossible of general application, and appears to be only applicable to the north bluff subject to very important modifications. One is the erratic theory. This theory involves the possibility of an erratic 1,000 yards by 200 yards in superficial area and unknown depth, and others smaller but still of monstrous size. It offers no explanation of the rude symmetry of tectonic structure exhibited by the chalk, nor any plausible origin for these erractics, which have no known counterpart in fossil contents, and cannot from the perfection in which they have retained their stratification and fossil contents have travelled far. It is also a coincidence almost past belief, until every other possible explanation has failed, that an ice-sheet should chance to leave at one spot all the known remnants (a very large number) of a very strongly marked epoch without the admixture of a single erratic mass belonging to any other epoch. If a final nail in the coffin of the erratic theory be required, it is to be found in the Mundesley well section recorded in the Geological Survey Memoir on the Upper Chalk of England as having shown a great thickness of chalk, obviously *in sitû*, containing *O. lunata* at intervals.

The other theory is that of the buried chalk cliff, set forth in my previous pamphlet (of which Mr. Jukes-Browne's buried sea stacks are really a variant very near the truth, but not quite borne out by my investigations). The numerous sections on the foreshore where the clay is piled up against apparently vertical faces of chalk, the uniformity with which the clay has hitherto been found to be bounded to seaward by chalk, the occasional disturbances in the chalk along its junction with the clay never penetrating more than a short distance into the body of the chalk, the newly exposed cavities in the southern part of the south bluff, and the great masses of flint shingle in the cliffs immediately above the bluffs, all tend strongly to confirm the supposition that the chalk once presented at this point a low cliff with projecting headlands to a sea lying where now we have the land, and that up against this cliff the boulder-clay was piled. It is not at all uncommon to find the chalk much disturbed along the junction with the clay, while a few yards further seawards there commences an extensive area of wholly undisturbed chalk, and this is no doubt due to the dislocation of the chalk in the face of the old cliff by clay forced into cracks and acting under continued pressure from behind like a gigantic wedge. The erratics behind the north bluff have almost demonstrably been torn from the parent mass by clay pressing up from below, which must have reached a position below them either in caves or along cracks.

There are, as will have been gathered, many apparent instances on the foreshore of clay passing under the chalk. Some of these are undoubtedly genuine cases, to be explained as above. But it is quite possible that the majority are only apparent. If boulder-clay was banked up against a vertical wall of chalk, the plane of junction would often be a waterway of some importance. The water percolating along this plane would, of course, have little or no effect on the boulder-clay, but would tend to dissolve away the chalk, and the deeper below the surface the water got the greater would be the pressure on it and consequently its solvent power. There would thus be a constant tendency for the chalk face to recede, and recede less rapidly at the surface than deeper down, and so to develop an overhanging vertical face. The clay, being comparatively plastic, would of course follow the receding chalk wall, and in time lie under the chalk for a short distance. The shortness of this distance would not be apparent in the foreshore sections we have, which are almost always along the chalk walls and never across them, but I have several times been able to satisfy myself by digging that the distance for which the infraposition of the clay to the chalk extended seawards was a matter of inches only.

It may perhaps be permissible to speculate on the epoch at which this chalk cliff existed. Now we know, of course, that the early Crag sea was a warm and tranquil sea, and therefore it must have been protected from the North Sea of the period by a land barrier, the gradual breaching of which would allow the gradual admission of colder water and Boreal forms, which can be so clearly traced in the upper Crag beds. Such a barrier, if it lay anywhere in or near Norfolk, must have been of chalk, which is the basement bed, so to speak, of the county, and we should therefore hope to find with great luck the cliffs left by the cutting through of the barrier, and possibly also the floor of chalk formed in the gap. Now we have between Cromer and Weybourne an almost flat surface of chalk at sea-level, which presumably has not been formed by the recent sea, as the cutting back of the cliffs always reveals a platform of chalk at their very base, which, except between Sheringham and Weybourne, shows no sign of rising into the cliff, and therefore must be of pre-glacial age. Is it fantastic to suggest that the chalk between Cromer and Weybourne is part of the floor of the old breach, and that at Trimmingham we have the only remains yet disclosed of the east cliffs formed by that breach, and that the west cliffs are buried at some point between the chalk at sea-level round Cromer and the chalk at a considerable height above it round Holt and Melton, a slight tilt having brought the cliffs at Trimmingham nearly down to modern sea-level? The behaviour of the Pliocene beds themselves confirms this supposition as to the relative Pliocene positions of the Trimmingham and Cromer chalk, for the Pliocene beds near Cromer are all above the surface of the chalk there, while we know on the authority of Mr. Reid that corresponding Pliocene beds at Trimmingham close by the chalk occur well below high tide mark, and consequently many feet *below* the highest point to which the undisturbed chalk there reaches in the south bluff. This theory would involve the existence at one time of a (probably now buried) chalk cliff running along the bed of the North Sea, and such a cliff would be a possible source, and the only one that can be suggested, for the erratics between Trimmingham and Weybourne. Some cliff the source must have been, for ice with all its powers can neither shovel up nor suck up large masses of chalk out of a horizontal surface. This hypothetical buried cliff would probably be running more or less north and south, and would therefore be nearer to the present coastline at Overstrand than further north, and the difference in distance travelled would account for the enormous difference between the condition of the Overstrand erratics, which have suffered somewhat, but not much, from pressure, and those west of Cromer, which have been crushed until they are barely coherent, and crumble most rapidly on exposure. The suggested Pliocene chalk cliffs would also afford a source for the enormous supply of carbonate of lime which must have been required for the building up of the vast masses of shells of which the lower Crag beds are composed.

[After this paper had taken more or less its present shape, Professor Bonney and Mr. Hill published in the GEOLOGICAL MAGAZINE for September, 1905, a paper dealing somewhat sketchily with the purely stratigraphical aspect of the Trimmingham Chalk on apparently very incomplete data. This paper has been effectively criticized by Mr. B. B. Woodward in the October number of the same Magazine, pp. 478 and 479, and by Sir Henry Howorth in the November number, and I have nothing to add to the criticisms made by these gentlemen, to whom I am much indebted for their intervention. We have, however, to thank Professor Bonney and Mr. Hill for a record of chalk at the base of the cliff under Trimmingham itself, where I have long expected it, but never had the good fortune to see it.]

PALÆONTOLOGY.

A. *Chalk of Trimmingham.*

The greater number of the additions and corrections to the list given in my previous pamphlet have been incorporated in the list to be found in the recent Survey Memoir above referred to, but for convenience a complete list of all corrections and additions is given here :—

SPONGIDA.

Add *Porosphæra globularis*, Phill.; *Ventriculites decurrens*, T. Smith; *V. impressus*, T. Smith; *V. quincuncialis*, T. Smith; *V. radiatus*, T. Smith.

Omit *P. Woodwardi*—the light recently thrown by Dr. Hinde on the species which has so long borne this name makes me doubtful if I can prove its occurrence.

ACTINOZOA.

Add *Diblasus Grevensis*, Lonsd.

Omit *Calamophyllia faxeensis*—the specimen which distantly suggested this species to Professor Deecke has proved to be a fish-spine (*Cœlorhynchus cretaceus*); *Onchotrochus serpentinus*—this appears to have been based on specimens of a very slender *Porina*.

ECHINODERMATA.

Add *Epiaster gibbus*, Lam.; *Micraster cor-anguinum*, Klein. One specimen of the former and two of the latter are in the collection of Mr. Savin. *Echinoconus Orbignyanus*, Ag. (the bun-shaped *Echinoconus* of my previous pamphlet according to Mr. Sherborn).

CIRRHIPEDIA.

Add *Pollicipes fallax*, Darw. (very abundant).

Substitute *Brachylepas cretaceus*, H. Woodw., for *Pollicipes cancellatus*, which has proved to be a synonym.

POLYZOA.

Add *Siphoniotyphlus tenuis*, Hag., a species of remarkable range for one so specialised.

LAMELLIBRANCHIATA.

Add *Avicula cærulescens*, Nilss.; *Ostrea canaliculata*, Sow.; *O. inæquicostata*, S. Woodw.—if the Trimmingham specimens are rightly identified, this species can hardly be identical with *O. semiplana*, as suggested in the recent Survey Memoir; *Plicatula sigillina*, S. P. Woodw.; *Spondylus spinosus*, Sow.

Correct *Diceras inæquirostratus* in Survey Memoir. This record appears to be founded on adherent valves of an *Exogyra* so identified at South Kensington.

GASTEROPODA.

Add *Dentalium* sp. There frequently occur casts of Gasteropods, mainly *Trochus* and *Cerithium*, but so small and delicate as to require an expert to identify them.

CEPHALOPODA.

Add *Bayfieldi*, F. & C., after *Nautilus*.

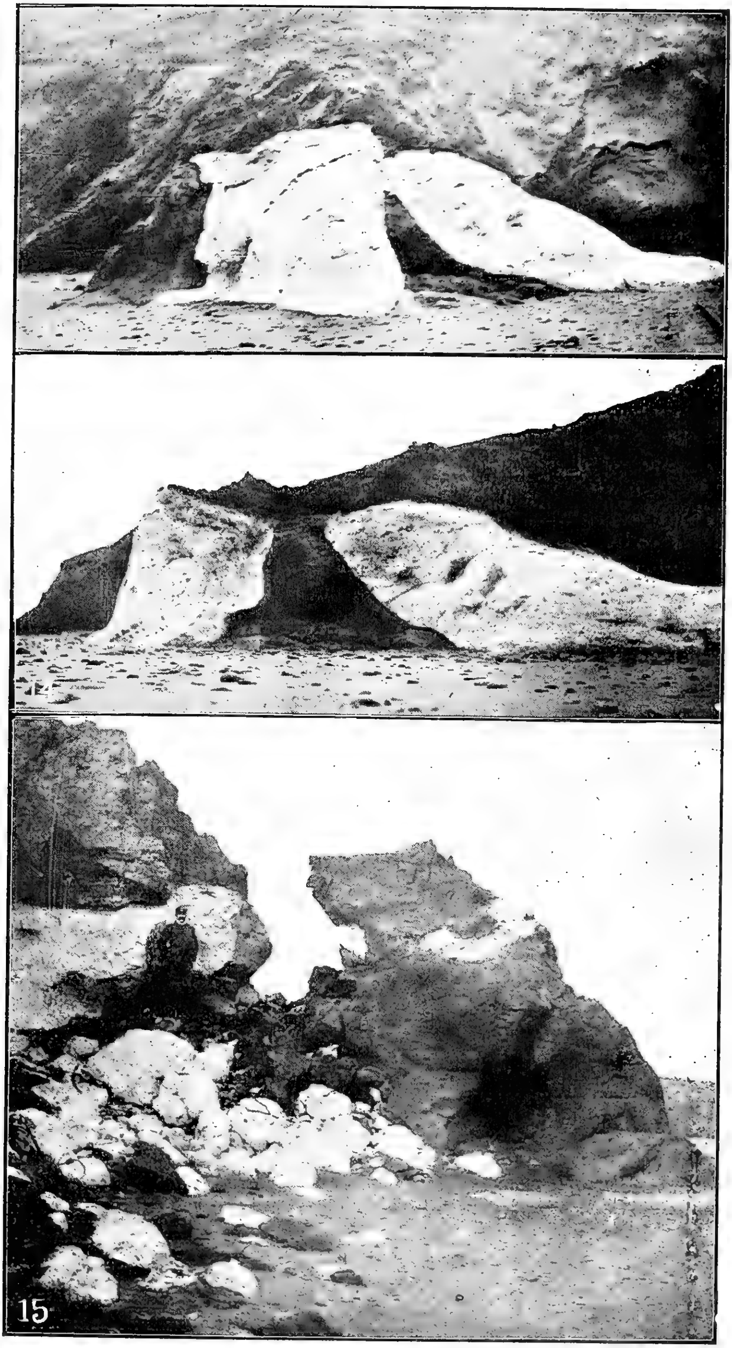
Substitute *Aptychus rugosus*, Sharpe, for *A. peramplus*.

Omit *Belemnitella* sp. Dr. Blackmore is convinced that the very numerous specimens of this slender form are only young *B. mucronata*, the infant mortality among which must have been terrible.

PISCES.

Add *Cœlorhynchus cretaceus*, Dix; *Corax* sp.; *Scaphanorhynchus subulatus*, Ag.

It will, perhaps, be well to comment on some statements made by Dr. Rowe in his paper on the Dorset Chalk, in which he compares the fauna of the *B. mucronata* zone in Dorset and Norfolk, as they are calculated to mislead anyone having only a slight knowledge of the Trimmingham fauna. He states that *Pecten concentricus* is common at Trimmingham. As I have never seen a specimen of it there, I can only conclude that he is confusing the smooth *Pecten Nilssoni* (which is common at Trimmingham) with *P. concentricus*. He also states that a certain hexagonal *Serpula* was considered by me to be *S. difformis*, but that it differed from the Trimmingham examples, "which are always pentagonal." He has here confused at least three perfectly distinct species. The first is a free-growing, tapering, uniformly *heptagonal* form of carious surface, which is either *S. difformis* or a very near relation. This form, or one barely separable from it, occurs also in the *B. mucronata* chalk of Hampshire down to its base. The second is a very remarkable form with a *polished* surface. It starts with a broad base and triangular cross-section with a strong dorsal carina, and is then incapable of being separated from *S. macropus*. But very soon the tube rises free from the base and *proceeds* to develop six more carinæ placed at regular intervals round the tube. But the new carinæ are not all developed at once, and the specimen forwarded to me by Dr. Rowe for identification was, if I remember rightly, a youngish specimen with six carinæ fully developed and the seventh just appearing. This form is not uncommon in the *B. mucronata* chalk of Hampshire, but I have not yet found it (at any rate, to be certain of it) at Trimmingham. At the time I saw Dr. Rowe's specimen I was still under the impression that this form would prove to be



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

S. difformis, so I gave this name to Dr. Rowe, but with the same caution with which, it will be seen, I recorded it at Trimmingham in my previous pamphlet. Whether it ought to be included in the same species as the typical *S. macropus* on account of its initial stage is a question for a specialist, but it seems to me very undesirable, seeing how greatly the two forms differ in the adult stage. (The question is further complicated by a Trimmingham species, which generally begins with a *macropus* stage like the form just described, and then grows to a great length as a free round tube slightly curved, with a carious surface and devoid of carinæ. The same form is, however, often to be found in the same beds free from its earliest infancy.) *S. canteriata*, the third species, is evidently the Trimmingham form which Dr. Rowe had in mind, as it is the only free pentagonal species at Trimmingham (except occasional specimens of *S. fluctuata*). Not content with gratuitously attributing to me an intention to identify his specimen of a heptagonal form with *S. canteriata*, which is never even hexagonal, he has made misstatements about that species from which a wider experience would have saved him. If he had said it was always pentagonal outside the Trimmingham Chalk he might well have been correct, as I have found only the pentagonal form in the various zones down to *M. cor-testudinarium*, in which it occasionally appears, but in the Trimmingham Chalk it is often tetragonal, and in some specimens passes from the one form to the other.

Dr. Rowe may be right in saying that *Pentacrinus Agassizi* and *Bronni* are very common at Norwich and Sheringham, but I confess I am much surprised at the statement, for I have not found a specimen of either form at either locality, and I have spent much time on the chalk around Sheringham, though comparatively little on that around Norwich.

B. *Chalk between Cromer and Weybourne.*

SPONGIDA.

Porosphæra globularis, Phill. (very large).
Ventriculites impressus, T. Smith.
V. radiatus, T. Smith.

ACTINOZOA.

Axogaster cretacea, Lonsd.
Stephanophyllia Michelini, Lonsd. (common).
Trochosmilia (*laxa* ?).

ECHINODERMATA.

Bourgueticrinus (joints, including one variety very typical at Trimmingham).
Cardiaster sp.
Cidaris.
Cyphosoma (*Königi* ?).
Echinoconus vulgaris, Röm.
Echinocorys vulgaris, Breyn.
Goniaster (ossicles).
Micraster cor-anguinum, Klein (common).

VERMES.

Serpula ampullacea, Sow.
S. canteriata, Hag.
S. carinella (?), Sow.
S. difformis (?), Dix.
S. fluctuata, S. Woodw.
Serpula granulata, Sow.
S. gordialis, Schloth.
S. lituitis, Defr.
S. plexus, Sow.

CIRRHIPEDIA.

Brachylepas cretacea, H. Woodw.
Pollicipes glaber, Röm.
Scalpellum maximum, Sow.

POLYZOA.

Homalostega pavonia, Hag.
Membranipora clathrata, Reuss.
Pachydera grandis, Mares.
Porina filograna, Goldf.

Many others of (at present) unknown zonal significance.

BRACHIOPODA.

Crania Egnabergensis, Retz.
C. Parisiensis, Defr.
Magas pumilus, Sow. (very common).
Rhynchonella limbata, Schloth.
Rh. plicatilis, Sow.
Rh. Reedensis, Eth.
Terebratula carnea, Sow.
T. obesa, Sow.
T. sexradiata, Sow.
Terebratulina striata, Wahl.
Thecidium Wetherelli, Morris.

LAMELLIBRANCHIATA.

Avicula cœrulescens, Nilss.
Inoceramus sp.
Lima granulata, Nilss.
L. pectinata, D'Orb.
Ostrea canaliculata, Sow.
O. inæquicostata (?), S. Woodw.
O. vesicularis, Lam.
Pecten cretosus, Defr.
Pecten pulchellus, Nilss.
P. quinquecostatus, Sow.
P. undulatus, Nilss.
Plicatula sigillina, S. P. Woodw.
Spondylus Dutempleanus, D'Orb.
S. latus, Sow.
S. spinosus, Sow.

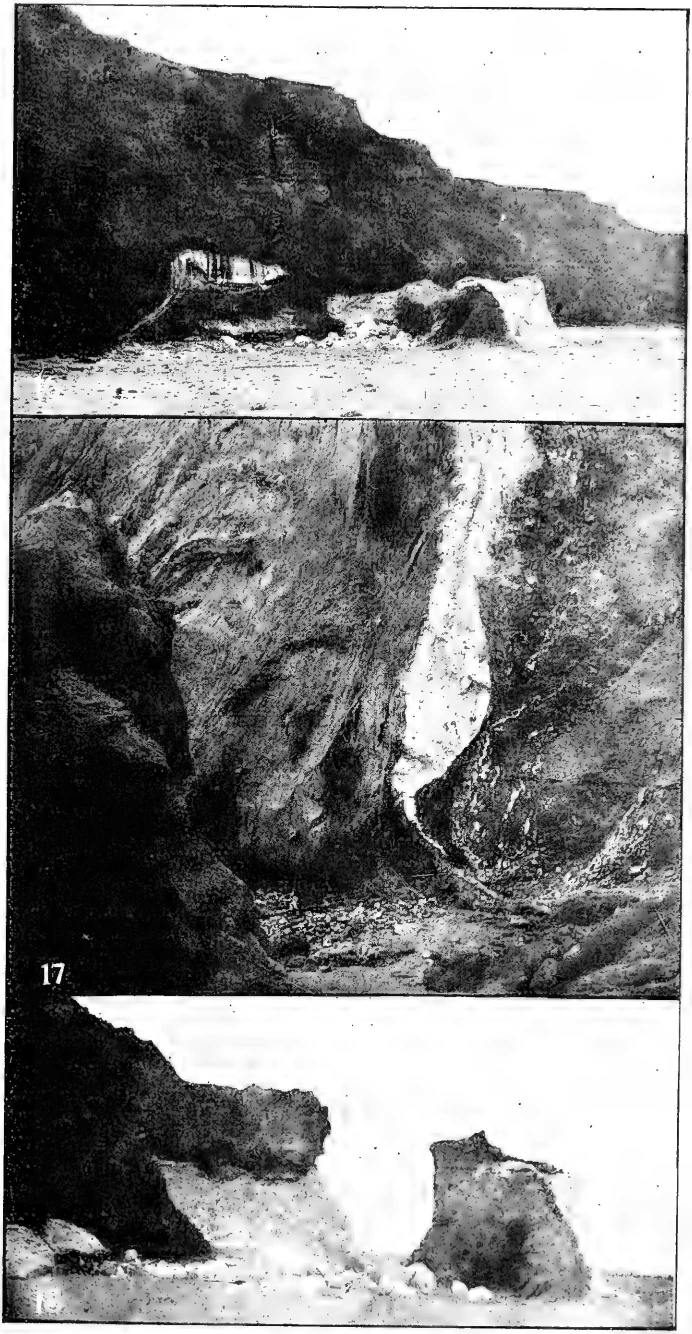
CEPHALOPODA.

Aptychus rugosus, Sharpe.
Belemnitella mucronata, Schloth.

PISCES.

Enchodus sp.

It is perhaps desirable to mention that these fossils come mainly from the western part of this chalk, i.e. about Sheringham and Weybourne. It may be partly owing to the greater facilities for collecting offered by the cliff exposures near Weybourne, but I have no doubt that it is also due to a genuine increase in the abundance of fossils as we get away from Cromer, where the chalk is wonderfully barren. Travelling in this direction, we are, according to Mr. Reid, passing from newer to older chalk, but I have great doubts about this. The only argument he adduces to support this view is that the dip of the chalk in the cliffs near Weybourne is to the east, and may be assumed to continue all the way (there certainly does not appear to be any traceable dip in any direction in the chalk on the foreshore). I have always doubted the existence of this steady eastward dip, and when in 1903 the chalk near Weybourne was exceptionally well exposed after a storm I studied it very carefully. I was able to trace the lines of flint very minutely, and I was absolutely convinced that for nearly three-quarters of a mile from Weybourne Gap the lines of flint are dipping steadily to the west. I have also observed indications that there is a syncline at West Runton, and not very far away a chance hole in the chalk with vertical sides showed a section across a flint line apparently lying in a small anticlinal. I am therefore more inclined to regard this chalk as, at any rate, undulating, if not actually dipping westward on the whole. The fossils of the chalk around Weybourne show a tendency towards the Trimmingham fauna, and it would be remarkable if between that chalk and the Trimmingham Chalk there really lay the very unfossiliferous chalk nearer Cromer.



Views of the Trimmingham Chalk Bluffs, Norfolk Coast.

(To illustrate Mr. R. M. Brydone's paper.)

An Appendix will follow, later on, with figures and descriptions of the Cirripedia and Polyzoa.—R. M. B.

EXPLANATION OF PLATES.

PLATE VIII.

FIG. 13.—North Bluff, seaward aspect; May, 1905.
,, 14.—North Bluff, seaward aspect, showing (but only faintly, owing to shadow) the chalk roof over the clay pinnacle.
,, 15.—October 2nd, 1905, showing the aspect from the head of the south bay the day after the chalk roof was broken through.

PLATE IX.

FIG. 16.—October 2nd, 1905. South bay.
,, 17.—October 2nd, 1905.
,, 18.—October 16th, 1905.

VII.—A METHOD OF CLASSIFYING IGNEOUS ROCKS ACCORDING TO THEIR CHEMICAL COMPOSITION.

By Dr. HUGH WARTH.

(WITH A FOLDING TABLE.)

THE chemical classification of igneous rocks is rendered difficult by the large number of substances which are present in them. H. S. Washington, who based his system of classification upon the composition of standard rock-forming minerals, found it necessary in his great work[1] to divide his 2,880 rocks into no less than 167 final groups in order to ensure a close proximity between the rocks within each group.

The number of rocks in any system of classification must rise so much more rapidly the greater the proximity of the individual rocks to each other. In the case of only a single constituent the deviation of individual rocks from the group average is inversely proportional to the number of groups. A similar law prevails when several constituents are considered at the same time, as will be shown in the following.

Five hundred rock analyses were selected at random for the purpose of classification. The average composition of this whole assembly of rocks was then calculated, and the mean deviation of the several substances was found by deducting the percentage of each substance present from the mean percentage of this substance in the five hundred rocks.

The differences obtained for all the rocks, positive as well as negative, were then added together, and the sum-total divided by 500 gave the mean deviation of each substance. It requires to be noted, however, that for the present purpose some of the substances were taken two and two together, and their combined deviations were thus ascertained. The following is the result:—

<table>
<tr><td>500 ROCKS.</td><td>SiO_2</td><td>Al_2O_3</td><td>Fe_2O_3</td><td>FeO</td><td>MgO</td><td>CaO</td><td>Na_2O</td><td>K_2O</td></tr>
<tr><td>Average composition ...</td><td>57·0</td><td>15·5</td><td>3·9</td><td>3·9</td><td>4·8</td><td>5·8</td><td>3·6</td><td>2·9</td></tr>
<tr><td>Mean deviation ... ...</td><td>± 9·6</td><td>3·0</td><td colspan="2">4·0</td><td colspan="2">7·0</td><td colspan="2">2·6</td></tr>
</table>

[1] H. S. Washington, "Chemical Analyses of Igneous Rocks"; Washington Government Printing Office, 1903.

The total mean deviation is 26·2. In the above average we omitted ·5 per cent. TiO_2, ·2 per cent. P_2O_5, 1·9 per cent. H_2O, because these substances are excluded from the partition scheme.

The next step that may now be taken is as follows:—Divide the 500 rocks into two kinds, those which have less than the average of 57·0 per cent. silica and those which have more. I find that 265 rocks belong to the former with an average of 48·3 per cent. silica, and 235 rocks to the latter class with an average of 66·9 per cent. silica. The mean total deviation within these two groups has now been reduced from 26·2 to 17·1. Dividing these two groups once more according to their silica percentage, one obtains four groups with respectively 43·4, 52·5, 61·0, and 72·7 per cent. silica. The average deviation is now 13·2, or about one-half of the original. It happens that these four groups nearly coincide with the old-established division of rocks into acid, intermediate, basic, and ultra-basic rocks, and it is noteworthy that this very simple classification reduces the deviation already to one-half of its original amount.

As will be seen later on, it needs four times as many groups to reduce the mean total deviation to approximately one-third of the original deviation, and H. S. Washington's elaborate system reduces it at the most to one-fourth.

If the above-mentioned fourfold grouping of the 500 rocks be continued by now partitioning according to the percentage of alumina, eight groups are obtained with a deviation of 10·9.

Further partition into 16 groups yielded different results according to the choice and order of substances. The following deviations are obtained:—

Order of Substances.	Total Deviation.
$Fe_2O_3 + FeO$, $MgO + CaO$, Al_2O_3, $Na_2O + K_2O$ ...	10·5
$Fe_2O_3 + FeO$, Al_2O_3, $MgO + CaO$, $Na_2O + K_2O$ ...	10·4
SiO_2, $Fe_2O_3 + FeO$, $MgO + CaO$, $Na_2O + K_2O$ ...	10·2
SiO_2, Al_2O_3, $MgO + CaO$, $Na_2O + K_2O$	9·7
Four bases, three last bases, two last bases, $Na_2O + K_2O$ ...	9·5
All four sets of bases, omitting successively the following: Al_2O_3, $Fe_2O_3 + FeO$, $MgO + CaO$, $Na_2O + K_2O$ ...	9·0

This last method of grouping, which gave the best result, is herewith adopted for use.

Further partition into 32 groups reduced the total deviation as follows:—

Order of Substances.	Total Deviation.
$Fe_2O_3 + FeO$, Al_2O_3, $MgO + CaO$, $Na_2O + K_2O$, all bases	7·7
All bases, successively minus the following: Al_2O_3, $Fe_2O_3 + FeO$, $MgO + CaO$, $Na_2O + K_2O$, and finally all bases (with a few modifications)	7·4

The same principle might be applied for the purpose of still further subdivision. With 128 groups it would be possible to treat all the seven bases separately. It would, however, be necessary to employ a larger number of analyses to secure accuracy.

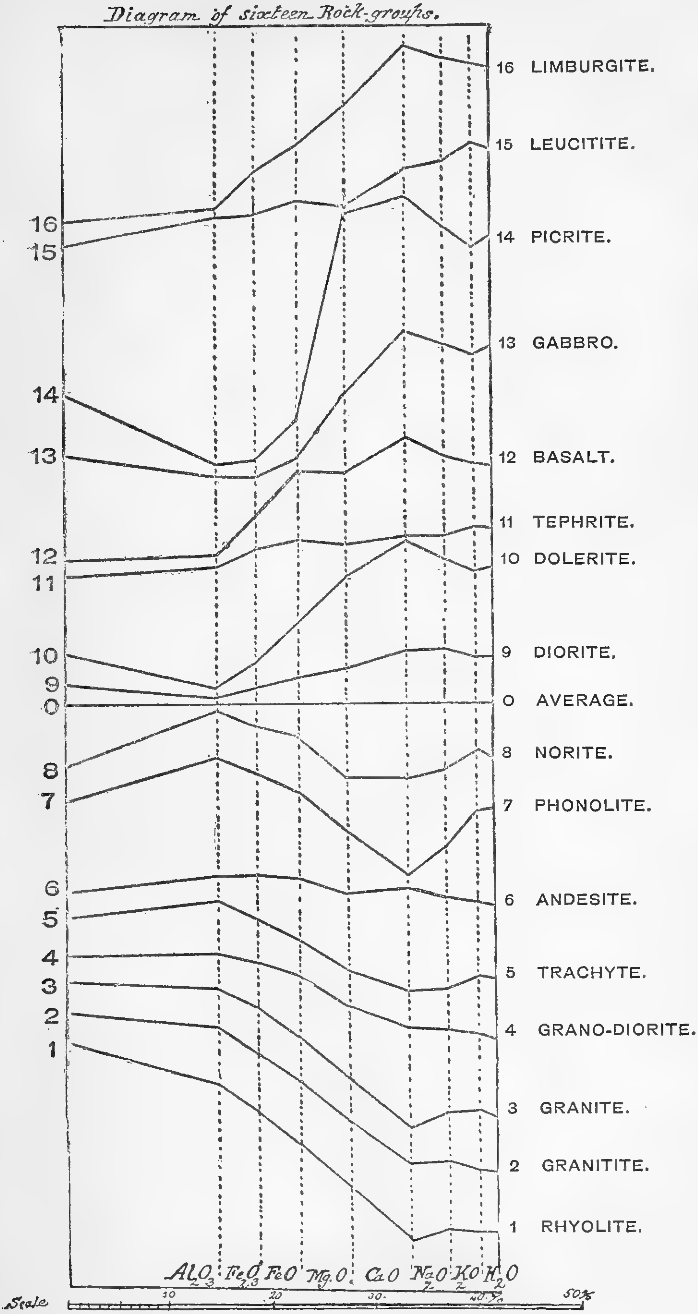


Diagram of sixteen Rock-groups.
16 LIMBURGITE.
15 LEUCITITE.
14 PICRITE.
13 GABBRO.
12 BASALT.
11 TEPHRITE.
10 DOLERITE.
9 DIORITE.
0 AVERAGE.
8 NORITE.
7 PHONOLITE.
6 ANDESITE.
5 TRACHYTE.
4 GRANO-DIORITE.
3 GRANITE.
2 GRANITITE.
1 RHYOLITE.
Al_2O_3 Fe_2O_3 FeO MgO CaO Na_2O K_2O H_2O
Scale 10 20 30 40% 50%

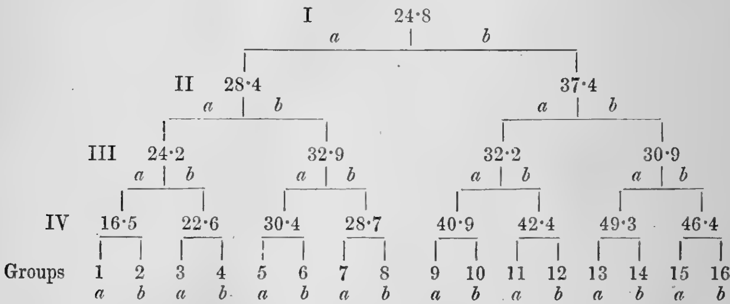
My present object is to employ a moderate number of divisions, and for this purpose 16 groups appear to answer best. The combination of similar bases has enabled me to simplify the system. The individual bases maintain generally a correct proportion, and when they do not the bases of a pair may easily be understood to replace each other (see Table II).

The separate table (Table I) shows the average compositions of the 16 groups which are here used. There is added for each group the name of a typical rock which occurs in the group. To facilitate the discussion of the table I also add a Diagram (p. 133) which requires some explanation. The vertical bands of the diagram are of such widths that they represent by the scale the average percentage of the seven basic oxides and of water.

If a line be drawn from point *O* of the diagram inclined at 45°, and if we then measure from the intersection of that line with the right margin of each band along that margin the sums of the bases Al_2O_3, $Al_2O_3 + Fe_2O_3$, $Al_2O_3 + Fe_2O_3 + FeO$, etc., etc., we obtain a straight horizontal line which stands for the average of 500 rocks. If we apply the corresponding numbers for any one of the rock groups we obtain the curves shown on the diagram. The acid rocks have descending curves, the basic rocks have ascending ones. The descent of a portion of any curve implies that the proportion of the respective bases is below the average, and *vice versâ.* Horizontal portions occur in a curve whenever the respective components are equal to the average of the 500 rocks.

In order to illustrate further the degree of proximity within the groups of rocks I herewith give an example of an entire group (Table II). This group No. 9, *b a a a*, has a mean total deviation of 9·4, which is very close to the average of all the groups and will therefore give a fair idea. Other more acid groups would show a greater proximity, whilst the most basic groups would be most divergent, as may be seen on the above-mentioned Table I.

Scheme of Division into 16 Rock-Groups.



Although the above system is only based upon 500 selected rocks, any number of others may be incorporated by following the same standard averages. In the separate Table I, the averages are given which served for the establishment of the 16 groups. These same

GEOL. MAG. 1906. Dec. V, Vol. III, No. III, Tables I and II.

TABLE I.—AVERAGE COMPOSITION OF THE SIXTEEN ADOPTED ROCK-GROUPS.

Group.	Formula. I	II	III	IV	SiO_2	TiO_2	T_2O_5	Al_2O_3		Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Total.		Rocks in each Group.	Typical Rock Name.	Total Deviation.
53·8				2·0	15·8	6·9	4·3	5·5	7·7	3·0	·7	·8					100·5	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.	
53·6				·9	14·2	1·5	8·1	7·1	8·5	1·8	2·0	2·6					100·3	H. S. Washington, p. 328.	Andesite.	Tuscany.	
53·0				·6	13·1	8·2	2·5	5·2	10·6	3·3	2·0	2·2					100·7	,, p. 324.	Basalt.	Volcano.	
52·8		2·1		·5	12·5	9·1	4·0	4·5	8·1	2·6	2·4	1·0					99·6	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.	
52·5			...		12·1	3·5	5·2	9·9	9·7	2·8	2·2	2·1					100·0	Cole's handbook.	Diorite.		
52·3		·6		·6	14·9	3·5	3·7	5·8	6·3	2·9	3·8	(5·3)					99·9	H. S. Washington, p. 270.	Kersantite.	Thüringerwald.	
52·2		1·4		·5	14·6	10·8	3·2	5·0	8·7	1·8	·6	·3					99·1	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.	
52·2		2·1		·1	12·2	10·1	2·9	5·5	7·1	3·8	2·2	1·1					99·3	,, 1904.	Dolerite.	Oberofleiden.	
51·3		1·4			15·5	3·2	7·1	4·4	9·2	3·8	1·2	(2·9)					100·0	Pamphlets, 1871.	Anamesite.	Dietesheim.	
51·2		1·0		·5	16·1	4·1	4·7	4·8	7·9	3·0	3·5	2·9					99·9	H. S. Washington, p. 266.	Aug. andesite.	National Park.	
51·2		2·4		·3	14·1	4·6	8·9	4·4	8·3	2·6	1·3	1·6					99·7	Cole's handbook.	Dolerite.	Durham.	
51·0		1·8		·7	14·5	4·2	4·4	8·2	5·1	1·8	7·2	1·0					99·9	H. S. Washington, p. 254.	Durbachite.	Black Forest.	
51·0		·7		·5	15·6	8·5	1·4	5·2	6·5	3·4	3·1	3·9					99·8	,, p. 274.	Hornbl. basalt?	National Park.	
50·3		1·0		·5	15·9	8·2	1·5	4·7	7·9	3·0	3·5	3·8					100·3	,, p. 268.	Gabbro porphyry.	Yellowstone Park.	
49·8		2·7		·7	15·3		7·7	6·6	7·2	2·7	4·4	4·0					101·1	,, p. 418.	Mica andesite.	New Mexico.	
49·6		·7		6·0	9·6	5·6	5·2	1·3	13·9	4·9	3·2	·4					100·3	,, p. 312.	Pyr. ap. syenite.	Montana.	
49·0		2·8			15·3	2·6	8·2	4·9	8·2	2·5	2·6	3·3					99·4	Hatch, textbook.	Dolerite.	Rowley.	
48·3		1·0		·2	17·1	1·9	4·9	3·1	9·8	3·1	2·4	8·5					100·2	H. S. Washington, p. 445.	Melaphyre.	Harz.	
54·0		·8		·5	14·1	4·9	4·7	5·6	7·6	3·0	2·9	1·9					100·0	...	Diorite.		
± 2·6			...		± 1·9	± 1·9		± 1·5		± 1·5		...					± 9·4				

TWO TABLES TO ILLUSTRATE DR. HUGH WARTH'S ARTICLE "ON A METHOD OF CLASSIFYING IGNEOUS ROCKS ACCORDING TO THEIR CHEMICAL COMPOSITION."—GEOL. MAG., MARCH, 1906, NO. 501.

TABLE I.—AVERAGE COMPOSITION OF THE SIXTEEN ADOPTED ROCK-GROUPS.

Group.	Formula. I	II	III	IV	SiO_2	TiO_2	T_2O_5	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Total.	Rocks in each Group.	Typical Rock Name.	Total Deviation.
1	*a*	*a*	*a*	*a*	76·4	·1		11·4	1·2	·7	·4	·8	3·3	3·9	1·8	100·0	35	Rhyolite.	6·4
2	*a*	*a*	*a*	*b*	73·4	·1		14·0	1·4	1·0	·8	1·8	2·7	3·2	1·5	99·9	26	Granitite.	5·7
3	*a*	*a*	*b*	*a*	70·6	·1		14·9	2·0	1·0	·4	1·1	3·8	4·6	1·2	99·7	41	Granite.	5·4
4	*a*	*a*	*b*	*b*	65·6	·3	·1	15·6	3·0	2·8	1·6	3·6	3·4	2·6	1·5	100·1	29	Grano-diorite.	7·7
5	*a*	*b*	*a*	*a*	63·2	·3	·1	17·3	2·3	1·8	1·6	3·6	4·9	3·3	1·7	100·1	37	Trachyte.	6·3
6	*a*	*b*	*a*	*b*	58·5	·3	·2	17·4	3·9	3·4	3·3	6·2	3·3	2·0	1·6	100·1	37	Andesite.	6·3
7	*a*	*b*	*b*	*a*	58·4	·2		19·9	2·2	2·1	·6	1·6	7·1	5·8	2·2	100·1	39	Phonolite.	6·4
8	*a*	*b*	*b*	*b*	55·4	·5	·2	20·8	3·4	3·1	1·7	4·5	5·5	3·7	1·4	100·2	19	Norite.	12·9
9	*b*	*a*	*a*	*a*	54·0	·8	·5	14·1	4·9	4·7	5·6	7·6	3·0	2·9	1·9	100·0	35	Diorite.	9·4
10	*b*	*a*	*a*	*b*	48·6	1·1	·2	12·3	5·9	8·1	9·4	9·3	2·3	·9	2·1	100·2	37	Dolerite.	12·3
11	*b*	*a*	*b*	*a*	52·4	·5	·2	16·4	5·5	5·8	3·4	6·5	4·4	2·9	2·0	100·0	25	Tephrite.	10·1
12	*b*	*a*	*b*	*b*	46·9	1·4	·2	16·2	7·4	8·2	5·0	9·0	2·7	1·3	1·6	99·9	33	Basalt.	9·4
13	*b*	*b*	*a*	*a*	46·1	·8	·2	13·5	3·9	5·4	11·3	11·9	2·4	1·8	2·6	99·9	26	Gabbro.	12·1
14	*b*	*b*	*a*	*b*	41·3	·7	·1	8·5	4·4	7·6	25·2	7·4	1·0	·4	3·3	99·9	23	Picrite.	14·8
15	*b*	*b*	*b*	*a*	47·3	·6	·3	18·5	4·0	5·2	4·5	9·4	5·1	3·6	1·6	100·1	29	Leucitite.	10·7
16	*b*	*b*	*b*	*b*	41·4	·9	·4	16·9	7·5	6·3	8·7	11·9	3·0	1·6	1·7	100·3	29	Limburgite.	13·9
Total average ...					57·0	·5	·2	15·5	3·9	3·9	4·8	5·8	3·6	2·9	1·9	100·0	500		
Mean deviation ...					± 2·3	...		± 1·8	± (1·6)		± (1·9)		± (1·4)		...	...	...	...	9·0

TABLE II.—GROUP 9 OF THE ADOPTED SERIES OF SIXTEEN ROCK-GROUPS.

b	*a*	*a*	*a*
I	II	III	IV
24·8	37·4	32·2	40·9
+	−	−	−

Total bases minus
Al_2O_3, (Fe_2O_3 + FeO), (MgO + CaO), (Na_2O + K_2O).

SiO_2	TiO_2	T_2O_5	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Total.	Author.	Rock Name.	Locality.
68·8	...		5·9	5·8	5·3	·1	2·1	7·5	4·3	...	100·0	H. S. Washington, p. 220.	Pantellerite.	Pantellaria.
58·2	...		14·9	8·3		3·0	8·0	3·3	3·5	·8	100·0	N. Jahrbuch, 1903.	Trachyte.	Mount Cimina.
57·6		·8	14·7	8·6		5·0	7·5	3·5	1·9	·8	100·3	H. S. Washington, p. 424.	Ol. pyr. andesite.	Lipari Islands.
57·4	...		16·9	2·5	5·2	5·5	7·3	3·3	1·9	·8	100·7	,, p. 274.	Pyrox. porphyrite.	Yellowstone Park.
57·4	...		15·7	2·1	5·2	8·8	4·9	3·1	1·5	·7	99·9	,, p. 276.	Basalt.	California.
57·3	·6	·2	16·4	1·7	4·8	6·7	7·7	3·0	1·6	·4	100·4	,, p. 278.	Quartz basalt.	California.
57·3	...		10·9	2·0	6·0	4·6	8·6	1·5	7·6	1·5	100·0	N. Jahrbuch, 1903.	Minette.	Bohemia.
56·2		·3	16·1	4·9	4·4	4·6	7·0	3·0	2·4	1·0	99·9	H. S. Washington, p. 276.	Hyp. andesite.	Colorado.
56·0	·7		12·5	·5	15·9	6·1	4·2	2·0	·7	·7	99·3	,, p. 420.	Hyp. andesite.	Spitzbergen.
55·8	1·1	·2	17·1	4·1	3·8	5·1	7·4	2·9	1·7	1·3	100·4	,, p. 232.	Pyr. andesite.	National Park.
55·4	...		16·8	9·3		5·2	7·6	3·6	1·4	1·2	100·5	,, p. 408.	Augite diorite.	Hungary.
54·6	·6		12·1	1·8	5·1	11·9	7·7	2·4	1·0	2·6	100·0	,, p. 320.	Quartz diorite.	California.
54·4	·3	·3	14·3	6·3	4·2	5·9	7·5	3·4	2·2	1·2	100·0	,, p. 278.	Diorite gneiss.	British Guiana.
54·3	...		10·1	7·1	5·8	6·5	8·9	4·1	2·2	·6	99·6	Cole's handbook.	Olivine dolerite.	Hessen.
54·2	·9	·5	14·4	2·3	4·8	7·7	7·0	2·3	3·3	2·6	100·1	H. S. Washington, p. 268.	Ol. weisselbergite.	Prussia.
54·2	2·7	1·6	10·2	3·5	·7	6·6	5·0	1·2	11·9	2·1	100·2	,, p. 312.	Orendite.	Wyoming.
54·1	...		15·0	4·1	5·1	7·3	7·7	2·0	3·5	1·5	100·3	Hatch, textbook.	Diorite.	Benan.
53·8		2·0	15·8	6·9	4·3	5·5	7·7	3·0	·7	·8	100·5	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.
53·6		·9	14·2	1·5	8·1	7·1	8·5	1·8	2·0	2·6	100·3	H. S. Washington, p. 328.	Andesite.	Tuscany.
53·0		·6	13·1	8·2	2·5	5·2	10·6	3·3	2·0	2·2	100·7	,, p. 324.	Basalt.	Volcano.
52·8	2·1	·5	12·5	9·1	4·0	4·5	8·1	2·6	2·4	1·0	99·6	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.
52·5	...		12·1	3·5	5·2	9·9	9·7	2·8	2·2	2·1	100·0	Cole's handbook.	Diorite.	
52·3	·6	·6	14·9	3·5	3·7	5·8	6·3	2·9	3·8	(5·3)	99·9	H. S. Washington, p. 270.	Kersantite.	Thüringerwald.
52·2	1·4	·5	14·6	10·8	3·2	5·0	8·7	1·8	·6	·3	99·1	N. Jahrbuch, 1904.	Dolerite.	Oberofleiden.
52·2	2·1	·1	12·2	10·1	2·9	5·5	7·1	3·8	2·2	1·1	99·3	,, 1904.	Dolerite.	Oberofleiden.
51·3	1·4		15·5	3·2	7·1	4·4	9·2	3·8	1·2	(2·9)	100·0	Pamphlets, 1871.	Anamesite.	Dietesheim.
51·2	1·0	·5	16·1	4·1	4·7	4·8	7·9	3·0	3·5	2·9	99·9	H. S. Washington, p. 266.	Aug. andesite.	National Park.
51·2	2·4	·3	14·1	4·6	8·9	4·4	8·3	2·6	1·3	1·6	99·7	Cole's handbook.	Dolerite.	Durham.
51·0	1·8	·7	14·5	4·2	4·4	8·2	5·1	1·8	7·2	1·0	99·9	H. S. Washington, p. 254.	Durbachite.	Black Forest.
51·0	·7	·5	15·6	8·5	1·4	5·2	6·5	3·4	3·1	3·9	99·8	,, p. 274.	Hornbl. basalt?	National Park.
50·3	1·0	·5	15·9	8·2	1·5	4·7	7·9	3·0	3·5	3·8	100·3	,, p. 268.	Gabbro porphyry.	Yellowstone Park.
49·8	2·7	·7	15·3		7·7	6·6	7·2	2·7	4·4	4·0	101·1	,, p. 418.	Mica andesite.	New Mexico.
49·6	·7	6·0	9·6	5·6	5·2	1·3	13·9	4·9	3·2	·4	100·3	,, p. 312.	Pyr. ap. syenite.	Montana.
49·0	2·8		15·3	2·6	8·2	4·9	8·2	2·5	2·6	3·3	99·4	Hatch, textbook.	Dolerite.	Rowley.
48·3	1·0	·2	17·1	1·9	4·9	3·1	9·8	3·1	2·4	8·5	100·2	H. S. Washington, p. 445.	Melaphyre.	Harz.
54·0	·8	·5	14·1	4·9	4·7	5·6	7·6	3·0	2·9	1·9	100·0	...	Diorite.	
± 2·6	...		± 1·9	± 1·9		± 1·5		± 1·5		...	± 9·4			

TWO TABLES TO ILLUSTRATE DR. HUGH WARTH'S ARTICLE "ON A METHOD OF CLASSIFYING IGNEOUS ROCKS ACCORDING TO THEIR CHEMICAL COMPOSITION."—GEOL. MAG., MARCH, 1906, NO. 501.

averages serve to find the group to which any other igneous rock belongs. The following two examples will illustrate this:—

No. 1, a specimen of Elvan from Cornwall, recorded in Cole's handbook.

No. 2, a rock named Teschenite from Cape Verde, recorded by H. S. Washington, p. 352.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O
No. 1 ...	71·4	15·4	·3	2·3	·2	·5	2·8	5·5	1·7
No. 2 ...	39·6	17·0	6·6	9·3	6·7	10·6	6·0	3·1	1·3

First calculate the four values I, II, III, IV, which represent the total of the seven bases (or four sets of bases) minus respectively Al_2O_3, $Fe_2O_3 + FeO$, $MgO + CaO$, $Na_2O + K_2O$. The values are as follows:—

	I.	II.	III.	IV.
No. 1 ...	11·6 ...	24·4 ...	26·3 ...	18·7
No. 2 ...	42·3 ...	43·4 ...	42·0 ...	50·2

Following the scheme, p. 134, we find that sum I of example No. 1 is below the average of 24·8, and is therefore to be marked as (*a*). For comparison with II the reader must now take the left-hand value of II = 28·4, and this gives again (*a*). For comparison with III we have thus again the left-hand value III = 24·2. We now have an excess and letter (*b*). The fourth letter is again (*a*), because 18·7 is smaller than 22·6. The entire formula for rock No. 1 is therefore (*a a b a*), group 3 (granite) of separate Table I.

Sample No. 2, compared in the same way with the scheme, p. 134, is found in all four cases to exceed the corresponding numbers of the scheme; the formula is therefore (*b b b b*), group 16 of Table I.

REVIEWS.

I.—Catalogue of the Fossil Plants of the Glossopteris Flora in the Department of Geology, British Museum (Natural History); being a monograph of the Permo-Carboniferous Flora of India and the Southern Hemisphere. By E. A. Newell Arber, M.A., F.L.S., F.G.S., Trinity College, Cambridge, University Demonstrator in Palæobotany. (London, 1905.)

THE present Keeper of the Geological Department of the British Museum has continued the wise policy of his predecessor in encouraging the production of comprehensive accounts of the fossil floras represented in the National Collection. Mr. Arber's volume supplies geologists and botanists with an excellent summary of the present state of our knowledge in regard to the Glossopteris Flora, and includes concise descriptions of the abundant material in the Fossil Plant Gallery. The excellent illustrations by Miss G. M. Woodward add considerably to the value of the work.

It is a striking fact that the six volumes dealing with Fossil Plants in the British Museum which have so far been published are written by men who are not members of the Museum Staff. By sanctioning the expenditure entailed in the production of these catalogues the Trustees have recognised the importance of the palæobotanical collections; but it is to be regretted that this branch of palæobotany has not been placed under the care of an expert assistant. This is not the place for an expression of opinion as to the best method of dealing with fossil plants in a Natural History Museum, but it is perhaps not unreasonable to suggest that the subject of palæobotany is worthy of recognition as an important branch of Natural Science which should be under the charge of a specialist competent to arrange, describe, and extend the collections under his care.

Mr. Arber's Introduction may be described as the best account which has so far been given of the botanical affinities and distribution of the Glossopteris Flora. The widely scattered literature on the Permo-Carboniferous vegetation from South America, South Africa, India, and Australia is summarised in a comprehensive Historical Sketch. In the descriptive portion of the volume the author has added considerably to the value of the work by including certain types which are not represented in the Museum. Under the Thallophyta are included the somewhat problematical fossils ascribed by Bertrand and Renault to the Algæ. Under the Equisetales the genera *Schizoneura* and *Phyllotheca* are fully described so far as the material permits, but in regard to the representatives of the Equisetales, as in the case of nearly all the fossil plants from the Glossopteris-bearing strata, there is a surprising dearth of material which throws light on the nature of the reproductive organs or on anatomical structure.

In the section dealing with ferns Mr. Arber contributes a carefully drawn up synopsis of the species of *Glossopteris* which cannot fail to be of value to students of this flora. Everyone with any knowledge of recent ferns admits the impossibility of attempting to recognise true specific characters in the numerous forms of frond and in the slight differences in venation characters; but some system, though an admittedly artificial one, is necessary as a working scheme for descriptive and cataloguing purposes. The account of the fructification of *Glossopteris,* based on the results of the author's original observations, is particularly interesting; supposed fertile fronds of this genus have often been described, but we have now for the first time a description of undoubted reproductive organs. Among the Gymnosperms are included several genera of more or less doubtful position, but it is refreshing to find one set of petrified specimens—referred to *Dadoxylon*—exhibiting anatomical characters in a good state of preservation. There is little doubt that the long strap-like leaves which it has been customary to refer to *Noeggerathiopsis* are generically identical with the European *Cordaites.* Mr. Arber, though retaining the former name, admits the close alliance of the northern and southern forms.

A perusal of the bibliography at the end of the volume affords some idea of the labour involved in monographing the Glossopteris

Flora. The task has been difficult. The imperfect nature of the specimens has rendered accurate diagnosis and determination impossible in many cases, but the author has faced the difficulties in a spirit of scientific caution, and there has been no attempt to overestimate the significance of unimportant characters. The volume before us will be thoroughly appreciated by residents in South Africa, Australia, and other countries where the Glossopteris Flora occurs, and we may confidently look forward to the discovery of better specimens which will afford the means of placing on a firmer basis of botanical knowledge the vegetation of Gondwana Land.

II.—A Guide to the Fossil Reptiles, Amphibians, and Fishes in the Department of Geology and Palæontology, British Museum (Natural History), Cromwell Road, London, S.W. Eighth edition (entirely re-written), 1905. 8vo; pp. 110, with 8 plates and 116 figures in the text. (Price 6*d.*)

(PLATE XII.)

The progress of biological science has been so great within the last fifty years that the barrier which once divided the two branches of study into fossil and recent animals has been swept away, and we find the student of zoology quite eager to learn all he can about those ancient forms of life, now long since extinct, and to trace out their relationship with their living descendants.

It thus happens that on entering the Geological Department we see the modern Indian Elephant installed close to the American Mastodon and the European Mammoth, while near by are the more ancient ancestral forms of *Palæomastodon, Mœritherium,* etc., from Egypt, together with the *Dinotherium* and the existing African Elephant to 'round up' the story of the Proboscidea.

On the modern Zoological side advances have also been made towards an *entente cordiale* between the recent and fossil Reptilia, and we find the centre of the gallery occupied by the newly acquired skeleton of *Diplodocus Carnegiei,* a huge Dinosaurian land reptile, 80 feet in length, from the Upper Jurassic strata of Wyoming Territory, U.S.A.,[1] surrounded by a court of recent Crocodiles, Tortoises, Snakes, and Lizards, whilst pictures and casts of various fossil forms are shown in the cases with their recent congeners.

These arrangements, of course, partake of compromise, but it would be next to impossible frequently to change the order of such vast collections as are preserved in the National Museum; the business is costly in the extreme, and the amount of labour involved simply stupendous. Professor Sir Wm. Flower, the late Director, commenced a rearrangement of a part of the collections, assisted by Mr. Lydekker, one of the most active and energetic of zoologists; but Flower died in 1899, and although Lydekker has continued his labours in association with Professor Ray Lankester, the present Director, the vast work of reorganizing the Zoological Galleries is still in progress.

[1] See Geol. Mag., December, 1905, p. 576, Pl. XXV.

Dealing only with extinct forms (save where a few living representatives have been introduced), the Keeper of the Department of Geology and Palæontology, Dr. Arthur Smith Woodward, and his predecessor, have devoted their entire energies during twenty-six years, since the removal from Bloomsbury, in bringing the great collections into order, and in the preparation of catalogues and guidebooks, of which quite a large number have been published.

Although the staff at the Keeper's command is but small, it has been most efficient in carrying on the general work, whilst a dozen or more scientific experts, specially engaged, have taken up the task of naming or arranging and cataloguing various groups to which each specialist had devoted himself. This explains the very excellent and 'up-to-date' appearance of the palæontological collections generally, both in the matter of arrangement and labelling, to which especial attention has been paid.

The Guide which is now before us—an entirely new edition—contains an account of the Reptiles, Amphibians, and Fishes which occupy 5 Galleries; the Reptilia taking up 54 table and wall-cases, the footprints of Reptiles, etc., 3 wall-cases, the Amphibia 4 cases, and the Fishes an entire Gallery, fitted up with 61 wall and table-cases. Four catalogues appeared between 1888 and 1890, by Mr. Lydekker, on the Fossil Reptilia and Amphibia, comprising over 1,200 pages of descriptions and 273 woodcuts in the text; but since then the collection has nearly doubled itself in extent.

The Guide now issued is so splendidly illustrated that it brings the account of this part of the Geological galleries well up to date. Some idea of the excellence of the figures may be gained by reference to the accompanying Plate XII, giving a view of two skulls of *Miolania*, the remarkable horned tortoise, one species of which was found in the so-called Cretaceous of Patagonia, the other in the Pleistocene of Queensland, Australia. Another illustration given is of *Diplodocus Carnegiei* (see GEOL. MAG., December, 1905, Plate XXV).

Among further striking and important additions recently made to the fossil Reptiles on the eastern side of the building may be mentioned the setting up of the limbs and tail of a Dinosaurian land reptile (*Cetiosaurus Leedsii*) discovered by Mr. Alfred N. Leeds in the Oxford Clay near Peterborough, of which a page-plate is given in the Guide. It was a beast as large as the *Diplodocus*, and closely allied to it.

Another striking object is the skeleton of a huge toothless flying reptile (*Pteranodon occidentalis*) from the Upper Cretaceous of Kansas, U.S.A. The bones, so far as obtained, are mounted on a life-size picture of the complete skeleton in wall-case 2, at the east end of the gallery. The total expanse of the wings is about eighteen feet. The great crest on the back of the skull may have served for the attachment of some of the muscles which moved these vast wings.

The skeleton of *Pariasaurus*, a huge Anomodont reptile from the Karoo Formation of Cape Colony, discovered by Professor H. G. Seeley; the articulated skeletons of two Plesiosaurs, reconstructed

A

B

Skulls of two species of a Horned Tortoise (*Miolania*).

A. *Miolania argentina*, from the supposed Cretaceous of Chubut, Patagonia.
B. *Miolania Oweni*, from the Pleistocene of Queensland, Australia.

from the actual bones out of the Oxford Clay near Peterborough, obtained by Mr. A. N. Leeds; the fine series of Ichthyosaurs and Plesiosaurs on the walls; the reproduction of the Bernissart *Iguanodon* from Belgium, in the centre of the gallery; and lastly, the reconstructed skeleton of *Polacanthus Foxii*, an armed reptile from the Wealden of the Isle of Wight (see Geol. Mag., June, 1905, p. 242, Plate XII), make up a most attractive and striking display of Mesozoic Reptilian life.

The Fish Gallery has always been a magnificent exhibition, and is still unsurpassed by any other in the world. In addition to all his other work Dr. Arthur Smith Woodward has spent 13 years in the production of four large volumes on the series of Fossil Fishes, covering 2,393 pages of text, with 138 text illustrations and 70 plates, including a large number of very beautiful outline restorations of special genera. The latest wonder is a tail of the gigantic *Leedsia problematica*, from the Oxford Clay of Peterborough, mounted on the east wall between cases 13 and 14. It has a span of 9 feet, and probably represented a fish 30 feet in length! The series of remains of giant armoured Devonian fishes from Ohio of the genus *Dinichthys* deserve to be specially mentioned, and the *nearly complete* examples of sharks, *Cladoselache*, from Cleveland, Ohio (also of Devonian age), some of which were 5 to 6 feet in length, showing the jaws with teeth, the paired fins and tail, with the outline of the body.

Another group of curious Palæozoic sharks, with a coiled up series of teeth (to which the genus *Edestus Davisii* belongs, see figure and description, Geol. Mag., 1886, p. 1, Plate I), has been discovered by Professor Karpinsky in the Permo-Carboniferous of Perm, Russia, having a coil of teeth so symmetrically arranged as to present a close resemblance to an Ammonite or other discoidally coiled fossil shell.

We wish that space permitted a longer notice, for the collections here described and illustrated so profusely in this little Guide, deserve to be even more widely known than they are; but such excellent handbooks, at so small a price, are sure to attract students; even the ordinary visitor, more bent upon pleasure than instruction, cannot fail to be delighted and amused and take away with the book some grains of knowledge. But it is especially for the young that these beautiful guidebooks are intended, and we hope the pictures may prove an attractive bait to many boys and girls who may thus turn out to be the geologists of the future.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 24th, 1906.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Igneous and Associated Sedimentary Rocks of Llangynog (Caermarthenshire)." By T. Crosbee Cantrill, B.Sc., and Herbert Henry Thomas, M.A., F.G.S.

The sedimentary rocks associated with the various igneous masses comprise the following:—

LOWER OLD RED SANDSTONE.	Red marls and sandstones, with cornstones and conglomerates at the base.
ORDOVICIAN (ARENIG).	*Didymograptus bifidus* Beds. Blue-black shales, with one or more thick bands of grit towards the base. *Tetragraptus* Beds. Black and buff shales with thin grit bands: thick bands of ashy grits and conglomerates towards the base.

These rocks are described in detail. They occur in two main anticlines, overfolded, and complicated by thrusts which cut out a great part of the intervening syncline. They are covered unconformably by the lower beds of the Old Red Sandstone. The igneous rocks occur in three well-defined areas, which belong to the same petrographical province, near Coomb, at Capel Bethesda, and at Lambstone. Both interbedded and intrusive rocks are represented, and full petrographical descriptions of all types are given in the paper. The latter include diabases, and the large porphyry mass of Lambstone. The extrusive rocks have been determined to occur in the following order:—(1) augite-andesites; (2) rhyolites; and (3) augite-andesites, with some hornblende-andesite. The extrusive rocks are interbedded with fluxion breccias and with tuffs; they are associated with the lower members of the *Tetragraptus* Beds, and are consequently of Lower Arenig age; while the intrusive rocks have been injected into the extrusive rocks, and have also affected the *Tetragraptus* Beds, but at what date exactly it is impossible to say, except that it antedates the Old Red Sandstone. Much of the folding and faulting was accomplished before the Lower Old Red Sandstone was deposited, but certain faults involve this formation, and make it clear that there was an important later movement.

2. "The Buttermere and Ennerdale Granophyre." By Robert Heron Rastall, B.A., F.G.S. (Christ's College, Cambridge).

This paper embodies the results of field-mapping and microscopical study of the large mass of igneous rocks known, collectively, as the Buttermere and Ennerdale Granophyre. From the facts put forward it is concluded that the intrusion is an example of an acid magma, which has crystallized under the peculiar set of conditions that gives rise to a very perfect development of granophyric structure. These conditions are probably, to a certain extent, intermediate between those of plutonic and true hypabyssal rocks. The masses appear to be of the 'cedar-tree' laccolite type intrusive about the junction of the Skiddaw Slates and the Borrowdale rocks, but penetrating into the higher rocks. Besides the normal acidic rock, which comprises the bulk of the intrusions, there are some marginal patches of more basic character, showing obvious genetic relationship, and slightly earlier in point of time than the intrusion of the acidic rock. These basic forerunners afford evidence of differentiation of the magna before intrusion—an example of Professor Brögger's deep magmatic differentiation. Considered as a whole, the character of the magma shows closer affinity to the tonalite group than to the true granites, although it is somewhat more acid than the majority of tonalites. The more basic types include dolerites, quartz-dolerites, and a rock type intermediate between quartz-dolerites and granophyres, for which no satisfactory name seems to exist. There is also a development of peculiar rock types as the result of the re-mixing of previously differentiated partial magmas of an acid and a basic character respectively. A study of the distribution of different types of granophyric structure shows a certain regularity of arrangement, and an attempt is made to reconcile these with known physical laws, especially with reference to eutectics; and it is concluded that the structure is the result of crystallization under conditions intermediate between those which produce typical plutonic and hypabyssal rocks.

II.—February 7th, 1906.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Carboniferous Limestone (Avonian) of the Mendip Area (Somerset), with especial reference to the Palæontological Sequence." By Thomas Franklin Sibly, B.Sc., F.G.S.

The Avonian rocks are exposed in four main anticlinal forms or periclines—those of Black Down, North Hill, Pen Hill, and Beacon Hill; each of which has an approximately east-and-west trend and has Old Red Sandstone exposed in its core. The following is the zonal succession:—

	Zones.	Subzones and Horizons.	Feet.
Kidwellian.	*Dibunophyllum*	D_2. *Lonsdalia floriformis.* D_1. *Dibunophyllum θ.*	500
Kidwellian.	*Seminula*	S_2. *Productus* aff. *Cora* mut. S_2. S_1. *P.* cf. *semireticulatus* mut. S_1.	720
Clevedonian.	*Syringothyris*	C. *S. cuspidata.*	550
		γ	
Clevedonian.	*Zaphrentis*	Z_2. *Z.* aff. *cornucopiæ.* Z_1. *Spirifer* aff. *clathratus.*	800
		β	
Clevedonian.	*Cleistopora*	K_2. *Spiriferina* cf. *octoplicata.* K_1. *Productus bassus.* M. (*Modiola*-phase.)	450

In the present paper, the faunal sequence is discussed in detail, attention being confined almost entirely to the corals and brachiopods, which predominate throughout the series. The lithological character of each zone and subzone is treated briefly. The general stratigraphy of the area is briefly discussed, reference being made to the more important forms. Following this, the exposures examined are classified in zonal order, and tabulated under the zonal headings. The best exposures of each zone receive special attention.

A correlation with the Bristol area brings out the following more important points. The faunal succession is essentially similar in the two areas; and in both there is good ground for a twofold division into Clevedonian and Kidwellian stages, the line of separation being drawn at the top of the *Syringothyris* Zone. The Mendip area exhibits, however: (1) a great expansion in the thickness of the *Zaphrentis* and *Syringothyris* Zones; (2) a continuously fossiliferous sequence from the top of the *Zaphrentis* Zone to the base of the *Seminula* Zone, possessing a characteristic coral and brachiopod fauna; and (3) a relative acceleration of the coral fauna on the brachiopod fauna, exhibited in the *Zaphrentis* Zone.

The paper contains a detailed account of the Ebbor Rocks District, near Wells, and concludes with notes on certain corals and brachiopods included in the faunal lists, together with descriptions of some new species and mutations.

2. "The Igneous Rocks of the Eastern Mendips." By Professor Sidney Hugh Reynolds, M.A., F.G.S.

The igneous rocks associated with the Old Red Sandstone of the Mendips are exposed along the crest of the range from Beacon Hill on the west to near Downhead on the east, a distance of rather more than 2 miles. Hitherto they have always been regarded as intrusive, but the opening of some new excavations has shown that they are associated with a considerable thickness of tuffs, and are in all probability contemporaneous lava-flows.

The exposures show a division into three sections—those of Beacon Hill, Moon's Hill, and Downhead; and a large quarry has been opened in the trap in each section. The trap, which can be traced fairly continuously from one end of the area to the other, is very uniform in character, consisting (as already noted by Dr. Teall) of a non-amygdaloidal pyroxene-andesite, which usually contains augite in addition to enstatite. A fine section of tuff some 100 feet thick is seen lying with perfect conformity below the trap in the New Quarry near Stoke Lane; and an interesting little exposure of tuff, remarkable for the numerous rounded blocks of trap present, is seen in the excavation for the rifle-butts on Beacon Hill. The tuff here dips under the Old Red Sandstone to the north. Although the tuff is seen *in situ* only at the above two points, loose pieces have been met with at a number of other spots all along the southern outcrop of the trap, and point clearly to the occurrence of a continuous band underlying it.

Though no sedimentary rocks are seen in direct contact with those of the igneous series, outcrops of Old Red Sandstone completely surround the exposures of trap and tuff, and occur in such close relation to them as to leave little room for doubt that the igneous series is of Old Red Sandstone age. On the other hand, Silurian fossils were met with below the igneous series at a point to the west of Downhead, and render it possible that the igneous rocks may be of Silurian age, and the equivalents of those which are exposed at Tortworth.

II.—Mineralogical Society of London.

January 23rd, 1906; Professor H. A. Miers, F.R.S., President, in the chair.—Studies in Crystallisation, Sodium Nitrate, by H. A. Miers and J. Chevalier. Microscopic observations were made upon solutions of known strength contained in open tubes or sealed tubes maintained at a known temperature, or in the form of drops upon a slide, with the object of comparing the growth of crystals in metastable and labile solutions respectively. The limits of the labile state (in which the solution can crystallise spontaneously) have been fixed by previous experiments by H. A. Miers and Miss F. Isaac. If a crystal of the salt be introduced into a supersaturated solution which is not labile, the centres of growth of new crystals are on its surface, and they grow in parallel positions upon it; if it be introduced into a labile solution the new centres of growth are in its neighbourhood, and the crystals fall upon it in various positions. If it be moved about in either, a cloud of crystals is produced; but in the metastable solution this appears to be due to minute crystals which are swept from its surface. A crystal having appeared spontaneously, can continue to grow in a labile solution without producing others in its neighbourhood; but if introduced, it at once produces a cloud. This may be because the growing crystal is surrounded by a zone of metastable solution.—Geikielite and the Ferro-magnesian Titanates, by T. Crook and B. M. Jones. Geikielite occurs in association with magnesian menaccanite and common ilmenite (menaccanite) in the gem gravels of the Balangoda and Rakwana districts of Ceylon. A considerable number of analyses indicate that Geikielite varies in composition, the iron oxides ranging from 8 to 14 per cent. No specimen has hitherto been found which contains less than 8·1 per cent. of iron oxide. For this reason the formula (Mg Fe) Ti O_3 is preferable to Mg Ti O_3, as expressing the true composition of Geikielite. Magnesian menaccanite containing about 28 per cent. of iron oxide is very closely allied to Geikielite in all its properties, more so than to common ilmenite. The alteration products of Geikielite are similar to those of ilmenite, consisting of rutile and so-called leucoxene; the latter is a mixture of amorphous titanic acid, sphene, and limonite. It seems advisable to classify the ferro-magnesian titanates as Ilmenites and Geikielites, treating magnesian menaccanite (which has the formula (Fe Mg) Ti O_3 where Fe : Mg = 1 : 1) as the middle member of the series.—G. F. Herbert Smith exhibited and explained the use of a diagram for the graphical determination of the refractive index from the prism angle and the angle of minimum deviation. He also explained a simple test for ascertaining the pair of faces corresponding to any refracted image.

CORRESPONDENCE.

MACHINE-MADE IMPLEMENTS.

Sir,—Since this article appeared, I have been able, in company with Mr. C. Bird, F.G.S., of Rochester, to visit a chalk wash-mill at the Borstall Cement Works near that city.

I found that the machinery used was much the same as that in the brickearth wash-mills referred to in my article of February, 1906, but I learnt this most important piece of information, not hitherto mentioned by anyone as far as I have been able to discover, viz., that during the 2 days, or 29 hours, that the mill is at work, *fresh charges of chalk are introduced*; this is of the utmost importance, as it affects materially the results obtained. I had only a very short time for my visit, but I think I got all the available information. The men told me that, as at Mantes, they removed all the visible flints, so that the remaining ones, which they do not want, are those concealed in the chalk. The harrows also, as in the Mantes mills, do not come within some inches of the bottom of the basin, and the speed would appear to be the same at Borstall as at Mantes.

From the flint refuse heap, "the heap of Eoliths" as M. Boule styles them, I got a very good selection, some of which, as the men were able to tell me, had been in *for the full time*, and some of which had been in *for only part of the time.*

Now from those that had been in for *only part of the time* I got some flints that, *if photographed,* would give very fair samples of Eoliths, though not comparable otherwise in true work, some showing bulbs of percussion and the fractures so polished that they have quite an *old* look. My own attempts at forgeries are useful, as they show me that I can produce in a short time this old polish, where the flint allows of this. So that I was quite prepared for the apparent old polish on newly fractured flints from the chalk. Some of these had still on them some of the white crust of flints fresh from the chalk.

But those flints that had been in the *full time were quite different from, and not Eoliths at all.* These must have sunk to the bottom, *quite out of reach of the harrows*, the "quasi-human element" referred to in my article of February, and thus were the results ultimately of *water-action only*, highly charged of course with chalk mud. These come out as almost perfectly *smooth spheres,* and quite unlike any *naturally water-worn* pebbles, and what one would naturally expect to be the outcome of flints, rotated at an uniform speed in a circular basin, and under conditions that do *not occur* in nature, save perhaps in a 'giant-cauldron.'

Those flints that *go in last,* especially if the space beyond the reach of the harrows be fully occupied, must be more or less, during that time, in contact with the harrows, and these are the pseudo-Eoliths.

So that we have this point, I think, clearly shown, and for the first time in this machine-made implement controversy, that the pseudo-Eoliths are the result of the pseudo-human element represented by the harrows, and that the pseudo-torrent action, apart from the harrows, only produces *spheres.* I made a selection of these from the battered, buffeted, rough, and imperfect, to the smooth and almost perfect sphere. F. J. Bennett.

West Malling.
February 14th, 1906.

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THE

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ORIGINAL ARTICLES.

I.—Lamarck and Playfair: A Geological Retrospect of the Year 1802.[1]

By Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S.,
President of the Geological Society.

When the "Alliance Française" did me the honour of inviting me to give an address on this interesting occasion, the choice of an appropriate subject of discourse presented at first some little difficulty. On the one hand, as a representative of science in the "Alliance Franco-Britannique," it appeared to be incumbent upon me to choose some topic of a scientific kind, and by preference one which would in some way link our two countries together in common bonds of association. On the other hand, it was obviously inadvisable that the theme should be of a technical character which would be little suited for a general audience. After some reflection I decided to present for your consideration a brief account of two remarkable volumes, both of which, dealing with geological questions, appeared in the year 1802, the one in Paris, the other in Edinburgh. Though the political sympathies which for so many generations had linked France and Scotland in a friendly alliance had fallen somewhat into abeyance by the beginning of last century, the two nations still continued to be drawn to each other in the realms of culture by a common ardour in the prosecution of science and philosophy, and by the mutual reaction which, in these great domains of human thought, they exerted on each other.

At the time which I have selected for review, the science of geology, though still in its infancy, had awakened widespread interest on both sides of the Channel. The French and English observers who pursued it kept themselves, for the most part, in touch with the progress of enquiry in both countries. Thus, it is pleasant to remember that Desmarest, one of the brightest lights in the history of French geology, though he had determined not to notice in his great "Géographie Physique" the work of living writers, departed from his rule in order to give his fellow-countrymen an

[1] An address delivered before the "Alliance Française" in the Sorbonne, Paris, on 26th February, 1906.

account of the important memoir in which the illustrious Scottish geologist, Hutton, had then recently published the first sketch of his "Theory of the Earth." On the other hand, Hutton, by the numerous references and citations in his writings, showed how closely he had studied and how generously he appreciated the publications of his French contemporaries.

Looking backward to the beginning of the nineteenth century, we see the European geologists of that time ranged in two opposite schools, which might be called hostile camps, that waged with each other an animated and prolonged warfare. Not until after the chief antagonists of that time had one by one passed away did the feud finally die out. On the one side, the crowded ranks of the Neptunists marched under a banner on which was boldly emblazoned the war-cry of "Water." These militant theorists maintained, as the cardinal article of their faith, that our globe was once surrounded with an universal ocean, from whose waters the oldest rocks of the terrestrial crust were successively deposited as chemical precipitates. They scouted the notion that the earth possessed a highly heated interior, and nicknamed as 'fire-philosophers' those who held such a belief. They contemptuously dismissed the idea that any of the rocks of the crust had been erupted from below in a molten condition. They accounted for volcanoes by boldly reviving the ancient hallucination that they were caused by the accidental ignition of subterranean beds of coal. Hence as, on that supposition, volcanic action could only have come into existence after vegetation had flourished for a long time upon the surface of the earth, so as to form there thick deposits of combustible materials, they affirmed that the appearance of volcanoes must be a comparatively late phenomenon in the history of our planet. They had not the least conception of any source of energy lodged in the interior of the earth. The broken and convoluted rocks of mountain-chains awakened in these men no doubt of the fundamental truth of their doctrine, for they complacently explained these stupendous structures as nothing more than the natural result of the dessication, fissuring, and subsidence of the universal aqueous deposits.

On the other side of the field of battle, the phalanx of the Plutonists or Vulcanists, less numerous but not less confident and strenuous, proudly brandished their flag which bore the watchword "Fire." With much more tolerance than was shown by their opponents, these combatants freely admitted that a large part of the earth's crust undoubtedly consists of materials that were laid down in the sea. But they contended that the subsequent uplifting of these materials into dry land and ranges of mountains arose from the expansive power of heat within the globe. Following Descartes and Leibnitz, they conceived that this intensely hot interior was the source whence many crystalline rocks had been forced upward into the cooler crust, and that from the same source the activity of modern volcanoes is still derived.

The dust and din of this warfare have long since subsided. Looking back from the point at which we have now arrived in the onward march of science, we may well wonder that such a controversy should ever have arisen at all, or that having been started it should have been waged so keenly and for so long. We must remember, however, that in those days the range of actual definite knowledge in regard to geological processes was still comparatively narrow, while at the same time the natural tendency to speculation and theory could be indulged in without much hindrance from the control of ascertained fact. On both sides of the dispute, imagination played a not unimportant part in the theoretical views proposed; but in this respect the partizans of Water must be allowed to have stood pre-eminent. Their complacent defiance of the laws of physics and chemistry, imperfectly as these were appreciated a hundred years ago, is one of the most curious episodes in the history of geology. The advocates of Fire came much nearer to the truth as we now understand it, though they too were inclined to push their distinctive opinions somewhat further than the known facts warranted.

It was while this contest of the rival schools had reached its height that the two volumes to which I wish to ask your attention made their appearance. Between the respective writers of these books—Jean-Baptiste de Lamarck and John Playfair—some curious parallels may be remarked. They were both intended by their parents to become ecclesiastics, the one in the Roman Catholic Church of France, the other in the Protestant Kirk of Scotland, but both eventually drifted into the ranks of science. Neither of them was a professed geologist, but was engaged, during most of his career, in the prosecution and teaching of widely different branches of knowledge. Both of them had passed middle life before they appear to have given much thought to the problems of geology, and neither of them published any special work on the subject save the volume which appeared in 1802. Each was led by a different path into the geological field of observation and theory, and, so far as known, neither had any acquaintance with what the other was engaged upon. While they entered upon the consideration of the subject from opposite sides of enquiry, they both endeavoured to take a broad view of Nature in order to frame a connected scheme of geological philosophy. And lastly, both sought to establish what in the language of their day was called a "Theory of the Earth"—in other words, a systematic grouping and discussion of the various processes whereby geological changes are effected.

Among the recorded careers of men of science, none surely is more picturesque than that of Lamarck. Born in 1744, of an old but not opulent family long settled in Picardy, he was, as I have said, originally destined for the Church, but when a lad of no more than 17 the martial traditions of his race proved too strong to be fettered by ecclesiastical restraints, and on the death of his father he boldly set out to offer himself as a volunteer in the French Army, then at war in Germany. He arrived at the front on the eve of a battle, at which he next day so distinguished himself for his coolness and bravery that he was at once promoted on the field to be an officer. Owing, however, to an accident that happened to him not long after the declaration of peace, he had to leave the Army. Already he had acquired a strong liking for botanical pursuits, and in spite of his struggle with poverty he was able to devote himself with so much ardour and success to these studies that before many years were passed he published, under Buffon's auspices, his "Flore Française," and was soon acclaimed as one of the most eminent botanists of his day. In watching the progress of his career we see how, through the terrors of the Revolution, he remained quietly at the post which he had obtained at the Jardin des Plantes; how he pleaded successfully for the adequate endowment and reorganisation of that institution and of the Muséum d'Histoire Naturelle; how at last when 50 years of age he was offered a Professorship at the Museum, not of botany, to which he had till then devoted his life, but of invertebrate zoology, which he had not specially studied; how, with a courage and self-reliance not less marked than he had shown on the battlefield, he accepted the appointment, and after middle life began to acquire and then to teach what was to him a new science; and how before the lapse of many years he made himself the most philosophical zoologist of his time, and the pioneer of the modern doctrine of biological evolution. Year after year he continued his indefatigable researches and issued his voluminous publications, until his eyesight gave way, and he spent the last ten years of his life in blindness. But even under this grievous infliction he refused to quit his task. Sustained by the devoted affection of his eldest daughter, to whom he dictated the concluding volume of his immortal "Animaux sans Vertèbres," he survived to reach the ripe age of 85.

During his studies as "Professor of zoology, of insects, worms, and microscopic animals," Lamarck perceived the importance of connecting his investigation of living forms with an examination of the extinct types preserved in the various formations of the earth's crust. He saw that the organic remains in the rocks not merely furnish materials for elucidating the structure and affinities of living animals, but supply data for the interpretation of the ancient history of the globe. So vigorously did he prosecute his researches and so deeply did he leave his mark on this great department of natural history, that he is now everywhere acknowledged to be not less entitled to the name of founder of Invertebrate Palæontology than his great contemporary Cuvier is to that of founder of the Vertebrate division of that science. It was doubtless in the course of his investigation of fossil organisms that Lamarck's attention became rivetted to the consideration of some of the more important problems in the domain of geology. That he had pondered long and profoundly over them and sought their solution by original methods of his own device was at last revealed to the world by his publication of a treatise to which he gave the name of "Hydrogéologie." This was a small volume of 268 pages which made its appearance at the beginning of the year 1802, eight years after his appointment as Professor at the Museum. It never reached a second edition; indeed, it would appear to have excited but little interest among his contemporaries. His crude speculations in physics and chemistry were not unnaturally regarded as the aberrations of a genius of which no serious notice need be taken, and his geological observations, some of which were at least as original and singular, seem to have been thought worthy of no better treatment. He inveighed against the methods and conclusions of the physicists and chemists of his day, though he does not appear to have himself studied these sciences experimentally, but to have evolved his ideas regarding them out of his own fertile brain. He went so far in his opposition to the current beliefs as to declare that even although the whole world should accept them he would be content to remain the solitary disbeliever.[1] He would seem to have been as good as his word, and to have scouted modern physics and chemistry as long as he lived.

Yet in neglecting his little volume, his contemporaries and their successors failed to perceive that amidst all its strange conceptions it made some really valuable contributions to a sound theory of the earth. In judging it we must bear in mind the general ignorance then prevalent as to what are now seen to be most obvious and elemental facts about the history of our globe; likewise the baneful influence of the orthodox theological creed that only some 6,000 years had passed away since the creation of the universe. We should remember, too, that the internecine dispute between the Neptunists and the Plutonists had brought discredit on the study of geology, which was taunted as a mere field of strife and visionary speculation, wherein men were too often guided rather by their desire to uphold their own theories or damage those of their opponents than by the wish patiently to collect the facts that would ultimately establish the truth.

Lamarck belonged to neither of the hostile schools, and he makes no allusion to them in his treatise. It is refreshing to turn from the angry debates and trifling observations of the time to his calm philosophical pages, and to come into touch there with a great mind which contemplated Nature as a whole and sought after the true interpretation of her working. He was essentially a biologist, and he was led to enter the geological domain, not as a partizan of any of the theories of the day, but as an ardent enquirer into the history of life upon the earth. He appeared as a bold pioneer into the vast and still little known field of the geological past, and though, as was only natural and at the time hardly avoidable, he wandered from the track, he yet succeeded in opening up some pathways where no previous explorer had appeared, and in clearing and widening others that had already been partially trodden.

One fundamental truth was vividly realised and eloquently proclaimed by Lamarck. At a time when the orthodox six thousand years were still generally believed to limit the age of the earth, he had acquired a profound conviction of the high antiquity both of the globe itself as a planet, and of the plant and animal life that has flourished on its surface. Again and again in

[1] "Hydrogéologie," p. 167.

his "Hydrogéologie" he pauses to dwell on this great fact of terrestrial history. "To Nature," he remarks, "time is nothing and is never a difficulty. She always has it at her disposal as a means without limit for the accomplishment of the greatest as well as of the least of her labours" (p. 67). "From the evidence furnished by the earth's crust and by the mass of the mountains, the antiquity of this globe is seen to be so vast as to be absolutely beyond the power of man to appreciate" (p. 88). "Yet how much will this antiquity seem to increase in man's eyes when he shall have been able to form a true idea of the origin of living bodies, as well as of the gradual development and perfection of these bodies; and, above all, when he shall recognise that lapse of time and the necessary conditions having been required to bring into existence all the living species which are now to be seen, he is himself the final result and present maximum of this development, of which the ultimate limit, if such should exist, can never be known" (p. 89).

Another essential principle of geology was recognised by Lamarck perhaps more clearly than by any of his predecessors since the time of Aristotle—the principle of constant change upon the surface of the earth. The limited range of knowledge then available on this subject prevented him, indeed, from forming any adequate conception of one great side of it. He did not recognise that besides the various agents that take their origin and do their work on the surface of the earth, there is another powerful source of energy lodged within the interior and manifesting itself from time to time by slow or by sudden movements that more or less change the face of the globe. He writes, indeed, of local catastrophes and of the elevations, subsidences, and heapings-up of material which may now and then result from volcanoes and earthquakes (pp. 83, 97), but that he could have had no adequate conception of the probable condition of the earth's interior and of its reaction on the surface may be inferred from his still accepting the ancient error that all volcanoes on the earth derive their heat and energy from the combustion of seams of coal and other inflammable materials buried within the crust of the earth (p. 111). Nor does he appear to have had any notion of the natural operations whereby land is elevated and mountain-chains are upheaved, for he explained these phenomena by a hypothesis which was hardly less extravagant than some of his speculations in physics and chemistry. Thus he held that the ocean-basins have been scoured out of the surface of the globe by the erosive action of the sea, which, in virtue of its tidal oscillation and westward movement, attacks the eastern coasts of the continents, and throws up its detritus on their western shores. He thought that in this way the vast hollow that holds the oceanic waters actually travels round the globe, and has done so completely more than once in the earth's history, each revolution requiring a period of nine hundred millions of years for its accomplishment (pp. 178, 266).

When he contemplated the progress of the changes that take place upon the surface of the earth Lamarck stood on firmer ground, for he drew his conclusions more from the facts of observation than from the fancies of untenable theory. In his survey of these superficial changes he was more particularly struck by the far-reaching importance of those which result from the universal decay of the surface of the land and the removal of the disintegrated material to the bed of the sea. This impressive department of geological science had attracted attention from an early period, and had been especially studied by more than one observer during Lamarck's lifetime. His great contemporary Hutton, for example, had made it a cardinal feature in the scheme of his theory of the earth. The French naturalist, however, though he was probably indebted to the work of his predecessors, appears to have acquired a more vivid appreciation than any of them of the several processes that contribute towards the universal degradation of the dry land. He perceived that nothing in Nature can ultimately resist the various atmospheric influences which are ceaselessly at work upon every portion of the earth's surface exposed to their attacks. But in his little treatise he does not dwell on this part of his subject, contenting himself with a brief enumeration of these influences, in which he clearly distinguishes the effect of alternate wetness and dryness, of heat and cold, and more particularly of frost. The general effect of the combined operation of these subaerial agencies is pronounced by him to be the ultimate destruction of every aggregation of mineral matter, although the rate of advance of this disintegration must greatly vary, according to the nature and condition of the materials on which it acts (pp. 10, 11).

In one important respect Lamarck's outlook upon Nature differed from that of any previous or contemporary observer who occupied himself in the study of geological processes. Before his time it was the inorganic series of these processes which almost exclusively received attention. But Lamarck was led to contemplate the whole subject from the biological side. His long years spent in the investigation of plants and his subsequent absorbing researches in the animal kingdom had profoundly impressed him with the importance of what he called the 'Pouvoir de la Vie'—the power of living organisms to build up substances and structures which could have arisen through the operation of no inorganic agents. He had already, in some of his published memoirs, called attention to this great subject and formulated some of the conclusions to which he had been led, and he now devoted to its discussion the longest chapter of his little geological treatise. To him the processes of life formed one of the grand elemental forces of Nature, independent of but co-operating with the various physical agencies in building up the materials of the terrestrial crust, and in effecting the constant decay and reconstruction of the surface of the earth. It is only of late years that the efficacy of plant and animal life, as a department of dynamical geology, has been generally recognised, although we are still far from having discovered all the various ways in which organic bodies, living and dead, produce changes in the mineral kingdom.

There can be no doubt that in this matter Lamarck realised far more clearly than had ever been done before that the organic world plays an important part among the geological operations which change the surface of the earth. Had he been content to state in explicit terms the facts of observation on which he relied, and to put forward tentatively, or at least less dogmatically, the conclusions which he drew from them, his views would not improbably have received the attention to which they would then have been justly entitled. But he submitted no evidence in support of his confident asseverations. He made statements as if they expressed admitted truths, when in reality they were for the most part either disputable or actually contrary to already ascertained fact. On such an unreliable basis his characteristic ardour led him to build a stupendous speculation, in the promulgation of which, besides giving flight to his winged imagination, he was able at the same time to proclaim his own peculiar chemical views and to express once more his scornful dissent from the prevailing chemistry of his day. It can hardly be matter for surprise that, as he himself complained, his opinions on these matters met with no serious attention.

It is interesting to trace the logical process by which so gifted a genius arrived at conclusions to which his contemporaries would pay no heed, and which his successors have consigned to oblivion. The external crust of the earth, which, in his opinion, might be three or four leagues in thickness, consists of various minerals and rocks almost wholly made up of compound substances. The materials of this crust have undoubtedly been exposed to the manifold agents of geological change, ever since the world began. According to the prevalent opinion in his time (an opinion which has been amply sustained by subsequent research) the elements have a natural tendency to enter into combination, and the general compound nature of the constituents of the crust could be cited in favour of the orthodox view. Lamarck, however, had formed a totally different judgment of the matter. His own investigations had led him to conclude that, owing to the operation of the agents of destruction, the tendency in Nature was in exactly the opposite direction, that is, towards the breaking up and simplification rather than to the formation of compound substances. He regarded the surface of the globe as a vast field whereon Nature is ceaselessly at work in destroying every compound and resolving it into its integral constituents. Not that this change is always effected at once, by a complete liberation of the components; it rather comes as the result of successive alteration, the cumulative effect of which is to leave the substances progressively less complex (p. 101). This process of disintegration appeared to him to arise sometimes from an inherent tendency in the material itself to split up into its component ingredients, but more frequently from the action of external provocative influences, such as those of heat, water, and saline solutions.

But if such be the normal order of things, how comes it, he asks, that the outer crust of our planet, which, for such a prolonged succession of ages, has been ceaselessly exposed to this destruction and simplification of composite bodies, should nevertheless now consist of substances which are almost entirely compounds? With the confident anticipation that how much soever his contemporaries and their successors might retard the recognition of what he felt assured was a great discovery made by himself, Lamarck announced that there must exist in Nature a certain powerful and ever active cause which, while it counteracts the natural tendency of compound substances to break up into their constituent parts, is ceaselessly at work on its own side in forming new combinations. He triumphantly declared that this potent cause can be none other than the organic action of plant and animal life. Maintaining that the elements could never of themselves have formed the host of compound bodies on the face and within the crust of the globe, he went on to assert that without the operation of life, the 'Pouvoir de la Vie,' not one of these compound bodies could ever have come into existence (p. 106). Not only did he affirm that by the immediate action of vegetation, carbon, bitumen, coal, alumina, potass, clays, iron, and other mineral substances are formed, and that the action of animals gives rise to calcareous material, phosphates, sulphur, nitre, and other compounds (pp. 111, 118, 141, 153), but he claimed that, without exception, all the compound substances in the inorganic world, minerals and rocks alike, are nothing but the remains and débris of once living bodies (p. 115).

Protrusions of igneous matter into the terrestrial crust have thus no place in his system. Yet although he believed all amorphous rocks to have been accumulated under water he rejected Werner's doctrine of an universal ocean. The origin of granite, for instance, he explained by a complicated process wherein the essential molecules of the several minerals that constitute the rock are first disintegrated by the action of organisms; these molecules are then transported from the land by rivers into the sea, where they are deposited and come together to form the aggregate granite mass (pp. 142–145). So far from looking upon the granitic core of a mountain-chain as a plutonic intrusion from an inner magma, he regarded it as evidence of the site of a former river-current, by which its materials were built up on the sea-floor during the retreat of the oceanic waters, and the consequent emergence of the western shores of the land (pp. 145–149). As some rivers flow in tolerably straight courses for hundreds of miles, he could see no reason why, as the sea retired, they should not have accumulated granitic ridges as long as the longest crystalline core now to be seen in any mountain-chain. Obviously not even the wildest hypothesis of the Freiberg School was more completely a child of the imagination than this extraordinary speculation of the illustrious biologist of Paris.[1]

[1] His speculations on this subject, however, were not all original on the part of Lamarck. Cuvier, in his "Discours sur les Révolutions de la Surface du Globe" (3rd ed., 1825, p. 24), alludes to their prevalence, especially in Germany, at least as far back as the beginning of the nineteenth century, and to their recent development by his French contemporary in the "Hydrogéologie" and "Philosophie Zoologique."

(*To be concluded in our next number.*)

II.—Notes on the Corries of the Comeragh Mountains, Co. Waterford.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XIII.)

THE corries and tarns of the Comeragh Mountains have received but scanty attention at the hands of geologists. In the Memoir of the Geological Survey [1] dealing with this portion of co. Waterford their position and height are mentioned, and reference is made to some of the glacial phenomena in their immediate neighbourhood, but no connected description of the whole group of corries is given. Kinahan, in his "Geology of Ireland" (1878), pp. 245, 310, refers briefly to them, and inclines to the view that they were cut out by the action of the sea on the flanks of the mountains, but that the rock-basins which they frequently contain were excavated by small glaciers. The position of the corries, chiefly on the north and east sides of these mountains, as elsewhere in Ireland, is attributed by him to the preservative action of the ice and snow, which would not melt in them so rapidly (owing to their colder aspect) as on the southern and western slopes, where the corries have been obliterated by denudation effected by ordinary subaerial agents. Carvill Lewis [2] refers to the glaciation of the Comeragh Mountains in several places, remarking that they "show signs of glaciation on their north-east side as high as 1,000 feet, up to which height they are rounded off and drift occurs. Above this they are jagged and contain cwms, glacial lakes, and other evidences of small local glaciers."

The following notes on these interesting corries must be considered to be only of a preliminary nature; a bathymetrical survey of the lakes themselves is necessary to complete their investigation, but possibly this may not be carried out for years owing to the absence of boats on their surface or in the neighbourhood and the difficulty and expense in conveying one to them.

Geological Structure of the District.

The mountains are entirely composed of Old Red Sandstone forming a wide flattened arch, or rather dome, of which the beds dip to the north and south respectively into the valleys of the Suir and Dungarvan, while to the west they dip at very low angles so as ultimately to pass under the Carboniferous Limestone in the district of Ballymacarbery. But this uniformity of structure is modified to some extent by small local folds and disturbances in the beds, the axes of which mostly trend east and west in accordance with the general system of folds affecting the Upper Palæozoic rocks of this part of Ireland. The eastern portion of the dome has been removed by denudation, exposing at the foot of the escarpment thus formed the much-worn platform of Ordovician rocks, on which the Old Red Sandstone rests with a very strong unconformity.

The Old Red Sandstone in the Comeraghs is estimated [3] to reach

[1] Mem. Geol. Surv. Ireland, Explan. Sheets 167, 168, etc., 1865, pp. 6, 7, 80.

[2] Carvill Lewis: "The Glacial Geology of Great Britain and Ireland," 1894, pp. 103, 133, 164.

[3] Mem. Geol. Surv. Ireland, Explan. Sheets 167, 168, etc., p. 14.

a total thickness of 3,200 feet, and consists of a locally developed basal breccia followed by about 1,000 feet of brownish-red conglomerate of various degrees of coarseness; and this is succeeded by reddish-brown shales, sandstones, grits, and strong conglomerates, with many white quartz pebbles, reaching a thickness of about 2,200 feet.

The jointing of the Old Red Sandstone rocks, both conglomerates and sandstones, is strikingly complete and well developed [1]; and the presence of these divisional planes and lines of weakness has an intimate connection with the production and preservation of the precipitous walls of the corries. The alternation of hard and soft beds of rock is clearly brought out by weathering in the cliff-faces of some of the latter, such as Coumshingaun, and results in the formation of successive small vertical cliffs or scars alternating with benches and talus slopes, expressing the vertical heterogeneity in the profile.

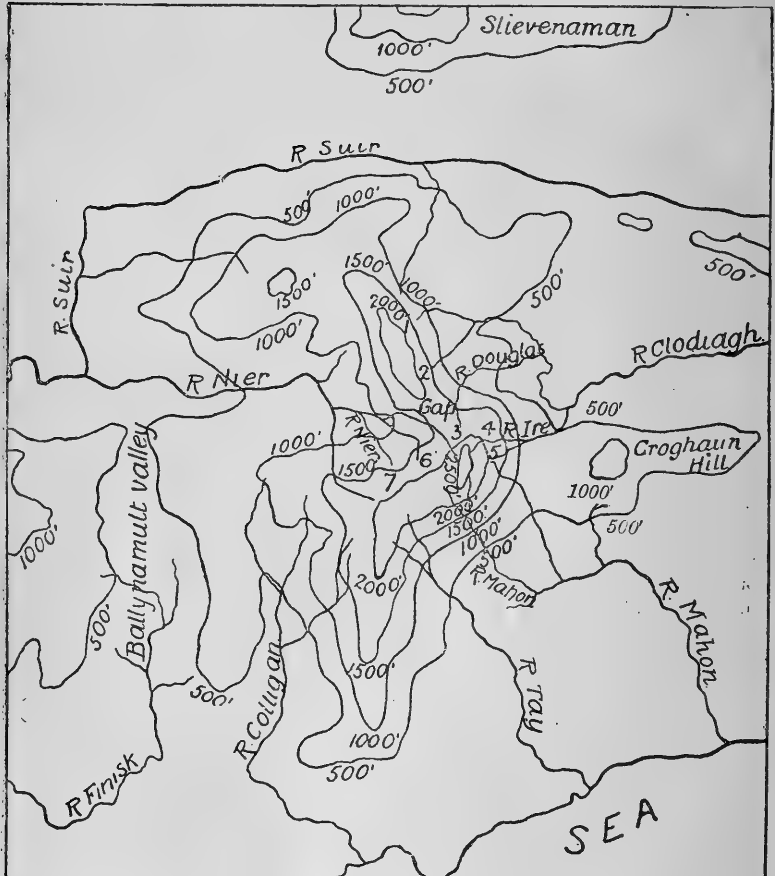
Orography of the District.

The Comeragh Mountains form a mass of high ground at the western end of co. Waterford, their main axis running nearly north and south; they rise to a maximum height of 2,597 feet above sea-level, and break off suddenly towards the east in a more or less regular escarpment, the summit of which is in most places over 2,000 feet high, but it sinks down gradually and loses its character to the north and south. The northern part of the range is sometimes known as the Reeks of Glenpatrick, and joins on to the line of lower rounded hills bordering the south side of the River Suir. The platform of older rocks which stretches away to the east with a gently undulating surface from the foot of the mountains is known as the plateau of Rathgormuck, and has an altitude of only 300–500 feet above the sea. On the west side the whole mass of the Comeragh Mountains is separated from the Knockmealdown Mountains by the long pass or valley of Ballynamult, which runs southward from the valley of the Suir. Behind the escarpment the Comeragh Mountains are deeply trenched by the valley of the Nier, which runs in a westerly direction so as almost to bisect them. This river, which ultimately joins the Suir just east of Newcastle, drains the greater portion of the western slopes and receives several tributary streams, some of which flow down from the cirque-headed valleys on its south side. The northern flanks of the mountains shed a few short unimportant streams direct into the Suir; and the south-west slopes are drained by the Colligan, which flows south into the sea at Dungarvan. The eastern escarpment, traced from its northern end, runs at first south-east at the foot of the Reeks, but at a point just south of Knockanaffrin Mountain it turns to the east, and continues in this direction for over one mile, forming a large embayment, at the bend of which is the important gap and pass into the head of the Nier Valley. This pass makes a conspicuous dip in the fairly uniform summit-line of the mountains, being only 1,500 feet above

[1] Haughton, "On the Physical Structure of the O.R.S. of Co. Waterford": Trans. Roy. Soc. Dublin, 1858, pp. 333–348.

sea-level, while on each side of it the top of the escarpment is over 2,000 feet high. A little north of Coumshingaun the escarpment again bends round and runs south for nearly three miles to the Mahon River.

In addition to the short, steep, grassy spurs which slope down from the face of the escarpment to the plain, and between which lie the rock-walled corries, there is an extensive promontory of hilly ground, composed of Old Red Sandstone and connected with the main mass by a low isthmus; it projects eastwards nearly opposite Coumshingaun for a distance of about four miles across the Lower Palæozoic platform, and rises towards its extremity into the prominent



Reduced to a scale 5 miles to 1 inch.

FIG. 1.—Contour-Map of the Comeragh Mountains and neighbourhood.

1, Lough More; 2, Coumduala Lough; 3, Coumgorra Loughs; 4, Crotty's Lough; 5, Coumshingaun Lough; 6, Comeragh Loughs; 7, Coumstilloge Loughs.

elevation known as Croghaun Hill, nearly 1,300 feet high. The eastern face of the Comeraghs is drained by many small streams, some of which are supplied by the tarns in the corries. North of the Croghaun spur these streams flow in a general eastward direction into the Clodiagh, which falls into the Suir, but south of Croghaun the streams run south-east to form the rivers Mahon and Tay, which enter the sea at Bonmahon and Stradbally respectively.

From the above description of the waterways it is seen that the Comeraghs give rise to a complete and independent drainage system on all sides, and form a local centre, as they are supposed to have done for the ice during the later stages of the Glacial Period.[1]

Distribution and Characters of the Corries and Tarns.

The corries in the Comeraghs fall into two groups, one of which lies along the steep eastern face of the mountains and the other along the south side of the Nier valley. In the former group they have mostly the character of mere niches in the escarpment, while in the latter group they attain nearly the dignity of short valleys. All are alike characterised by steep mural precipices and by their floor lying at some height above that of the thalweg of the main valley or the base of the escarpment, so that they possess the appearance of 'hanging valleys.' In the eastern series of corries not all have received names; only those which contain lakes are marked on the map with separate designations, but there exist several others which deserve notice.

We may first enumerate those which contain lakes, commencing at the northern end, and then proceed to describe them all in detail.

I (a). *Corries and their lakes in the Reeks of Glenpatrick.*

1. Lough More.
2. Coumduala Lough.

(b). *South of the great embayment.*

3. Coumgorra Lough.
4. Crotty's Lough.
5. Coumshingaun Lough.

II (c). *Corries and their lakes on the south side of the Nier Valley.*

6. Comeragh Loughs.
7. Coumstilloge Loughs.

The Reeks of Glenpatrick have only two corries occupied by lakes on their eastern face, but there are several other corries on the escarpment, the floors of which are occupied with great sloping heaps of talus from the cliffs above. A lake may have previously existed in them, but has been overwhelmed and filled up by the accumulation of this débris. In one case the absence of a barrier of moraine or scree material across the mouth, such as is found in all the others which hold a tarn, may account for this deficiency.

[1] Mem. Geol. Surv. Ireland, Explan. Sheets 167, 168, etc., p. 80. Kinahan: Geol. of Ireland, p. 245. Hull: Phys. Geol. Geogr. Ireland, 1878, pp. 103, 263.

There is one such lakeless corrie on the north of Knockanaffrin, and like all the corries on the Reeks it is shallow and wide-mouthed, consisting simply of a slightly curved amphitheatre of cliffs descending precipitously to a gently inclined floor, which from the mouth slopes more steeply to the plain below. The small streams which issue from these tarnless corries north of Knockanaffrin run down over the surface of the ground in shallow channels to join the Glasha River, which enters the Suir near Gurteen.

The two lakes, known as *Lough More* and *Coumduala Lough*, lie under the higher part of the escarpment, the former on the north side of Knockanaffrin and the latter on the south side. The altitude of *Lough More* is 1,518 feet, and it is situated in a wide, shallow alcove with the cliffs rising 550 feet above it. In size it only measures about 200 yards in length, and the stream issuing from it runs down to join the Clodiagh. A dam of morainic material rises about 60 feet above the water's level and holds up the lake.

Scale: 4 inches to 1 mile.

FIG. 2.—Sketch-map of Coumgorra. FIG. 3.—Sketch-map of Crotty's Lough Corrie.

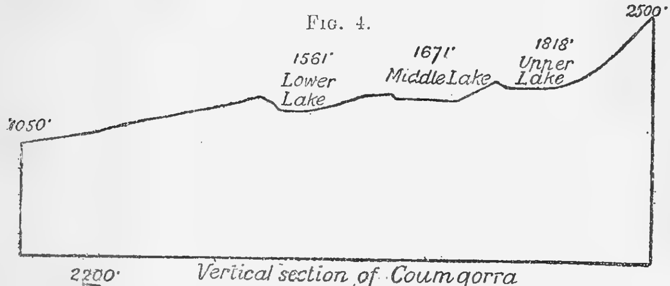
Coumduala Lough lies at an altitude of 1,533 feet in a shallow amphitheatre where the escarpment is nearly 2,100 feet high; screes cover the foot of the cliffs, and the lake, which is held up by a dam on the north-east, has its length (250 yards) parallel to the trend of the escarpment, and therefore across the mouth of the corrie. Its overflow is conducted down to the Clodiagh by a stream from its south-east corner.

From Knockanaffrin the escarpment decreases in height towards the Gap and curves round in an irregular semicircular line of cliffs and scars so as to form a large broken corrie, but without any definite floor, as the slope at the base of the cliffs is covered with talus and morainic heaps. One of the head-streams of the Clodiagh arises in this amphitheatre.

None of the foregoing corries or tarns are comparable in importance to the large ones south of the Gap which have now to be described, and comprise those known as *Coumgorra, Crotty's Lough,* and *Coumshingaun.* All these contain lakes, and are situated close together. Thus, Coumgorra is only 500 yards distant from Crotty's Lough on the northward-facing part of the escarpment; and Coumshingaun, which looks west, lies only 650 yards south of Crotty's, while the divide separating the head of Coumgorra from Coumshingaun is not much over 700 yards wide. This triangular group of corries affords the most striking features of their class, and therefore merits special attention.

The corrie nearest the Gap is known as *Coumgorra,* and contains three lakes at successive levels; the two lower ones are merely expansions of the stream behind and between heaps of morainic material. This stream, which connects the three lakes, flows from

Fig. 4.



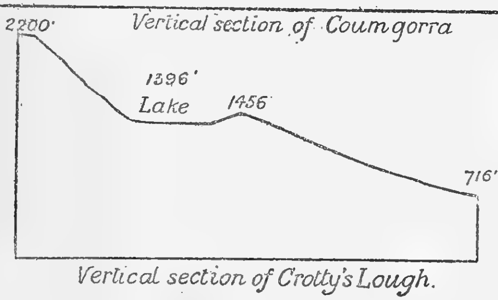


Fig. 5.

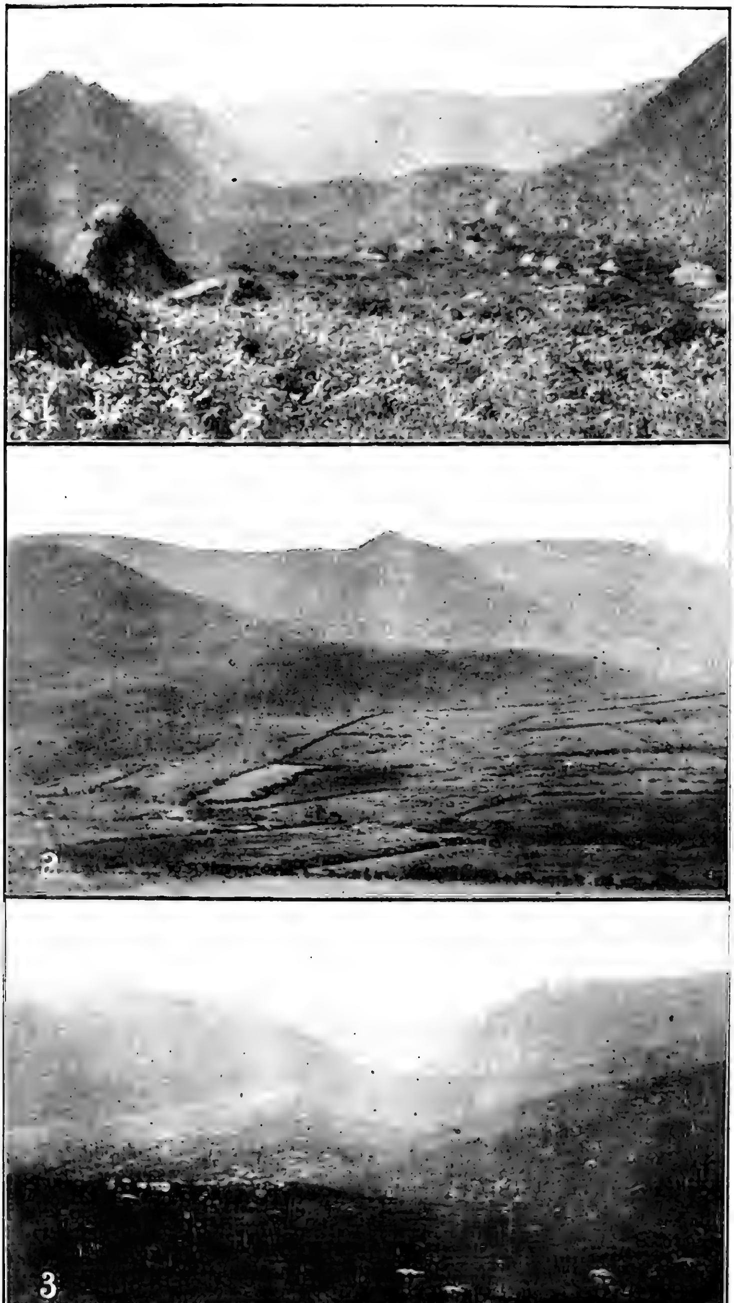
Vertical scale: 2,000 feet to 1 inch.
Horizontal scale: 1,760 feet to 1 inch.

the mouth of the corrie in a north-easterly direction as the River Douglas to join the Clodiagh at Ross Bridge. The corrie itself is of large size, and opens northwards; it has an irregular shape, and on investigation is found to be composed of two contiguous and partly confluent amphitheatres, a weathered and semi-detached pinnacle of rock marking the point of intersection of the two curved lines of cliffs. The outer amphitheatre forms the western side of this composite corrie and is not deeply cut back, but the cliffs encircling it are higher and more precipitous, rising about 1,000 feet above their talus-strewn base, and more than 2,500 feet above sea-level. The two lower lakes lie in this outer corrie, but not close under its cliffs nor at the same level. Their origin is obvious, the stream from the uppermost and inner lake having expanded into irregular small sheets of water in its attempts to escape between the confused mounds of moraine which obstructed its direct course, and through which it has not yet been able to establish a regular curve of erosion by cutting out a channel for itself. The inner corrie of Coumgorra faces north-west, and is likewise surrounded by bare craggy precipices with a fairly even skyline; the tarn lies at a height of 1,818 feet above the sea, and the mountain behind it has an altitude of over 2,400 feet.

This tarn—Coumgorra Lough proper—measures about 180 yards long by 120 yards wide, and is held up by a regular grass-covered bank of morainic material with such a straight course and even top as to present a most artificial appearance. The water escapes from the lake underground at the western corner, percolating through the loose material of the dam and flowing thence down to the middle lake. This lakelet lies at a level of 1,671 feet between somewhat irregularly disposed morainic mounds, which do not unite to form a single dam. The lowest lake lies about 100 feet lower down, and is of the same nature and origin; the mounds which hold the water back rise 50–100 feet above its level, and rest on the corrie-floor at its very mouth. Beyond and outside them the steeper slopes of the mountain descend at once for a continuous 500–600 feet till we reach another more or less level platform or broad shelf, formed by another but more evenly distributed mass of moraine, extending outwards in a roughly crescentic fashion for some distance over the plain, at the base to which it descends by a short steep face. Original irregularity of accumulation and subsequent denudation have obscured to some extent the outlines of this lower moraine, but its main features can be distinctly traced. There is nothing to indicate the existence of a rock-basin in the case of any of these Coumgorra tarns, and the stream from them runs either over or through morainic material in each case. The small erosive power of the stream, owing to the pure nature of its water, is noticeable. The moraines have the usual character of those of valley glaciers, and the large proportion of big angular blocks in their composition and on their uneven and scantily-clad surface gives the ground which they cover a wild and rugged appearance.

In size the composite corrie of Coumgorra measures about 1,100 yards from its mouth to its head, and has a width across its entrance of rather over 900 yards.

The next corrie to the east is that containing *Crotty's Lough*, which is an irregularly-shaped piece of water with its longest axis measuring about 350 yards and lying transverse to the mouth of the corrie. The level of the tarn is marked as 1,396 feet above the sea. The corrie faces north-east, and is formed by lofty cliffs on the west, south, and east sides. On the western side the precipice is vertical for several hundred feet in its upper part, and its top is over 1,000 feet above the water's edge. Steep grass-clad screes slope three-quarters of the way up the face of the cliffs at the head of the lake; and at the south-east corner two prominent bare rocky crags



Corries in the Comeragh Mountains.

rise up above the general rim of cliffs, one of which contains Crotty's Cave, and is a landmark for many miles. The eastern side of the corrie is mostly formed by a less precipitous spur from the mountain-side. The mouth is partially blocked by a conspicuous rounded hill strewn with large boulders and rising about 100 feet above the level of the water. On its outer or northern side this hill descends steeply for about 450 feet to a broad, roughly semicircular shelf with fairly level surface, probably representing an old moraine. The latter has an abrupt edge which slopes down suddenly to the plain about 300 feet below.

On each side of the rounded hill at the mouth of the corrie there is a possible outlet for the waters of the lake; the one on the north-west side would be over solid rock, and a rise of five or six feet in the level of the water would cause the outflow to be by this channel. On the other or eastern side the rounded hill is joined to the mountain spur by a ridge of morainic material which blocks up the wider and more natural outlet, and the lake discharges itself at this point by the water percolating through the dam and issuing on its further side in a series of springs which feed the swamps and give rise to the streamlet running down a depression in a north-easterly direction. It is noticeable that the rocky lip of the lake on the west is lower than the top of the dam on the east, but the outflow of the lake is nevertheless at a lower level on the other side of the median hill, which indeed appears to consist entirely of morainic material and to represent merely an unusually large and regular morainic mound. No solid rock is visible in its composition above the level of the lake, and there is no direct evidence that we have to deal with a true rock-basin in this instance.

(*To be continued.*)

III.—The Geological History of South Africa.[1]

By Dr. F. H. Hatch, F.G.S., M.I.C.E.,
President of the Geological Society of South Africa.

(*Concluded from the March Number, p.* 104.)

3. *Geological History of the Rocks.*

AFTER the granites, gneisses, schists, and sediments which make up the Swaziland System had been elevated to form a continental area extending over the northern and western portions of South Africa, denudation began, and the material thus produced was carried to the sea to form the Witwatersrand Beds. The nature of these sediments — they consist of conglomerates, grits, and shales — indicates a marine period with shallow-water conditions, which continued almost uninterruptedly during their deposition. They were accumulated first on a sinking, and then on a rising sea bottom, for the lower beds are composed largely of mud and fine sand, conglomerates only becoming abundant in the upper beds, which were formed in the later portion of the period when the

[1] Presidential Address delivered by Dr. F. H. Hatch to the Geological Society of South Africa, 29th January, 1906.

sea had become sufficiently shallow to allow of the accumulation of shingle and gravel. There is evidence in the Southern Transvaal that the land from which the sediments were mainly derived lay to the west, the sea to the east, for the lower Witwatersrand Beds, which consist solely of mudstones and fine sandstones in the east, gradually develop conglomerates with a decreasing amount of shale towards the west.

The northern shore-line of the Witwatersrand sea probably did not extend north of the 25th parallel of latitude, for in the Northern Transvaal we find the Waterberg Sandstone resting directly on the granites and gneisses of the Swaziland System, while in Southern Rhodesia, north of Bulawayo, the oldest deposits resting on these rocks are the Sijarira sandstones,[1] which immediately underlie the Matobola Coal-measures, in which fossils indicating a Permo-Carboniferous age have been found.

After the close of the Witwatersrand period, which was brought about by the final elevation of these beds above sea-level, they in their turn became exposed to the disintegrating forces of denudation, the resultant débris being transported and spread out by the heavy flood waters of torrential rivers, since we find the Ventersdorp period ushered in by the accumulation of coarse conglomerates and boulder beds, in which occur fragments of such characteristic beds of the preceding formation as Hospital Hill Slate and the auriferous conglomerates of the Upper Witwatersrand Series. This denudation produced the second break in the succession, marked as Unconformity No. II in the scheme given on page 98. The Ventersdorp period is particularly marked by volcanic manifestations, vast thicknesses of basic and acid lavas, volcanic breccia and tuffs having been accumulated, probably on a land surface.

Before the next submergence, that of the Potchefstroom period, the vast piles of volcanic accumulations, together with the boulder beds and coarse conglomerates of the Ventersdorp System, were long exposed to denudation, as there is a break (Unconformity No. III) between this and the succeeding system, the lowest member of which, the Black Reef Series, is found lying unconformably on every older formation down to the granite and schists of the Swaziland System. At some time before the deposition of the Black Reef and Dolomite Series, the Witwatersrand Beds had been subjected to a folding movement, as the latter are found bent into gentle synclines and anticlines, on the denuded remnants of which the former lie undisturbed.[2] The Potchefstroom System consists of three members: a small development of sandstone at the bottom with a basal conglomerate, dolomitic limestone and shales in the middle, and a great thickness of shales and sandstones on the top. This succession indicates a comparatively rapid submergence, continued until clear water conditions were reached, in which the accumulation of calcareous sediments became possible.

[1] A. J. C. Molyneux: Q.J.G.S., vol. lix (1903), p. 283.

[2] F. H. Hatch, "The Extension of the Witwatersrand Beds eastward under the Dolomite," etc.: loc. cit., p. 68.

The period during which the muds and sands now forming the Pretoria Series were deposited was probably one of slow oscillation between rising and sinking, the conditions representing on the whole a shallow-water phase. The shore-line of a bay-like portion of the sea in which the sediments of the Potchefstroom formation were deposited is well marked in the Transvaal by the outcrop of the Black Reef Quartzite, as may be seen by consulting a geological map of the Transvaal, but some allowance must of course be made for subsequent denudation, especially in the Lydenburg district. The main sea, however, extended over the southern portion of Bechuanaland and Griqualand, between the Vaal and Orange Rivers.

The final emergence of the rocks of the Potchefstroom System produced, by denudation, another great break in the succession, namely, the unconformity (No. IV) which separates the Waterberg from the Potchefstroom System. During the interval represented by this break, the beds of the latter were tilted, flexured, and dislocated. The resultant land surface furnished the material for the building up of the Waterberg formation. The basal conglomerates and breccias of the latter were first formed, namely, during the subsiding period. From the fact, to which attention has been drawn by Mr. Holmes, that pebbles of red felsite are found in these basal conglomerates,[1] it is probable that an eruption of acid lavas began while the Potchefstroom strata were being upraised; this igneous activity was probably long continued, for quite recently Mr. Mellor[2] has described in the lowest portion of the Waterberg Series at Rhenosterkop the occurrence of fragmental beds consisting for the most part of igneous material, from which he draws the conclusion that this period was marked by vigorous contemporaneous volcanic action, and he makes an interesting comparison with the conditions that obtained at the commencement of the Old Red Sandstone period in Scotland.

The character of the Waterberg rocks, consisting as they do largely of conglomerates, grits, and coarse sandstones, indicates shallow-water conditions in a slowly subsiding area. The constant occurrence of false bedding points to rapid sedimentation in shallow waters affected by strong and variable currents.[3] The pebbles of the basal conglomerate consist largely of quartzite derived from the Pretoria Beds, and there is evidence that the Waterberg sediments were deposited against an old land surface of the Pretoria rocks, which underwent denudation to supply the necessary material. The present distribution of the Pretoria Beds along the southern margin of the Waterberg Sandstone probably marks the shore-line of the sea or lake in which the latter was laid down. This sea extended over the greater part of the Northern

[1] G. G. Holmes, "Some Notes on the Geology of the Northern Transvaal": Trans. Geol. Soc. S. Afr., vol. vii (1904), pp. 55–56. "The Geology of a part of the Rustenburg District": Trans. Geol. Soc. S. Afr., vol. viii (1905), p. 6.

[2] E. T. Mellor, "Volcanic Action in the Waterberg Formation": Trans. Geol. Soc. S. Afr., vol. viii (1905), p. 38.

[3] E. T. Mellor: Transvaal Geol. Surv. Rep., 1903, p. 17.

Transvaal, and probably included a portion of Southern Rhodesia; it may have been landlocked, for the facts that the Waterberg formation has been found resting on an uneven floor, and that near the base very coarse irregular conglomerates[1] are met with, seem to militate against this formation being a true marine deposit.

The Cape Colony representative of the Waterberg Sandstone, namely, the Table Mountain Sandstone, also consists of sandstone, but with less conglomerate. Conglomerates, although scarce, however, do occur, and Rogers has described in the Pakhuis Pass, near Clanwilliam, the occurrence of ice-scratched pebbles which appear to have come from a glaciated region, and to have been carried to their present site by the agency of floating ice.[2] From an increase in the degree of coarseness of the sediments towards the west, and the greater frequency of conglomerates in the Piquetberg division and the Olifants River Mountains, Rogers argues that their source must have lain in that direction, and that the sediments were accumulated at no great distance and in shallow water. In his view the Table Mountain Sandstone is probably of fluviatile origin.[3]

The Table Mountain Sandstone is followed conformably at the Cape by the Bokkeveld Beds, the character of which points to a continuance of the subsiding phase. The fossil remains indicate marine conditions, although the frequent occurrence of false bedding in the sandstones precludes the possibility of very deep waters. The fossil fauna of the Bokkeveld Beds shows that they are homotaxial with the Devonian System, but whether Upper, Middle, or Lower has not yet been decided. The upper beds of the Bokkeveld and the succeeding Witteberg Beds indicate a change to lacustrine or fluviatile conditions, the beds consisting of mudstones and sandstones which, with the exception of a few plant remains, are barren of organisms. It is possible, as suggested by Mr. Rogers,[4] that at about the middle of the Bokkeveld period open communication with the sea may have been again cut off, deposition subsequently taking place by fluviatile agencies in inland seas. This would account for the absence of marine organisms in these beds. At the Cape the Witteberg Beds are followed without a break by the shales forming the lowest beds of the Dwyka Series. Northwards, however, the Witteberg and Bokkeveld Beds gradually thin out, and the Dwyka Series finally rests unconformably on the Table Mountain Sandstone. From this the deduction can be made that owing to the elevation of the beds above sea-level, they became subject to denudation before the commencement of the Dwyka epoch, and it is even possible that still further north denudation may have commenced before the Witteberg epoch, so that the latter series was never deposited in

[1] E. T. Mellor, "The Waterberg Sandstone Formation": Trans. Geol. Soc. S. Afr., vol. vii (1904), p. 40. Mr. Mellor instances the occurrence of boulders ranging up to 8 feet in diameter. These must have been transported by streams of a torrential character.

[2] A. W. Rogers, "The Glacial Conglomerate in the Table Mountain Series near Clanwilliam": Trans. S. Afr. Phil. Soc., vol. xvi (1905), p. 1.

[3] A. W. Rogers: "The Geology of South Africa," p. 395.

[4] "Geology of the Cape Colony," p. 396.

these northern regions; and in the Transvaal it is most likely that even the Bokkeveld Series was never represented. During the accumulation of the Dwyka Series the northern part of South Africa was covered with ice, for it is now generally admitted that the Dwyka Conglomerate has been formed of rock fragments, boulders, and mud, which have been carried towards their present site by glaciers moving from a northern mountainous country southward. That the highest portions of these mountains were probably situated in the Northern Transvaal somewhere about the present Waterberg district, is indicated by the distribution of the glacial conglomerate.

The Dwyka Series as well as the rest of the Karroo rocks appears to have accumulated in a great inland sea which occupied practically the whole of Central South Africa as at present constituted. The southern shore-line of this vast lake extended east and west along the northern margin of the present coast ranges of Southern Cape Colony. To the east it passed into the present Indian Ocean somewhere about the Gualana River, returning at Port St. John, whence it stretched north-eastward parallel to the present coast of Natal, the north-western boundary extending roughly along the present course of the Vaal River as far as Vereeniging. The fossil evidence points to fresh-water, or at least to brackish conditions, and the frequent occurrence of false bedding, ripple-marks, sun-cracks, worm burrows, etc., indicates that the water could not have been deep. The Dwyka Conglomerate was deposited partly in this lake by the agency of floating ice; partly it consists of ancient moraines the accumulation of which slowly followed the retreating ice northwards. In conformity with this twofold mode of origin, there are two facies of the Dwyka Series: a northern, lying unconformably on an uneven surface (often grooved and polished) of the older rocks, and a southern, resting conformably on the uppermost member of the Cape System. In the Transvaal the Dwyka covering has preserved interesting features of the pre-Karroo land surface. Thus Mr. Mellor[1] considers that the valleys of the Elands River, Bronkhorstspruit, and the Wilge River are of pre-Karroo origin. At the beginning of Karroo times they became filled with the conglomerate, and have in recent times been re-excavated. The coal deposits, which at Vereeniging and elsewhere in the Southern Transvaal and at Dundee and Newcastle in Natal are found in the Ecca Beds immediately above the Dwyka Conglomerate, show that a luxuriant tropical vegetation flourished in the Ecca epoch; while the fact, first pointed out by E. J. Dunn,[2] that seams of breccia of almost identical character with the Dwyka are interbedded with the coal at Vereeniging, seems to indicate that glaciers were still in existence while the coal beds were being deposited. Professor Edgeworth David[3] has described a similar occurrence in New South

[1] E. T. Mellor: Transvaal Geol. Surv. Rep., 1903, p. 20.

[2] E. J. Dunn, "Notes on the Dwyka Coal-measures": Trans. S. Afr. Phil. Soc., vol. xi (1900), p. 67.

[3] Edgeworth David, "Evidences of Glacial Action in Australia in Permo-Carboniferous Time": Q.J G.S., vol. lii (1896), p. 289.

Wales, where a group of Coal-measures over 230 feet thick and comprising from 20 to 40 feet of coal is sandwiched in between the erratic bearing horizon of the 'Lower Marine Series' and the similar horizon of the Upper Marine Series. There appears to be indicated in these facts a recurrence of a glacial epoch separated by a milder interglacial period. Professor Penck, however, to whom I showed specimens of these later breccias in borehole cores from the Vereeniging Coalfield, thought they probably represented a rewash or remanié of the true Dwyka. With regard to the age of the Transvaal coal, the occurrence of *Sigillaria Brardi* at Vereeniging supplies a link with Europe, and on this evidence Seward[1] assigns the beds to the Permo-Carboniferous period, and suggests that the commingling of *Sigillaria* species with the *Glossopteris* flora indicates an overlapping of two distinct botanical provinces.

A recurrence of the conditions suitable for the formation of coal deposits took place at a much later epoch in the Karroo period, namely, at the beginning of Stormberg times (Molteno Beds). Between the two horizons there are some 7,000 feet of strata in the geological column, 5,000 feet of which are made up of the Beaufort Series, which requires no special mention here, except for the abundant occurrence in it of the remarkable labyrinthodont and dinosaur remains. The bones of these animals must have been washed into the lake by rivers.

At the top of the Stormberg Series, and consequently occupying the highest position in the system, are the basic lavas and ash-beds of the Volcanic Group. The interstratification of ash-beds and lava-flows with sandstone points to some subaqueous eruption; but the bulk of the later flows were subaerial, and the accumulation of such a vast pile of volcanic material—it is some 4,000 feet thick—determined the watershed of the Drakensberg as it exists to-day in Basutoland and the Eastern Province of Cape Colony. Many of the vents by which the eruptions took place have been found,[2] cutting through the Cave Sandstone, by the Cape Geological Survey; but Mr. Schwarz is of the opinion that fissure eruption also played a part in the formation of the volcanic beds.

It is interesting to note that the remarkable series of lavas occupying the so-called Springbok Flats in the Transvaal, and known as the Bushveld Amygdaloid, has been found by the Transvaal Survey to overlie sandstones which are considered to be of Karroo age, and has been provisionally referred to the Stormberg epoch.[3] There is certainly a remarkable resemblance in the

[1] A. C. Seward: Q.J.G.S., 1897, p. 322.

[2] An interesting account of the geological history of these eruptions is given by Mr. du Toit in a paper on "The Forming of the Drakensberg": Trans. S. Afr. Phil. Soc., vol. xvi, pt. 1 (1905), p. 65. See also "Report on part of the Matatiele Division, with an Account of the Petrography of the Volcanic Rocks," by E. H. L. Schwarz: Geol. Comm. Rep. for 1902, p. 11; Capetown, 1903. Also "Geological Survey of Elliott and Xalanga," by A. L. du Toit: Geol. Comm. Rep. for 1903, p. 109; Cape Town, 1904.

[3] E. T. Mellor: Transvaal Geol. Surv. Rep., 1904, p. 31; Pretoria, 1905. Also Trans. Geol. Soc. S. Afr., vol. viii (1905), p. 37.

petrographical habit of these amygdaloids to the lavas of the Volcanic Group of the Drakensberg and Malutiberg. In this connection, the discovery by the Survey of a 'pipe amygdaloid' in the Bushveld lavas, similar to the characteristic rock of the Stormberg Volcanic Group, is noteworthy.

The dolerite intrusions, which are so widely distributed in the Karroo rocks, and form such a striking feature in their scenery, belong to a period somewhat posterior to the volcanic eruptions of the Stormberg epoch; their late limit is fixed by the fact that boulders of the typical dolerite have been found in the Umtamvuna (Upper Cretaceous) rocks of the Pondoland coast.[1] Intermediate in age between the Stormberg volcanoes and the period of intrusion of the Karroo dolerites, are the volcanic pipes so well known on account of the diamond being a constituent of their breccia filling at Kimberley and in the Transvaal. The facts on which this argument is based are as follows:—The Stormberg lavas are occasionally penetrated by dykes,[2] which probably belong to the Karroo dolerites, while Messrs. Rogers and Du Toit[3] have shown that the Sutherland pipes, which are analogous to the diamond-bearing deposits, except that they do not yield diamonds, are of later age than the latter.

The exact period at which the Cape Formation and the overlying Karroo Beds were folded to form the great mountain ranges of the Southern Cape (the Zwarteberg, Langeberg, etc.) cannot be fixed, but it was after the deposition of the Lower Karroo Beds, as these are involved in the folding, and before the deposition of the Uitenhage Beds, since the latter lie undisturbed on the folded Cape Formation.

To summarise: we have in South Africa evidence of the former existence of at least three periods during which the greater portion of South Africa was elevated above sea-level, besides the one we live in, which has endured since Karroo times. The first of these is indicated by the break in the succession below the Witwatersrand System; the second by the volcanic and fluviatile deposits of the Ventersdorp System, and the unconformity between the latter and the succeeding Potchefstroom System; and the third by the break between the Potchefstroom and the Waterberg Sandstone. Between these must have intervened three periods, during which a large portion of South Africa was submerged, and the marine and littoral sediments of the Witwatersrand, the Potchefstroom, and the Cape Systems were deposited; and a long period of fresh-water sedimentation during which the Karroo rocks were accumulated by the agency of vast river systems discharging into great lakes. The coastal deposits (the Uitenhage and Umtamvuna Series), which are marine deposits of a later (Cretaceous) period, are not considered here, as they play only an insignificant part in the geology of South Africa; and I have limited myself to the close of the Karroo period.

[1] Rogers & Schwarz: Ann. Rep. Geol. Comm., 1901, pp. 25–46; Capetown, 1902.

[2] A. C. du Toit, "The Forming of the Drakensberg": Trans. S. Afr. Phil. Soc., vol. xvi (1905), p. 67.

[3] Rogers & Du Toit, "The Sutherland Volcanic Pipes and their Relationship to other Vents in South Africa": Trans. S. Afr. Phil. Soc., vol. xv (1901), p. 61.

It is not likely that at any period since its first upheaval the whole of South Africa has been submerged; indeed, there is evidence that the northern region remained uncovered and subject to erosion up to the commencement of Karroo times. On the other hand, it is unlikely that the continent has always had its present limits; the similarity of the remarkable Damuda-Talchir flora of India, the Newcastle flora of Australia, and the Lower Karroo flora of South Africa indicates that in Permo-Carboniferous times South Africa was probably united to India and Australia to form one great continent, which Suess[1] has named Gondwanaland. Blanford[2] even suggests that in Mesozoic times South Africa was also connected with South America, so that "a girdle of land may have extended round nearly three-quarters of the earth's circumference," from Peru to New Zealand.

Volcanoes have played a great rôle in the geological history of South Africa, and the traces of this igneous activity survive in the form of lavas, with or without volcanic tuffs and breccias, or in the various forms of intrusive igneous material (laccolites, sills, dykes, etc.), or again as volcanic necks and 'pipes.' There are at least five distinct periods in which South Africa has been the theatre of intense igneous activity, and the ages of these may be arranged as follows:—

1. Between the close of the Witwatersrand and the commencement of the Potchefstroom periods, the period of the eruption of the Ventersdorp lavas, tuffs, and breccias.
2. A period commencing after the close of Potchefstroom, and extending into the early Waterberg times, in which the intrusion and eruption of the Red Granite and associated felsite took place.
3. At the close of the Stormberg epoch, eruption of the Stormberg lavas.
4. Between the close of the Karroo period and the commencement of the Umtamvuna (Upper Cretaceous) epoch, intrusion of the dolerite dykes and sills.
5. After the intrusion of the dolerites, formation of the pipe breccias.

With this summary I must bring my account of the geological history of South Africa to a close, although I have but touched the fringe of the subject. Much remains to be discovered before the secrets of the past can be completely deciphered, and it must be remembered that geology in South Africa is still young. It shows, however, a vigorous growth for all its youth, and I am convinced that in the next few years great progress and many new discoveries will be made. In this progress the Geological Society of South Africa will doubtless have a large share, and uphold or increase the high standing it has already won.

[1] "Das Antlitz der Erde," vol. i, p. 768; Vienna, 1885.
[2] W. T. Blanford: Presidential Address, Proc. Geol. Soc., vol. xlvi (1890), p. 106.

ORDER OF SUPERPOSITION OF THE STRATIFIED ROCKS OF SOUTH AFRICA.

European Equivalents.	Southern Cape Colony.			Transvaal.
Rhætic.	Karroo System.	Stormberg	Volcanic Group. Cave Sandstone. Red Beds. Molteno Beds.	*Missing.*
Permo-Carboniferous...		Beaufort		*Missing.*
	...	Ecca and Dwyka		= Ecca and Dwyka.
				~~ (Unconformity No. V.)
Devonian...	Cape System.	Witteberg		*Missing.*
		Bokkeveld		*Missing.*
		Table Mountain Sandstone		= Waterberg Sandstone.
		~~		~~~~~~~~ (Unconformity No. IV.)
				Potchefstroom System. { Pretoria Beds. Dolomite Series. Black Reef Series.
				~~ (Unconformity No. III.)
				Ventersdorp System. { Boulder Beds, Volcanic Breccias, Klipriversberg Amygdaloid, etc. Elsburg Conglomerates.
				~~ (Unconformity No. II.)
				Witwatersrand System. { Upper Witwatersrand Beds. Lower Witwatersrand Beds.
				~~ (Unconformity No. I.)
Archæan.	Malmesbury Series.			= Swaziland System.

Note.—This slip is intended to correct the Table given in Dr. F. H. Hatch's Address, Part I, p. 98, in the March number, 1906, in which, by an error, the Devonian formation was made to embrace with a bracket *all* the older Transvaal rocks.—EDIT. GEOL. MAG.

IV.—Superheated Water.

By A. R. Hunt, F.L.S., F.G.S.

THE abstract in the Geological Magazine of Professor Beck's paper on ore veins and pegmatites is of great interest to myself, as it deals with two points which I pressed on geologists in 1894 and earlier, viz., the crystallisation of vein-minerals out of superheated water, and the doubtful origin of that water. The special difficulty is raised by the Dartmoor veins, as the water they contain, together with the granites, is sometimes salt and sometimes fresh, and is of all degrees of original supersaturation. I wrote as follows:

"The question as to the marine or plutonic origin of the brine-inclusions referred to is of transcendent importance in connection with the question as to whether the water ejected by volcanoes is of meteoric or marine origin, or derived from the interior magma" (Geol. Mag., 1894, p. 99).

Then, referring to the various theories current about the Dartmoor granite, I wrote:

"It would greatly facilitate further research in the Dartmoor area if the following three points could be definitely decided:—

"(1) Whether the volcanic hypothesis is tenable?

"(2) Whether the chlorides in the quartzes are of marine or plutonic derivation?

"(3) An explanation of the immediate juxtaposition of brine and fresh-water inclusions."

The latter are sometimes within $\frac{1}{20000}$ of an inch of each other. One of these pairs is figured and described on p. 102 of the paper referred to.

At the time I wrote, in 1894, I laboured under the extraordinary delusion that I had originated the idea of the marine origin of the brine locked up in veins and granites, having arrived at that conclusion entirely through the $\frac{1}{8}$ and $\frac{1}{16}$ objectives. I thought it a problem of micro-petrology solely. But Sir Henry de la Beche had actually before 1839 postulated the action of superheated salt water (i.e. "greatly heated water under pressure") in deep-seated and therefore "greatly heated" fissures in the earth's crust (Report Devon and Cornwall, p. 387). De la Beche's priority of suggestion I fully acknowledged in the Geological Magazine in 1901, in "The Age of the Earth and the Sodium of the Sea," but I never succeeded in making a single convert, and the late General MacMahon assured me with equal kindness and candour that he thought my theory unthinkable.

I should be well satisfied if I could only establish the first step, viz. the crystallisation of veins and pegmatites from superheated water, as I would trust all the rest to follow. According to Professor Beck this first step is allowed by such distinguished foreign observers as Messrs. Brögger, Rosenbusch, Arrhenius, Vogt, Grubermann, and others.

In 1889 I wrote that the "brine and salt crystals . . . tell us clearly enough that we have superheated water to deal with, and water highly charged with salts; but water it is, and not gas . . . " (Trans. Dev. Assoc., 1889, p. 244).

Granted this first step, and I believe we shall ultimately reach the following conclusion, viz., that our planet consolidated first on the surface of the molten spheroid, in the form of a floating slag; that all the plutonic rocks, as we know them, are the result of the world-old conflict between the waters on the surface and the heat beneath the surface; and that all the water we see locked up in granites and schists, whether in the form of water or of hydrous minerals, came originally from above and not from below. It will no doubt be considered a very large order, but I believe there is a sufficient deposit in the bank of fact to meet the whole draft.

Perhaps, to make sure, I had better explain that by 'meteoric' water I only meant water derived from the atmosphere, as distinguished from water derived from the sea.

Professor Beck makes the important incidental remark that tourmaline is "the characteristic mineral of all pegmatites." Although, according to English textbooks, tourmaline is only an occasional constituent of English pegmatites, I wish that when it does therein occur it might be accepted as an original mineral, and not derived from mica. Certainly, if characteristic, it can scarcely be derived and secondary.

An interesting subject in connection with superheated water is the plutonic character of the changes so commonly observed in diabases. In the course of my examination of the Devonshire green schists I examined several of the most altered Devonian diabases, and was much interested to note that one not only met with very active bubbles in the secondary minerals, but also crystal deposits in the fluid inclusions, similar to those in granite, only not markedly cubic. Then in the green schists we find fluid inclusions in the secondary albite granules. To find what were once possibly volcanic tuffs exhibiting full plutonic characteristics was to myself interesting and unexpected; but when I brought this, to me, novel aspect of superheated water, under the description of hydrothermal metamorphosis, before the British Association at Belfast, a friend kindly informed me that the Committee of Section C did not consider my subject new.

Dr. Sorby, no doubt, referred to the inclusions in the quartzes of schists, both detrital grains and secondary, in his addresses to the Microscopical and Geological Societies, but I was quite unaware that any work had been done on the inclusions in the secondary quartzes and felspars of green schists and diabases. When one carefully explores one of these quartz grains in an altered diabase, under a high power and strong light, the phenomena seen are strikingly similar to the secondary quartzes seen in some plutonic felspars; both containing, as they sometimes do, belonites, active bubbles, and deposited crystals. Both results seem due to corrosion by superheated water charged with minerals and salts, followed by the crystallisation of fresh minerals out of such water.

Of course, in my own case, these have been only chance observations incidental to other work, and I only wish I knew where the special subject has been studied and described. The hydrothermal phenomena of the Devonian diabases, of the Devonshire quartz- and mica-schists, and of the green rocks, and of the so-called pegmatite felspathic veins connected with the green rocks—these present to my mind the most interesting problems in the debatable Devonshire area, and, compared with them, the question as to whether the schists are Archæan or Devonian, or, as has recently been suggested, any possible age between those geological horizons, does not matter the toss up of a bad halfpenny. Certainly, if neither Archæan nor Devonian I do not care what they are.

I may perhaps explain that I have never possessed a first-rate petrological microscope, and that for the work above referred to the small students' microscopes are about as useful as a pocket lens, as a mechanical stage and a somewhat elaborate achromatic condenser are as essential as are high-powered objectives. But the old microscopes with these fittings are lacking in other advantages. This fact, in addition to my not being well grounded in the identification of minerals, makes it impossible for me to attempt any difficult work myself, and that is really the reason why I have so often pressed these questions upon others, when every motive of self-interest would have bade me avoid unpopular doctrines and keep to the beaten track.

The motion of bubbles is the easiest proof of the presence of fluid. The following device, to induce a bubble to move, may not be known to all microscopists. If the substage condenser is furnished with a rotating diaphragm, to allow of oblique light from any point, such a diaphragm, if rotated under strong lamp light, will often make a bubble move owing to the heat thrown laterally upon the fluid inclusion.

Considering the attention paid to the subject of superheated water by Dr. Sorby and my eminent namesake, the late Dr. Sterry Hunt, more than a quarter of a century ago, it is most remarkable that the investigation has not been followed up with more vigour and determination by their successors. It is well worth conquering.

V.—The Pendleton Earth-shake of November 25th, 1905.

By Charles Davison, Sc.D., F.G.S.

PENDLETON lies on the north-west side of Manchester and within the borough of Salford, and is traversed by the well-known Pendleton or Irwell Valley fault, a fault which has been traced for more than twenty miles from the neighbourhood of Bolton to that of Poynton in Cheshire. The fault is still slowly growing, for, on February 10th, 1889, a slip near Bolton gave rise to an earthquake of intensity 6, felt over an area of about 2,500 square miles.[1] Small superficial movements may also be taking place close to

[1] Geol. Mag., Dec. III, Vol. VIII (1891), pp. 306–316.

Pendleton, though here probably aided by mining operations. Within the last seven years there have been local shakes on three occasions, namely, February 27th, 1899, April 7th, 1900, and November 25th, 1905. The materials for the study of the first two of these shakes are not quite sufficient to determine the boundaries of their disturbed areas with accuracy. The areas appear, however, to have been approximately circular in form and about four or five miles in diameter. In both cases the intensity of the shock was 4, or nearly 5. In 1899 the centre of the disturbed area was about half a mile north of Pendleton and a short distance on the north-east or downthrow side of the Pendleton fault; in 1900 it lay a mile or two farther to the south or south-south-east of the former centre.[1]

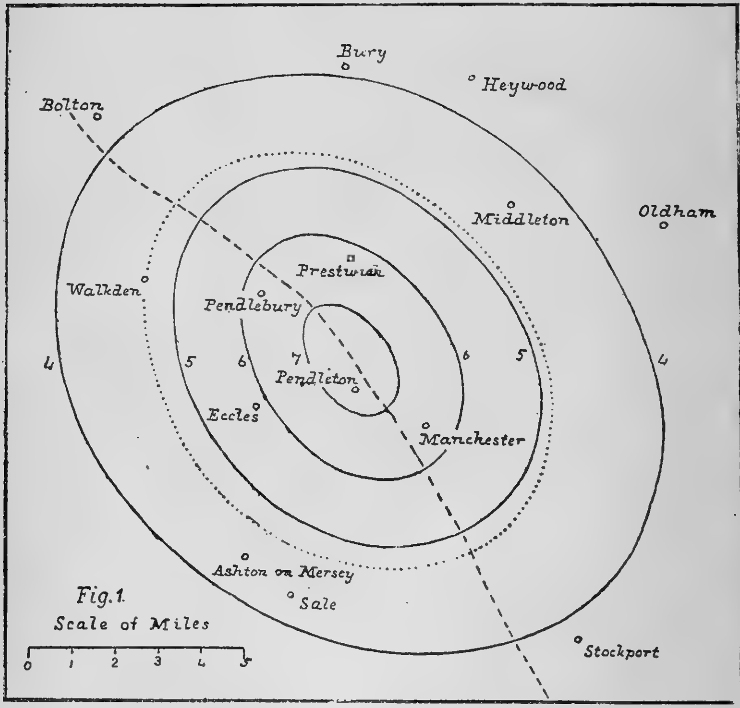


FIG. 1.—Isoseismal lines of Pendleton Earth-shake, Nov. 25th, 1905.

The earth-shake of November 25th, 1905, was strong enough to be noticed in many besides local newspapers, and was investigated without delay. The materials for its study are therefore abundant, the following account being based on 139 records from 45 places, and on negative records from 4 places.

[1] GEOL. MAG., Dec. IV, Vol. VII (1900), p. 175; Dec. IV, Vol. VIII (1901), p. 361.

The shock occurred at 3.42 a.m., the centre of the disturbed area being $\frac{3}{4}$ mile north of the centre of Pendleton (in lat. 53° 29·6′ N., long. 2° 15·8′ W.). At this place the intensity of the shock was 7, and not much below 8, for there was some slight damage done, several chimney-pots and one chimney-stack being thrown down. On the accompanying map (Fig. 1, which is bounded by the parallels of 53° 37′ and 53° 23′ N. lat. and by the meridians of 2° 4′ and 2° 29′ W. long.) four isoseismals are shown, corresponding to intensities 7 to 4. The isoseismal 7 is 3 miles long, $1\frac{3}{4}$ miles wide, and 4 square miles in area, but, towards the east, the curve may not be quite accurately drawn. The next isoseismal, of intensity 6, is 6 miles long, $4\frac{1}{2}$ miles wide, and contains 21 square miles; the isoseismal 5 is $9\frac{1}{2}$ miles long, $7\frac{1}{2}$ miles wide, and 56 square miles in area; while the isoseismal 4, which bounds the disturbed area, is $15\frac{1}{4}$ miles long, 12 miles wide, and includes an area of 144 square miles. The longer axes of the isoseismal lines are parallel or nearly so, and run from N. 37° W. to S. 37° E. The distances between the isoseismals are approximately the same on both sides of the longer axes.

The shock was brief in all parts of the disturbed area, the average of 11 estimates of the duration being $2\frac{1}{2}$ seconds. It consisted of a few prominent vibrations, quick-period tremors having been apparently absent.

The sound-area, which is bounded by the dotted line on the map, is $10\frac{3}{4}$ miles long, $8\frac{1}{4}$ miles wide, and contains 70 square miles. It includes the whole of the isoseismal 5, but falls short of the isoseismal 4 in all directions. The sound was heard by 75 per cent. of the observers. By 14 per cent. of these it was compared to passing traction engines, etc., by 13 per cent. to thunder, by 4 to wind, 9 to loads of stones falling, 31 to the fall of a heavy body, and by 29 per cent. to explosions; that is, 31 per cent. of the observers refer to types of long, and 69 to types of short, duration. The beginning of the sound preceded that of the shock in 49 per cent. of the records, coincided with it in 24, and followed it in 27, per cent.; while the end of the sound preceded that of the shock in 13 per cent. of the records, coincided with it in 16, and followed it in 71, per cent. The duration of the sound was greater than that of the shock in 87, and equal to it in 13, per cent. of the records.

In the rapid decline of intensity outwards from the epicentre, and in the nature of the sound-phenomena, the Pendleton earth-shake differs widely from other shocks in Great Britain.

(i) Decline of Intensity.—During the last seventeen years there have been eight British earthquakes of intensity 7 (and nearly 8), namely, the Inverness earthquakes of 1890 and 1901, the Pembroke earthquakes of 1892 and 1893, the Derby earthquakes of 1903 and 1904, the Carnarvon earthquake of 1903, and the Doncaster earthquake of 1905. In the following Table, the average areas contained by the different isoseismals are contrasted with the corresponding figures for the Pendleton earth-shake :—

Isoseismal.	Area in Square Miles.	
	Average of the above earthquakes.	Pendleton earth-shake.
7	500	4
6	2,500	21
5	8,300	56
4	22,000	144

(ii) Sound-Phenomena.—In earthquakes which disturb an area of not more than a few hundred square miles the average percentage of audibility is about 98, and the sound-area coincides with, or overlaps, the disturbed area. Thus, in its audibility and contracted sound-area, the Pendleton earth-shake differs from other shocks with a small disturbed area. Nor does it differ less in the nature of the sound, as will be seen from the next Table, in which the figures represent percentages of the total number of comparisons to the different types mentioned, for slight British earthquakes, the Pendleton earth-shake, and similar earth-shakes of small and approximately circular disturbed areas.

Sound-type.	Slight Earthquakes.	Pendleton Earth-shake.	Small Earth-shakes.
Passing waggons, etc.	31	14	...
Thunder	35	13	6
Wind	3	4	...
Loads of stones falling	8	9	12
Fall of heavy body ...	6	31	35
Explosions	14	29	47
Miscellaneous ...	4	...	...

The Pendleton earth-shake bears, indeed, a closer resemblance to the earthquakes which are characteristic of volcanic regions. For the sake of comparison, I reproduce in Fig. 2 the map of the isoseismal lines of the Etnean earthquake of August 8, 1894,[1] on half the scale of the map of the Pendleton shake. The curve marked A bounds the ruinous zone, in which buildings were destroyed and several persons killed. The curve B bounds the "very strong" zone, in which slight damage to buildings occurred; the curve C the "strong" zone, in which the shock was strong enough to make lamps, etc., swing; while, in the "slight" zone indicated by the curve D, the shock was just strong enough to be sensible.

In both cases it is clear, from the rapid decline in intensity, that the focus was situated at a very small depth. Secondly, in the Pendleton earth-shake, it follows, from the nature of the sound, that the focus was of larger dimensions than in the weak earth-shakes,

[1] M. Baratta, "Intorno ai recenti fenomeni endogeni avvenuti nella regione Etnea": Boll. della Soc. Geogr. Ital., Oct. 1894.

but smaller than in that of the slight, but true, earthquakes. Judging from the lengths of the axes of the inner isoseismal, it can hardly have been less than one mile, and may have been as much as one and a half miles, in length.

If the earth-shake were due to fault-slipping, the direction of the originating fault must be parallel or nearly so to that of the longer axes of the isoseismal lines, or about N. 37° W. to S. 37° E.; its hade being indeterminate, since each pair of isoseismal lines is separated by the same distance on both sides of the longer axes.[1]

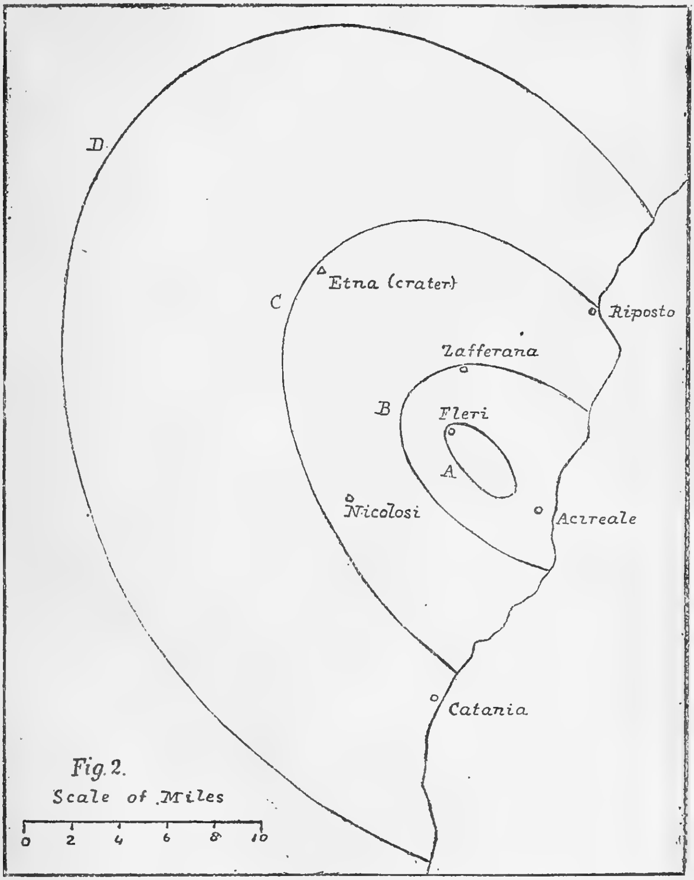


Fig. 2.—Isoseismal lines of Etnean Earthquake, Aug. 8th, 1894.

Now, in the neighbourhood of Pendleton, the mean direction of the Pendleton fault is from N. 34° W. to S. 34° E., and from its position, as indicated by the broken line on the map, we may,

[1] This would be the case if the vertical dimension of the focus was small.

I think, conclude that the earth-shake was due probably to a slip of this fault, but possibly to a subsidence along a band determined by, and closely adjoining, the fault. What the depth of the focus was we have no means of determining exactly, but it can hardly have been greater, and was probably much less, than a quarter of a mile, that is, considerably less than the depth of the present workings, which are from 800 to 1,100 yards below the surface.

That the shock was primarily due to work in connection with the mines there can, I think, be little doubt. The slip, whether along the fault or otherwise, can hardly have been precipitated directly by the withdrawal of the coal, but rather, as suggested to me by Mr. Joseph Dickinson, by the pumping of water in the overlying beds.[1] On this supposition, the slight depth of the focus, its great horizontal and small vertical dimensions, and the long interval that has elapsed since the working of the coal near the fault, would all receive a satisfactory explanation.

VI.—A Cordierite-bearing Lava from the Lake District.

By Alfred Harker, M.A., F.R.S.

ALTHOUGH the volcanic rocks of the English Lake District have received notice from time to time, any systematic account of them from the petrographical side has yet to be written. The most recent contribution, by the late Mr. E. E. Walker,[2] treated especially of the mode of occurrence of the garnet, which is so common a constituent, not only of the lavas and tuffs, but of the associated intrusive rocks, probably referable to the same Ordovician age. There can be no doubt that this mineral is sometimes a primary constituent, but very often a product of metamorphism. The object of the present note is to record the occurrence in one instance of a rarer mineral, which has not hitherto been observed in this series of rocks. Cordierite is found as a product of thermal metamorphism in the Coniston Flags near the Shap Granite,[3] and in the Skiddaw Slates of the Skiddaw granite area.[4] In the latter it is remarkably abundant and wide-spread.[5] The mineral is now found to occur, as an exceptional constituent, in the volcanic series.

The specimen was collected sixteen years ago on Sty Head Pass, just south of the watershed. As it does not, to the eye, present any unusual appearance, its occurrence was not more particularly noted. It comes then in the midst of the volcanic succession, between the principal group of basic lavas and the thick breccias and tuffs which build the central mountains of the district. Dr. Marr[6] has expressed the opinion that a large part of the garnetiferous rocks which occur

[1] For a similar suggestion see Geol. Mag., Dec. V, Vol. II (1905), p. 223.
[2] Quart. Journ. Geol. Soc., vol. lx (1904), pp. 70–104.
[3] Hutchings, Geol. Mag., 1894, pp. 65, 66.
[4] Harker, ibid., pp. 169, 170.
[5] Harker, *Naturalist*, 1906.
[6] Proc. Geol. Assoc., vol. xvi (1900), pp. 476, 477, and map, pl. xiii.

at or about this horizon are intrusive; but the rock in question has the characters of a lava, and those with which it is associated are apparently lavas and breccias. Most of these rocks on Sty Head Pass are more or less richly garnetiferous, but this specimen contains no garnet.

A thin slice (No. 1240 of the Sedgwick Museum collection) shows crystals of cordierite and felspar, with other minerals less abundant, in a fine-textured felspathic ground-mass. The cordierite crystals are about ·03 inch long and ·02 inch broad, and are invariably complex twins. A cross-section shows a hexagonal outline and, between crossed nicols, the well-known division into six fields, of which each opposite pair have like optical orientation. The mineral is partly fresh, partly converted into a finely divided scaly aggregate of a pale yellowish green colour, which may be identified with the usual 'pinite' alteration-product, probably a mixture of white mica and chlorite. The porphyritic felspars, giving rectangular sections ·02 to ·05 inch long, usually show twin-lamellæ, with the low extinction-angles of oligoclase. There are also untwinned crystals, which seem to be orthoclase. A few chloritic and ferruginous patches probably represent decayed augite, and there are occasional small crystals of magnetite and apatite. The ground-mass consists essentially of minute felspar rods with sensibly straight extinction. It thus appears that the rock has trachytic rather than andesitic characters, but it is not fresh enough for a very satisfactory diagnosis.

It is well known that cordierite occurs in some abundance in certain volcanic rocks, notably in andesites in the Eifel and the Cabo de Gata district. In such cases, even when the mode of occurrence of the mineral proves it to have crystallized from the igneous magma, there is evidence that the magma had been contaminated by dissolving non-igneous material.[1] A like origin may perhaps be suspected in the case of the cordierite (usually replaced by 'pinite') in some granites and quartz-porphyries, as in Cornwall, Brittany, and the Black Forest. Nevertheless, there is no obvious reason why cordierite should not occur exceptionally (as corundum undoubtedly does) as a normal constituent of igneous rocks. In the Sty Head lava there is nothing to suggest directly that the magma has enclosed and absorbed foreign material, and the rock occurs in the midst of a thick series of purely volcanic nature. Excepting the Skiddaw Slates at the base, which contain a few unimportant lava-flows, and the Coniston Limestone group at the top, with which the latest lavas are interbedded, the Lake District succession presents an unbroken sequence of volcanic rocks, with no trace of sedimentary material. Without expressing any opinion as to the origin of the cordierite, I leave the question in the hope that it may be elucidated by the discovery of other occurrences.

[1] For a discussion of this question see Teall, Proc. Geol. Assoc., vol. xvi (1899), pp. 61–74.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 16th, 1906.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Annual General Meeting.

The Reports of the Council and of the Library and Museum Committee for the year 1905, proofs of which had been previously distributed to the Fellows, were read. This year again the Council announced a decrease in the number of Fellows, although the number elected was 48 (2 more than in 1904). Of these, 36 paid their admission fees before the end of the year; making, with 13 previously elected Fellows, a total accession of 49 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 61 (8 more than in 1904), the actual decrease in the number of Fellows being, therefore, 12 (as compared with a decrease of 3 in 1904). The total number of Fellows on December 31st, 1905, was 1239.

The balance-sheet for that year showed receipts to the amount of £3,371 9*s.* 7*d.* (including a balance of £409 7*s.* 7*d.* brought forward from 1904), and an expenditure of £3,066 6*s.* 10*d.*

It was stated that increasingly rapid progress was being made with Mr. C. Davies Sherborn's manuscript Card-Catalogue of the Library, and that "the end was now in sight."

It was further stated that, Mr. Sherborn having intimated his inability to undertake, after the end of 1905, the preparation of the catalogue-slips for the International Catalogue of Scientific Literature, a Committee was appointed to review the part hitherto taken by the Society in furnishing the slips for British Geology to the Central Bureau, and that Committee had recommended the discontinuance of the work under present conditions. The Committee had also recommended that modifications be made in the Society's Record of Geological Literature, so as to include all geological literature published in Britain, and that slips from the aforesaid Record shall be available for the purposes of the Central Bureau of the International Catalogue of Scientific Literature.

It was announced that substantial progress had been made in the preparation of the forthcoming Centenary Record of the Society, initiated by Mr. Horace B. Woodward.

Reference was made to the lamented decease of Dr. W. T. Blanford, and to the steps taken to fill up the vacancies in the Treasurership and on the Council which his decease had created.

The list of Awards of the various Medals and Proceeds of Donation Funds in the gift of the Council was read.

The Report of the Library and Museum Committee enumerated the extensive additions made to the Society's Library, and gave some details as to the Card-Catalogue.

The Reports having been received, the President presented the Wollaston Medal to Dr. Henry Woodward, F.R.S., addressing him as follows:—

Dr. Woodward,—The Wollaston Medal, the highest honour which it is in the power of the Society to bestow, has been unanimously awarded to you by the Council in recognition of your researches concerning the mineral structure of the Earth, and particularly of your valuable contributions to the science of Palæontology, and more especially to our knowledge of the fossil Arthropoda.

There are many reasons why your fellow-workers and friends should rejoice at this award.

As Director of the Geological Department of the British Museum, your duties must have been heavy, but you have found time for an extraordinary amount of work in addition to that necessitated by your official position.

Many are the learned Societies which are indebted to you for counsel. Besides our own I may mention the Zoological, Palæontographical, Microscopical, and Malacological Societies, the Geologists' Association, and the Museums Association. Your labours on behalf of these Societies have been recognized by your having been called upon to occupy the Presidential Chair of the greater number of them.

The debt which geologists owe to you as Editor of the GEOLOGICAL MAGAZINE was admitted by Dr. Bonney, when, twenty years ago, on behalf of numerous subscribers he presented a testimonial to you in these apartments. That debt is now more than doubled, for you have been Editor of the Magazine for over forty years, and during the greater part of that period its chief Editor. In addition to this we are deeply grateful to you, and especially to her who has ever interested herself in your labours, for the "Index to the Geological Magazine" which appeared last year. It is a happy circumstance that the bestowal of this Medal upon you occurs in a month which witnesses the publication of the 500th number of that Magazine. Long may the Magazine continue to flourish in the hands of its present Editor!

Dr. Bonney, on the occasion to which I have alluded, paid a just tribute to your great kindness to other workers, and especially to the encouragement that you have ever given to the young. I gratefully remember the time when I, as an undergraduate, entered with feelings of trepidation the room of the Geological Department of the British Museum, then at Bloomsbury, how I was at once put at ease by you, and the help which I received. My experience has been that of many, and all who have benefited by your kindness will feel pleasure in the award of this Medal to you.

But although the services which I have mentioned are reasons for rejoicing at the award, they are merely subsidiary reasons for the bestowal of the Medal. The recipients of the Wollaston Medal have always qualified for it by increasing our knowledge of the mineral structure of the Earth by their own researches. It is unnecessary to say that you also have done this. Your contributions to the study of the palæontology of the Invertebrates, and especially of the fossil Arthropoda, are known to all workers, and need no further comment on my part.

I am glad that during the years of my occupation of this Chair the Wollaston Medal has been awarded to two British geologists, the one a distinguished petrologist, the other an eminent palæontologist.

Dr. Woodward, in reply, said:—

Mr. President,—It is now forty years ago (on February 16th, 1866) that I received from the President, Mr. William John Hamilton, at Somerset House, the award of the Balance of the Wollaston Donation Fund. I was then only a youth of 34 years of age, and little dreamed that I should be honoured by receiving at your hands to-day this Medal, the highest recognition that the Council can bestow.

I feel justified, however, in attributing this great honour quite as much to the personal friendship of the Council as to any merit of my own; but I am happy to find that this friendly disposition is also shared by a large body of the Fellows of the Society outside the Council, who have by letter and word of mouth expressed their kindly approval of the Council's choice.

I was elected a Fellow of this Society in 1864, and from 1867 until 1902 I have been (off and on) a Member of the Council (for a period of 35 years), and served also the office of President (1894–6), so that I naturally feel more deeply interested in the welfare of this Society than in any other, although I have been for many years, and am still, intimately associated with several other scientific bodies of kindred pursuits to our own.

You have alluded, Sir, in very favourable terms to my work, and I specially desire to thank you for your most kind reference to Mrs. Woodward's assistance in it, during all the years which are past, when we have worked side by side; but it would be incredible if, having had the grand opportunities afforded to me during forty-three years in the British Museum, I had not winnowed out some store of good grain as a contribution to the stock of palæontological knowledge in so long a life.

Whether as Editor of the Geological Magazine or in the Geological Department of the British Museum, my greatest aim and object in life has always been to be of assistance to others, and for this, I am glad to say, I have won the friendship and good-will of a very large circle of my fellow-workers, who have by their kindness rewarded me a hundredfold, as you, Sir, in the name of the Council have done to-day by the bestowal of this Medal, for which my grateful thanks are due.

The President then presented the Murchison Medal to Mr. Charles Thomas Clough, M.A., of H.M. Geological Survey, addressing him in the following words:—

Mr. Clough,—The Council have awarded the Murchison Medal to you, in recognition of your invaluable contributions to Geological Science by means of the maps and memoirs executed by you for H.M. Geological Survey.

Your detailed observations on the igneous and metamorphic rocks of Northern Britain have furnished geologists with most important material for the elucidation of many intricate problems. Your work is largely recorded in the various Memoirs of the Geological Survey. I may especially refer to those Memoirs which treat of the geology of the Cheviot Hills and of the Cowal District of Argyllshire, although your contributions to our science are also included in several other volumes of which you are one of the authors.

Your work is also recorded on the maps of those areas which you have surveyed. To produce those maps required, in addition to the ordinary accomplishments of a geological surveyor, petrographical and other knowledge of a very special kind, and they form a fitting monument to your skill. Their remarkable execution was recognized by the selection of certain of those of Ross-shire for exhibition at the St. Louis Exhibition, as examples of the maps on the 6 inch scale which are produced by the Geological Surveyors of this country.

Once again the Murchison Medal is awarded to a member of that Survey of which the founder was for so long chief. It is a source of gratification to me that, in the two years of my office as President, medals have been awarded to two old members of my own College, pupils of my College tutor, Dr. Bonney.

Mr. Clough replied as follows:—

Mr. President,—I thank the Council of the Geological Society very much for the honour that they have conferred upon me, and you, Sir, for the very kind words in which you have spoken of my work. I am conscious that this presentation is a matter not purely to myself—that it is another recognition by this Society of the value of the detailed co-operative work carried on by the Geological Survey—and it is to me a great additional pleasure to be thus tacitly associated in your minds with colleagues and friends with whom I have spent so many happy years. I have now been on the staff of the Geological Survey for more than thirty years, and I have seen that we sometimes get on the wrong track—that we have our 'downs' as well as our 'ups'—but we feel that, through all vicissitudes, a foundation of honest work is always appreciated by our brethren of the hammer.

It is a pleasure also on this occasion to acknowledge my personal indebtedness to my old friends and teachers of Cambridge days, and particularly to Professor Bonney and Professor Hughes. I feel indeed that I owe to others more than I can tell.

In handing the Lyell Medal, awarded to Professor Frank Dawson Adams, Ph.D., to Sir Archibald Geikie, Sc.D., Sec.R.S., for transmission to the recipient, the President addressed him as follows:—

Sir Archibald Geikie,—The Lyell Medal is awarded to Professor Frank D. Adams as a mark of honorary distinction, and as an expression on the part of the Council that he has deserved well of the science, particularly by his contributions to our knowledge of the Geology of Canada.

Professor Adams has been actively engaged in the study of the rocks of the great Dominion, and by work in the field and the laboratory has contributed largely to our knowledge of their petrography and their genesis. The study of those ancient rocks, the pre-Cambrian age of which was first demonstrated in Canada, has advanced far during recent years; but they are still to some degree enshrouded in mystery, and the labours of our Medallist are throwing light upon the obscurity.

He is also occupied with work among igneous rocks bearing upon problems connected with petrographical provinces and the differentiation of igneous magmas. I may more especially allude to his paper on "The Monteregian Hills—a Canadian Petrographical Province," published in the Journal of Geology for April–May, 1903.

Nor has he occupied himself with observation to the neglect of experiment, and one result of his laboratory work is that most interesting and suggestive paper, "An Experimental Investigation into the Flow of Marble," written in conjunction with Dr. J. T. Nicholson, and published in the Philosophical Transactions of the Royal Society (ser. A, vol. cxcv, p. 363). The experiments described in this paper tend to prove that not only

"The solid earth on which we stand,
In tracts of fluent heat began,
And grew to seeming random forms,
The seeming prey of cyclic storms,"

but that, even now, internal tracts which are in the ordinary sense solid,

"flow
From form to form,"

with results which have a most important effect upon various rock-structures.

Professor Adams is successful also as a teacher, and we rejoice to know that, under his care, a geological school flourishes in McGill University, endeared to us all by its association with the name of Sir William Dawson.

We regret Professor Adams's absence to-day. Let us hope that we may welcome him and many other geologists who are advancing our science in many parts of the Empire, on that auspicious occasion in the coming year when we shall celebrate the centenary of the foundation of our Society.

Sir Archibald Geikie, in reply, expressed the pleasure with which he received this Medal on behalf of his friend Professor Adams, from whom the following letter had just been received in answer to the Secretary's announcement of the award:—

"Petrographical Laboratory, McGill University, Montreal, February 2nd, 1906.

"Professor Edmund J. Garwood, M.A., Secretary of the Geological Society.

"Dear Sir,—

"I have received your kind letter conveying the very welcome and most unexpected information that the Council of the Geological Society have this year awarded to me the Lyell Medal. I regret extremely that it is impossible for me to be in London at the time of the annual meeting, so that I might have the pleasure of receiving the Medal in person.

"It is impossible for me to express adequately my thanks to the Council of the Geological Society for the great and unexpected honour which they have done me. Sir Charles Lyell's name, known as it is wherever geology is taught, is among us here associated with very kindly memories. For, during his second visit to America, Sir Charles met Dr. (afterwards Sir William) Dawson, then a young man commencing his geological work, and with him visited and studied the now renowned Joggins section of the Carboniferous of Nova Scotia. Lyell's help, counsel, and encouragement at that time, greatly stimulated Dawson to increased endeavour and further work. In 1881 Dawson became the recipient of the Lyell Medal, indicating that his endeavours had been crowned with some measure of success. As Sir William Dawson was my earliest teacher in geology, as well as my predecessor in the Chair which I now hold, the award of the Lyell Medal a second time to the Logan Professor of Geology at McGill University will still further serve to perpetuate Lyell's memory here, and to strengthen the bond of union between the geologists of Canada and the great Geological Society which has its seat at the Capital of the Empire.

"Please convey to the Council of the Society my sincere appreciation of the honour which they have done me, and accept my best thanks for the very kind words of your letter in which you conveyed the announcement of the gift.

"I remain, yours most sincerely,

"FRANK D. ADAMS."

Professor Adams was still in the full vigour of life, and there was every reason to hope that his distinguished career would be prolonged for many years to come. That his geological activity shows no sign of slackening is proved by an intimation which the speaker had recently received from him, that he had completed the detailed investigation of a wide Archæan tract of Canada, and that the paper containing the account of this investigation might be expected in this country at an early date. His researches on the flow of rocks are also still in progress, and some further results on this interesting subject may be looked for before long. No more fitting recipient of this medal could have been selected than the geologist who carries on so ably the traditions of Logan and Dawson in Canada.

The President then presented the Prestwich Medal to Mr. William Whitaker, F.R.S., addressing him as follows :—

Mr. Whitaker,—The Prestwich Medal is awarded to you as an acknowledgment of the work that you have done for the advancement of geology, particularly by your researches among the Tertiary strata of the London and Hampshire Basins. Twenty years ago the Council awarded to you the Murchison Medal as an acknowledgment of your contributions to our science, which were particularized by the President of that day. Since then you have not been idle, and your recent work has been conducted on lines similar to those along which your earlier labours were carried on.

The Prestwich Medal is, however, doubtless awarded to you, not so much on account of what you have done since receiving the Murchison Medal, as in recognition of the value of your researches in those parts of our science which were advanced in a high degree by the founder of the medal which I am about to hand to you, namely, the study of the Tertiary and Quaternary deposits. The importance of your labours among the Tertiary deposits was aptly acknowledged by Dr. Bonney in 1886, in the following words :—

"Your papers on the western end of the London Basin, and on the Lower London Tertiaries of Kent, deserve to be ranked with the classic memoirs of Prestwich, as elucidating the geology of what I may call the Home District."

You have also followed in the footsteps of Prestwich in matters of economic geology. I may especially refer to the question of water-supply and to the study of underground geology, for which you, the recipient of the Medal, like its founder, have done so much.

In these circumstances, it must be a source of satisfaction to you as well as to your friends to find that the Council have added a new link connecting your name with that of Sir Joseph Prestwich.

Six years ago the honour fell to me of receiving a medal from your hands. It now falls to my lot to convey one to you, and it gives me much pleasure to hand it to a geologist with whom I have been on terms of friendship for thirty years.

Mr. Whitaker, in reply, said :—

Mr. President,—During the course of my official life on the Geological Survey it was my lot to work over ground that had been examined in detail by Prestwich, and the geology of which was described in the remarkable set of papers which he read to the Society.

In my work I was struck by the accuracy of observation and the judgment in inference shown by our past master in stratigraphy.

In another matter, too, I have had to follow along a line in which Prestwich was perhaps the pioneer, that is, the application of geology to questions of water-supply and kindred practical subjects.

It has been to me a constant pleasure to follow in the footsteps of one from whom I have learnt so much; and that, in the opinion of the Council, I have been a not unworthy follower, is evidenced by the award to me of the Medal that bears his honoured name.

I am proud, therefore, to-day in having my name again associated with that of one for whom I have always had a great regard, as a geologist and a friend.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Dr. Finlay Lorimer Kitchin, M.A., the President addressed him in the following words:—

Dr. Kitchin,—The Balance of the Proceeds of the Wollaston Donation Fund is awarded to you as an acknowledgment of the value of your investigations on the Fossil Brachiopoda and other Invertebrata.

You took exceptional pains to fit yourself for your future calling by a prolonged course of study. After a successful career at Cambridge you proceeded to Munich, to study palæontology under a great master—the revered Zittel. The results of your training have been already shown by your various papers on Invertebrate Palæontology, among which I would specially allude to your work on the Jurassic Fauna of Cutch, published in the *Palæontologia Indica.*

In your present position your time, like that of most professional geologists, is no doubt largely occupied by routine work, but what you have already done encourages us to hope that your contributions to the science of palæontology will rank with those of your distinguished predecessors in the post which you now occupy.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Herbert Lapworth, B.Sc., addressing him as follows:—

Mr. Herbert Lapworth,—The Balance of the Proceeds of the Murchison Geological Fund is awarded to you in acknowledgment of your investigations among the Llandovery rocks of the Rhayader district.

During the intervals of a busy professional life you have devoted your attention to a line of research with which the name of Lapworth will ever be associated. The success of your investigations will be admitted by all who have read your admirable paper in the 56th volume of our Quarterly Journal. Of that paper I need merely say that it is worthy of the son of Charles Lapworth. We trust that our Journal will, in future years, contain many other equally valuable contributions from your pen.

I have much pleasure in handing to you this award, bestowed by the Council as an incentive to further work.

In presenting a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. William George Fearnsides, M.A., the President addressed him as follows:—

Mr. Fearnsides,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund is awarded to you by the Council in recognition of your valuable contributions to our knowledge of the Lower Palæozoic and Cretaceous rocks.

Your first contribution to the Quarterly Journal recorded an interesting discovery on the borders of our University town, where one might have expected that little remained to be done. But, like so many Cambridge men, you, dissatisfied with the simplicity of the Mesozoic rocks of East Anglia, turned your attention to the older rocks of the western tracts of Britain; and that you have there already obtained most valuable results is proved by your admirable paper on "The Geology of Arenig Fawr and Moel Llyfnant," published in last year's Quarterly Journal.

Your friends know that this is but a beginning, and that you have already done much work in Wales and elsewhere which is not yet published. We shall look forward with confidence to the results of your continued researches; and it gives me much pleasure to hand to you this proof of the Council's approbation of what you have already done, and of their interest in your future work.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Richard H. Solly, M.A., to Professor W. W. Watts, F.R.S., Sec.G.S., for transmission to the recipient, addressing him in the following words:—

Professor Watts,—The other moiety of the Lyell Geological Fund has been awarded to Mr. Richard H. Solly as an acknowledgment of the valuable work done by him on the minerals of the Binnenthal and elsewhere. Mr. Solly has carried out his labours under difficulties, and in some degree with a lack of encouragement which would have disheartened many workers. Nevertheless he has steadily proceeded with his self-appointed task, and made substantial additions to his science. He is still engaged in his work on the Binnenthal, where he has discovered seven new minerals which he has described.

Will you express a hope to Mr. Solly that this award may act as an incentive to the prosecution of his researches, proving as it does that his work is appreciated by the Council of this Society?

In presenting a sum of twenty-five pounds from the Barlow-Jameson Fund to Mr. Henry C. Beasley, the President addressed him as follows:—

Mr. Beasley,—The sum of twenty-five pounds from the Barlow-Jameson Fund is awarded to you by the Council in recognition of your important work on the Triassic rocks. In connection with that work I may refer to your valuable descriptions of footprints from the Trias, in which you have abstained from burdening our fossil lists with new names. You have travelled much on either side of the Atlantic, obtaining thereby much useful information concerning geological matters, more especially with reference to the Triassic rocks.

I may also allude to your work on Glacial Geology, and to a suggestive paper on the water ejected from volcanoes.

I hope that this award of the Council will encourage you in the further prosecution of your fruitful researches.

The President then proceeded to read his Anniversary Address, giving first of all obituary notices of several Fellows deceased since the last annual meeting, including Dr. W. T. Blanford (elected a Fellow in 1860), Baron Ferdinand von Richthofen (el. For. Memb. 1888), Prof. G. Dewalque (el. For. Memb. 1880), Prof. F. V. Raulin (el. For. Corr. 1866), Mr. H. B. Medlicott (el. 1856), Capt. F. W. Hutton (el. 1860), Mr. J. Mansergh (el. 1876), Sir John B. Phear (el. 1852), Mr. W. J. Woodall (el. 1857), Mr. W. H. Goss (el. 1881), and Mr. T. Barron (el. 1896).

He then proceeded to describe "The Influence of the Geological Structure of English Lakeland upon its present Features.—A Study in Physiography."

After a brief account of the light thrown upon the structure of Lakeland by the writings of Otley, Hopkins, Clifton Ward, Goodchild, and Strahan, he considered his subject under the following heads:—

I. Events prior to the Uplift which produced the Dome.
II. Production of the Dome.
III. Initiation of the Drainage-lines.
IV. Effects of the three Types of Rocks upon the Scenery.
V. Modification of the old Drainage-lines.
VI. Depression of the Outskirts.
VII. Effects of Meteorological Conditions. (1) General.
VIII. ,, ,, ,, (2) The Glacial Period.
IX. Conclusion.

Of the events prior to the dome-shaped uplift he laid greatest stress upon the movements of Devonian times, which had caused the Lower Palæozoic rocks to be affected by a series of fractures forming a roughly rhomboidal network, the fissures being marked by belts of broken rock along their courses. These belts were spoken of as 'shatter-belts,' and their nature and distribution described.

He accepted Hopkins's view of the formation of a dome comparable in shape to a 'caddy-spoon' with the short handle to the east, and argued that a subsidiary uplift occurred over the site of the Howgill Fells and adjoining country, and other subsidiary uplifts possibly over the Skiddaw and Helvellyn tracts. Between these uplifts and the Pennine Chain were the depressions of Edenside on the north-east, and of Morecambe Bay and the neighbouring lowlands on the south-east.

He gave further reasons in support of the view, previously put forward independently by Goodchild and himself, that the uplift of the dome and the final movements of the Pennine Chain were of Tertiary date.

After commenting on the now generally received view that rocks of New Red Sandstone age, and perhaps of later date, extended over the district, he discussed the nature of the radial drainage impressed upon these newer rocks during the uplift of the dome, and the removal of these rocks in the district itself by denudation, producing a superimposed drainage on the Lower Palæozoic rocks.

He then discussed the changes which took place in the valleys as the result of the imposition of the rivers upon the ancient rocks, and maintained that diversion of the river-courses had largely taken place owing to the easier erosion along the shatter-belts, describing in detail the cases of the Langdale, Duddon, and Borrowdale drainage areas in support of his views.

In this part of the address the position of the principal hanging-valleys was indicated, and it was pointed out that there were two sets, namely, those which 'mouthed' into valleys that had been deepened in softer rocks, and those which 'mouthed' into portions of main valleys that had been deepened along shatter-belts.

When discussing the effects of meteorological conditions he commented on hill-outlines, which he had elsewhere mentioned, where the upper parts of hill-slopes presented a convex outline towards west and south, and a concave curve towards east and north. This he attempted to explain as due to the more profuse growth of vegetation on the slopes facing west and south.

In discussing glacial changes, he admitted that in former papers he had over-estimated the importance of glacial dams in holding up the waters of lakes, and now recognized that Watendlath Tarn, Elterwater, and Thirlmere occurred in true rock-basins, and that other lakes of the district were therefore, in all probability, partly rock-basins.

He believed that some of his views would be proved capable of more than local application, and that they proved the importance of the study, on the part of the geographer, of geological details in addition to general geological structure.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* H. H. Arnold-Bemrose, J.P., M.A.; Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec.R.S.; R. S. Herries, M.A.; F. L. Kitchin, M.A., Ph.D.; P. Lake, M.A.; G. W. Lamplugh, F.R.S.; R. Lydekker, B.A., F.R.S.; B. McNeill, Assoc.R.S.M.; J. E. Marr, Sc.D., F.R.S.; H. W. Monckton, Treas.L.S.; F. W. Rudler, I.S.O.; L. J. Spencer, M.A.; A. Strahan, M.A., F.R.S.; C. Fox Strangways; J. J. H. Teall, M.A., D.Sc., F.R.S.; R. H. Tiddeman, M.A.; Professor W. W. Watts, M.A., M.Sc., F.R.S.; Rev. H. H. Winwood, M.A.; A. S. Woodward, LL.D., F.R.S., F.L.S.; and H. B. Woodward, F.R.S.

Officers: — *President:* Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec.R.S. *Vice-Presidents:* R. S. Herries, M.A.; J. E. Marr, Sc.D., F.R.S.; A. Strahan, M.A., F.R.S.; and J. J. H. Teall, M.A., D.Sc., F.R.S. *Secretaries:* Professor E. J. Garwood, M.A., and Professor W. W. Watts, M.A., M.Sc., F.R.S. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* H. W. Monckton, Treas.L.S.

II.—February 21st, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair. The following communications were read:—

1. "The Constitution of the Interior of the Earth, as revealed by Earthquakes." By Richard Dixon Oldham, F.G.S.

This paper is not devoted to a fresh theory of the earth, but is intended to set forth some of the information which can be obtained from the study of the records of distant earthquakes. The modern seismograph has given to geology a new instrument of research, and extended its scope much in the same way as the spectroscope extended the scope of astronomy, by enabling us to see into, and determine the physical constitution of, the interior of the earth at depths removed from any other possible means of research.

The distant record of a great earthquake exhibits three distinct phases, of which the third represents wave-motion which has travelled along the surface of the earth and is not dealt with in this paper, as it can give no information regarding the interior of the earth. The other two phases form the preliminary tremors, and it is shown that they represent the emergence of two distinct forms of wave-motion, which have been propagated through the earth.

A study of the intervals taken by these waves to reach remote points shows that, up to a distance of 120° of arc from the origin, they are propagated at a rate which increases with the depth of the wave-path, and reaches an average of over 10 km. sec. in the case of the first-phase, and over 6 km. sec. in the case of the second-phase waves. The increase, being gradual and continuous, may be attributed to the effect of increased pressure and temperature, and there is no indication of any change in physical constitution of the material traversed by waves which emerge at 120° or less from the origin.

Beyond this limit the first-phase waves show a reduction in the mean rate of transmission, while the second-phase waves are not to be found where they would be expected, but at about 11′ later. The interpretation is that the wave-paths emerging at these greater distances have entered a central core, in which the rate of transmission of the first-phase waves is reduced to about nine-tenths, and of the second-phase waves to about one-half, of the rate in the outer shell. The great reduction of rate in the case of the second-phase waves means great refraction, and the wave-paths which emerge at distances of over 130° from the origin must have reached their emergence after passing on the farther side of the centre of the earth; the increase of length of wave-path means a longer interval between origin and emergence, and the sudden increase of interval at about 130° is explicable in this way. An alternative explanation is that the second-phase waves are extinguished at these distances, but this explanation is not regarded as probable by the author.

Either alternative leads to the conclusion that, after the outermost crust of the earth is passed, there is no indication of any material or rapid change of physical condition, nor probably of chemical composition, until a depth of about six-tenths of the radius is reached; but that below this there is a rapid passage to matter which has very different physical properties, if not also differing in chemical constitution. Without advancing any hypothesis as to the nature of this difference, the author points out that it will have to be reckoned with in any theory of the earth.

2. "The Tarannon Series of Tarannon." By Miss Ethel M. R. Wood, D.Sc. (Communicated by Professor Charles Lapworth, M.Sc., LL.D., F.R.S., F.G.S.)

A general historical review is given of the existing state of knowledge respecting the character and fossils of the strata included under the general title of 'Tarannon' on the maps of the Geological Survey in Wales. The Tarannon strata are most fully developed in the Llanbrynmair-Tarannon district, after which they are named; and the present paper gives the results of a detailed survey of the entire Tarannon Series as there exhibited. Various sections—typical and confirmatory—are described, showing the local sequence of the strata. Lists of the contained graptolites are given, and the species are paralleled with those from the corresponding beds of the South of Scotland, the Lake District, North Wales, Central Wales, and Sweden, demonstrating the similarity of the graptolitic succession in all these districts.

The authoress establishes the following local sequence:—

C. Wenlock Series.
- C*b*. Fynyddog Group.
- C*a*. Nant-ysgollon Group.
  - Zones of *Monograptus riccartonensis* and *Cyrtograptus Murchisoni*.

B. Tarannon Series.
- B*d*. Dolgau Group. (Zone of *M. crenulatus.*)
- B*c*. Talerddig Group. (Zone of *M. griestonensis.*)
- B*b*. Gelli Group. (Zone of *M. crispus.*)
- B*a*. Brynmair Group. (Zone of *M. turriculatus.*)

A. Llandovery Series.
- A*c*. Twymyn Group.
  - Zone of *M. Sedgwickii.*
  - Zone of *Cephalograptus cometa.*
- A*b*. Dolgadfan Group.
  - Zone of *M. convolutus.*
  - Zone of *M. fimbriatus.*
- A*a*. Fachdre Group.
  - Zone of *Dimorphograptus Swanstoni.*

The Tarannon Series in this district has a maximum thickness of 3,500 feet, but thins somewhat as it is traced north-westward. It rests conformably on Llandovery rocks below, and passes up without a break into Wenlock beds above. This rock-series is stratigraphically continuous from base to summit, and includes the four divisions of the Brynmair, Gelli, Talerddig, and Dolgau Groups, which, while they possess distinctive features of their own, are bound together by common palæontological characters. The lowest two, namely, the Brynmair and Gelli Groups, consist mainly of grey shales and mudstones with beds of thin flags, which increase in number and thickness as one ascends the sequence. The Talerddig Group is distinctly an arenaceous one, and contains numerous bands of thick grit which are generally massed together at four or five distinct horizons. The highest member of the series, the Dolgau Group, answering to the local 'Tarannon Shales' of the Geological Survey, consists of pale-grey and purple mudstones, the latter being inconstant in number and thickness in different parts of the district.

The strata of the overlying Wenlock Series present all the characters of the Denbigh Grits and Flags of North Wales. Some 2,000 feet are developed in this district, the upper beds consisting of grits and flags, while the lower are mainly shales and mudstones.

The Llandovery Series, which underlies the Tarannon Series, has, at present, been recognized only in the western part of the district, namely, in the valley of the Twymyn, and its rocks are brought to the surface by an anticlinal fold. Representatives of nearly the whole of the Llandovery beds have been met with at different localities, and five distinct graptolitic zones have been recognized. The rocks, which consist almost entirely of soft shales and mudstones, are probably not more than 400 feet thick.

A comparison of the graptolitic lists shows that the Tarannon Series, as here defined, corresponds almost exactly with the Gala or Queensberry Group of the South of Scotland, includes all the palæontological zones hitherto assigned to the Tarannon, and fills up the whole period intervening between the Llandovery below and the Wenlock above. It includes the extreme beds which have been mapped as Tarannon by the Geological Survey in Wales; and in the Tarannon District, at all events, the thickness of the series is equivalent to its maximum development elsewhere.

CORRESPONDENCE.

SMALL FOSSIL SHELLS PRESERVED WITHIN THE INTERIOR OF LARGER ONES AND IN THE BODY-CHAMBER OF CEPHALOPODS.

Sir,—It is a well-known fact to all collectors of fossils and practical geologists, that in the interior or body-cavity of larger fossils very often smaller ones may be found splendidly preserved, which otherwise are not to be got at all, or only in a very poor state, being crushed or weathered or wholly destroyed. In this way, when I worked, especially on the Tertiaries, I obtained the very finest and rarest things by taking home with me portions of broken and badly damaged specimens of larger species and examining their contents at leisure. Very often, too, I found extremely fine and interesting fossils in the interior of Mesozoic and Palæozoic shells, in the moulds or casts of the living or body-chambers of Ammonites and other Cephalopoda, whose preceding chambers sometimes had completely disappeared. Dr. Krause described a complete specimen of a crab, *Glyphæa leionoton*, found in the living chamber of an *Ammonites gigas* from our Portland Beds (Zeitschrift Deutsch. Geol. Ges., xliii, p. 194, pl. x, fig. 1), and I got only last summer a very fine complete specimen of *Æger*, n.sp. (?), with the antennæ preserved, in the living chamber of a large *Stephanoceras* from our Middle Jurassic beds. I therefore cannot agree with the view expressed in the English edition of Zittel's Textbook of Palæontology (translated and edited by C. R. Eastman, p. 658), that "some of these bodies (viz., *Cardiocaris, Pholadocaris*, and *Spathiocaris*), which have been found in the living chamber of *Goniatites* (*G. intumescens*), *have undoubtedly served as opercula or aptychi of these Cephalopods.*" I may add that they are not commonly found there, and if there, as usual together with specimens of *Orthoceras, Cardiola*, small *Goniatites, Entomis*, and other fossils, certainly have nothing to do with the organisation of *Goniatites intumescens*, but only happen to occur associated with it in the same rock.

A. von Koenen.

Royal Geological Museum and
University of Göttingen, Germany.

OBITUARY.

JOHN GEORGE GOODCHILD, F.G.S.

Born May 26, 1844. Died February 21, 1906.

It is with much regret we have to record the death of a valued member of the Geological Survey of Scotland, who for some years had filled the office of Curator of the Geological Survey Collections in the Royal Scottish Museum, and who died in Edinburgh on the 21st February after a lingering illness. Born near London on 26th May, 1844, he joined the Geological Survey in 1867, and for many years was engaged in mapping areas in the north of England, particularly in the neighbourhood of the Lake District. Thereafter he was removed to the Survey Office in Jermyn Street, London, and in 1887 was transferred to Scotland, where he was placed in charge of the collections obtained by the Scottish staff, and deposited in the Royal Scottish Museum, an appointment for which he was specially adapted. In recent years he had charge of the Scottish Mineral Collection in the same museum, which led him to devote a large amount of time to the special study of mineralogy. Gifted with remarkable fluency and lucidity of exposition, he became widely known as a successful lecturer on geology. During 1884, 1885, and 1886, he gave courses of lectures on physical geography, geology, and palæontology at Toynbee Hall, and since he settled in Edinburgh he had lectured on these subjects at the Heriot-Watt College and other institutions. Possessing remarkable powers of receptivity, a mind extremely susceptible of new ideas, and a facile pen, he contributed a very large number of papers—about 200—on a wide range of subjects to the Proceedings of various scientific societies in England and Scotland, and no fewer than 24 to the pages of the Geological Magazine (1874–1902). He also edited the important work in two volumes on Scottish Mineralogy, by the late Professor Heddle, published after Prof. Heddle's death. In recognition of his labours he was awarded, in 1874, the Wollaston Fund by the Geological Society of London. His versatile gifts were further shown by his keen interest in other branches of science, his knowledge of botany and ornithology being considerable. All these varied qualifications made him a valuable conductor of field-excursions, and an exponent of geological problems among numerous scientific societies. His restless mental and bodily energy, reacting on a constitution never very robust, may be said to have shortened his career. He leaves a widow and three sons, the eldest of whom graduated with honours at Cambridge, and is now Principal of the Technical College at Wandsworth, London; the second is a magazine artist, and the third recently graduated in medicine at Edinburgh University.

At a meeting of the Edinburgh Geological Society on Feb. 21st, Mr. James Currie, F.R.S.E., the President, moved, and Dr. J. Horne, F.R.S., seconded, the following resolution, which was at once carried:—"That the Edinburgh Geological Society desires to place on record their appreciation of the valuable work done by the late Mr. Goodchild in the sphere of general geology, and more especially in the elucidation of problems connected with Scottish geology and mineralogy, and expresses its sincere sympathy with his widow and family."—*The Scotsman*, February 22nd, 1906.

THOMAS BARRON, A.R.C.S., F.G.S.

Born 1867. Died January 30, 1906.

Thomas Barron was educated at Greenlaw public school, Berwickshire, and afterwards attended the Science and Art Classes at Hume. He gained a medal with first-class honours and a scholarship in the Normal School of Science (as it was then called) at South Kensington. In that school he continued his studies; he was elected an Associate of the Royal College of Science, and eventually he became Assistant Demonstrator to Professor Judd.

In 1896 he communicated to the Geological Magazine a paper "On a new British Rock containing Nepheline and Riebeckite."

He was subsequently appointed to a post on the Geological Survey of Egypt, and there he laboured with signal success.

In 1901, with Dr. W. F. Hume, he contributed to the Geological Magazine "Notes on the Geology of the Eastern Desert of Egypt," and in 1903 was issued the full Report of the Geological Survey (dated 1902) on the "Topography and Geology of the Eastern Desert of Egypt," with maps, plates, and sections. His services were called for on questions of irrigation, in the survey of the peninsula of Sinai, and in an exploration for coal in Abyssinia. In 1904 he conducted an expedition in the Soudan with the object of finding water, and in the following year he became Geological Surveyor to the Soudan Government.

He died of enteric fever at El Koweit, Suakim, on the 30th of January, aged 39.

WILLIAM CUNNINGTON, F.G.S.

Born 1813. Died February, 1906.

The death, in his ninety-third year, of William Cunnington removes one of the more distinguished local geologists and antiquaries whose observations and collections have done much to advance science. During the middle portion of last century the name of William Cunnington, of Devizes, became familiar to geologists. His extensive collection of the Cretaceous fossils of Wiltshire furnished materials which aided Davidson in his Monograph on Cretaceous Brachiopoda, Wright in his Cretaceous Echinodermata, and Daniel Sharpe in his Cretaceous Cephalopoda; and in the last-mentioned work *Ammonites Cunningtoni*, from the Lower Chalk near Devizes, was named in his honour. For many years Cunnington was one of the honorary secretaries of the Palæontographical Society. He was elected a Fellow of the Geological Society in 1854. He obtained a fine series of sponges from the Upper Greensand of Warminster, and many of these are described or mentioned in Dr. G. J. Hinde's "Catalogue of the Fossil Sponges in the Geological Department of the British Museum."

He was a grandson of William Cunnington, F.S.A., of Heytesbury in Wiltshire, who was interested in geological pursuits, probably through acquaintance with William Smith, and celebrated for his antiquarian researches in the county, in which he was associated with Sir Richard Colt Hoare. While a lad he began to collect fossils from the chalk-pits of Upavon, and subsequently, when he had settled at Devizes as a wine merchant, he assiduously studied the local geology—especially the strata from the Great Oolite Series to the Portland Beds, the Lower Greensand, the Gault, Upper Greensand, and Chalk; and he ultimately amassed a collection of more than 20,000 fossils. He was one of the founders of the Devizes Museum, and was honorary curator from the time of its opening in 1853.

One of his earliest papers was "On the Fossil Cephalopoda from the Oxford Clay constituting the genus *Belemnoteuthis* (Pearce)," *London Geol. Journ.*, No. 3, 1847, p. 1. Most of his contributions to geological literature were, however, published in the Magazine of the Wiltshire Archæological and Natural History Society; they included papers on "The Mammalian Drift of Wiltshire" (1857), "The Bradford Clay" (1859), "Geology of Wiltshire" (1869), and "Geology of the neighbourhood of Westbury Station" (1872). To the Geological Society he communicated in 1850 a paper "On a section of the Lower Greensand at Seend, near Devizes" (Q.J.G.S., vi, 453), and a second paper in 1898 "On some Palæolithic Implements from the Plateau-Gravels, and their evidence concerning 'Eolithic' Man" (Q.J.G.S., liv, 291). He also published in *Natural Science,* vol. xi (1897), p. 327, a paper on "The Authenticity of Plateau-Man," in which he doubted the human origin of the 'Eolithic' chipping.

Mr. Cunnington retired from Devizes many years ago and settled in London.

His collections of fossils have been placed in the British Museum (Natural History), in the Museum of Practical Geology, and in the Devizes Museum.

For some of the above particulars we are indebted to "The History of the Collections contained in the Natural History Departments of the British Museum," vol. i (1904), pp. 281–2.

Under the title of "Fossils used as Ornaments" there is a reprint[1] in the Geological Magazine, 1893, p. 248, of an interesting article "On a Crapaudine Locket found in St. John's Churchyard, Devizes," by William Cunnington, F.G.S., of which figures are given. The interest to geologists lies in the fact that the sides of the locket are formed of two detached circular palatal teeth of *Lepidotus maximus,* Wagner = *Sphærodus gigas,* Ag., from the Kimmeridge Clay of Shotover.

MISCELLANEOUS.

Chair of Geology in the Royal College of Science, South Kensington.—The President of the Board of Education has appointed Professor W. W. Watts, M.A., F.R.S., of Birmingham University, to the Chair of Geology at the Royal College of Science, South Kensington, vacant by the retirement of Prof. Judd, C.B., F.R.S.

In view of the changes in organisation that may be found desirable in the Royal College of Science and the Royal School of Mines after the consideration of the report of the Department Committee on the college, it has been thought best to make this appointment a temporary one.

Professor Watts was a Fellow of Sidney Sussex College, Cambridge, from 1888 to 1894, and a member of the Geological Survey from 1891 to 1897. He has acted successively as Deputy Professor of Geology at Leeds, Birmingham, and Oxford. At the present time he is Assistant Professor of Geology and Professor of Geography at the Birmingham University, and is Secretary of the Geological Society.—*Standard, January 23rd,* 1906.

[1] See the Wilts Archæological Magazine, 1870, No. xxxv, p. 249.

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THE

GEOLOGICAL MAGAZINE.

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No. V.—MAY, 1906.

ORIGINAL ARTICLES.

I.—Lamarck and Playfair: A Geological Retrospect of the Year 1802.[1]

By Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec. R.S.,
President of the Geological Society.

(*Concluded from the April Number, p.* 153.)

If Lamarck allowed his brilliant faculty of generalisation to lead him far astray in his opinions regarding the origin of rocks, he had formed a saner judgment on the causes that have developed the present terrestrial topography. The first chapter of the "Hydrogéologie" is devoted to a consideration of the natural results that arise from the circulation of water over the surface of the land. This subject, he remarks, affords less scope than any other for the exercise of the imagination in framing hypotheses, for it can be studied on a basis of facts which are generally familiar. Though the question required to be considered in his treatise and was capable of easy solution, yet it seemed to him to be novel, at least from a general point of view, and to have been previously neglected by physicists and naturalists. He appears to have formed his conclusions regarding it independently, and to have been unaware how far he had been anticipated by previous observers. It is singular that he makes no allusion to the work of his distinguished fellow-countryman Desmarest, who some thirty years previously had demonstrated, from a prolonged and minute investigation of the volcanic history of Auvergne, that the valleys of that region have been excavated by the streams which flow in them. He does not refer to the enunciation of the same doctrine by De Saussure a few years later in regard to the valleys of the Alps, nor to the clear presentation of similar views by Hutton, whose system had been expounded to French readers by Desmarest. But though he was mistaken in supposing that the doctrine was novel, Lamarck was not surpassed by any of his predecessors in the firmness with which he espoused it, and in the clearness with which he presented it to the world. Realising so fully as he did the magnitude of the scale

[1] An address delivered before the "Alliance Française" in the Sorbonne, Paris, on 26th February, 1906.

on which the surface of the land undergoes disintegration, he could see no difficulty in conceiving that the mere passage of running water over that surface must inevitably lead to the erosion of a system of drainage-lines from the mountain-crests down to the margin of the sea. In language closely similar to that employed at the same time by Playfair in the volume which appeared at Edinburgh, he remarks:—"If we suppose the exposed part of the surface of the earth to have been originally a vast plain, unvaried either by mountains or valleys, and having no other curvature than that of the general form of the globe, though such a supposition is not necessary, seeing that the lands successively abandoned by the ocean in its westerly movement would not all be without irregularities in their surface, I can easily show that at the end of a certain period of time the influence of the subaerial waters will have modified or destroyed the regularity of surface of this plain, and will ultimately form mountains like those which are familiar to us" (pp. 11, 12). "This sequence of events is that followed by Nature in her known methods and processes which can be seen in progress every day before our eyes. It is thus evident to me that every mountain which is not the result of volcanic eruption or of some other local catastrophe has been cut out of a plain, and that its peaks and crests mark the relics of the ancient level of that plain" (p. 14).

That this interpretation holds true for the abundant hills and mountains composed of horizontal or little disturbed stratified formations is now an accepted conclusion of modern geology. But it will not explain the origin of the great mountain-chains of the earth's surface, which have been upheaved during the violent plication and rupture of the terrestrial crust. Of the real structure of such chains comparatively little was known in Lamarck's time, and even that little was not appreciated by him. He thought that the inclined arrangement of strata in many mountains was original, and might generally be taken to indicate the position of the shores on which the sediments were deposited, though it might in some cases be due to local disturbance. He knew that sometimes the strata in a mountain-chain are found to be vertical, but he would not on that account invoke for their explanation some universal catastrophe as had been advocated by other writers,[1] but contented himself with a vague reference to local subsidences (pp. 22, 23).

In his account of what he conceived to take place when the land is laid bare in consequence of the westward migration of the ocean, Lamarck involved himself in some curious contradictions. In the mental picture which he drew of the successive emergence of the marine deposits, including the granite ridges which had been laid down upon the sea-floor, he imagined that the surface of the plain, thus transformed into an area of land, was gradually heightened by the accumulation upon it of the remains of organisms, more especially

[1] He not improbably had Cuvier in his mind, who held this opinion and afterwards gave it prominence in his "Discours sur les Révolutions de la Surface du Globe," wherein he asserted that the occurrence of such a catastrophe, some 6,000 years ago, was one of the best ascertained facts in geology.

of vegetation. He thought that this organic deposit increased in thickness at the rate of one foot in a century, so that in no long course of time it must deeply bury the old sea-floor and even cover up the ridges of deposited granite. He did not show, however, by what means this general elevation of the surface of the plain could possibly be accomplished in face of the universal degradation caused by atmospheric decay and the circulation of water over the land—a destructive combination which he had already admitted that nothing can resist. Nor did he offer any explanation of the cause of the ultimate cessation of the upward growth of the organic deposit, or why after burying the granite ridges it eventually failed to keep pace with the erosive action of rain and rivers. Without noticing such obvious and serious objections to his theories, he could only contemplate the final result of the long process of earth-sculpture—the trenching of the terrestrial plain by running water, into gullies, gorges, and valleys, and at last the uncovering of the hard central cores of granite now to be seen in the heart of so many mountain-chains (pp. 149, 178).

It was when he left such speculations as these, for which no adequate basis of ascertained fact then existed, and turned his consummate genius to the patient study of the organic remains imbedded in the earth's crust, that Lamarck conferred the most valuable and imperishable benefits on the infant science of geology. The word 'fossil' had up to his time been indiscriminately applied to any substance dug out of the ground. Every mineral and rock was in this sense a fossil. But Lamarck, recognising the pre-eminent importance of organic remains as monuments of the history of the globe, first restricted the use of the word to them alone, and his example has since been everywhere followed. In the "Hydrogéologie" he pointed out that as fossil shells are nearly all of marine types their evidence could be used to demonstrate that the sea once covered the site of what is now land, and this by no mere transient and violent inundation, but tranquilly and for vast periods of time. As Lavoisier had done before him, he distinguished among them some that belonged to littoral or shallow-water species and others that were deep-sea or pelagic forms. He entered into a lengthened argument to disprove what had been for so many generations the orthodox belief that the shells found far inland and in the heart of mountains are memorials of Noah's Flood. Dwelling on the manner in which pelagic and littoral shells are found in separate beds, piled above each other, he insisted on the evidence thus furnished of successive quiet and long-continued deposition on the sea-bottom. He pointed to the significant occurrence of the two valves of bivalve shells still adhering to each other as proof that these organisms, instead of having been violently huddled together by some great catastrophe, had manifestly lived and died where their remains are now found. When he considered the abundance of marine organisms in our present seas and the vast amount of carbonate of lime secreted by them from the oceanic waters, he felt convinced that the masses of limestone which form so important a part of the outer crust of the earth represent marine organic accumulations of former ages, although in course of time, by the operation of various causes, all trace of organised structures may have disappeared from them.

The "Hydrogéologie" was Lamarck's single treatise specially devoted to the discussion of geological problems, but it formed only the beginning of the labours by which he conferred the most signal benefits on geology and earned for himself the name of founder of invertebrate palæontology. For a long succession of years after the appearance of that volume in 1802 he gave much of his time and thought to the study of the fossil shells of the Paris Basin, and published the valuable series of memoirs on these organic remains which revealed the zoological riches of the Tertiary deposits of that region, and likewise served as an accurate basis for the detailed investigation of these deposits by Cuvier and Brongniart, who thereby did so much to lay the foundations of stratigraphical geology. These later achievements of the illustrious biologist, however, and his contributions to the theory of organic evolution lie beyond the scope of the present address. I have wished to direct attention to one of his less known works which, while it displays his weaknesses as well as his strength, is full of his philosophical genius and of that broad commanding view of all the wide domains of Nature which was so eminently characteristic of Lamarck.

From Paris and its busy laboratories and museums in which Lamarck quietly did his work, let us turn to Edinburgh, where at the same time a few thoughtful and enthusiastic men were discussing the same problems and were evolving some of the fundamental conceptions that have shaped the course of modern geology. James Hutton, the greatest genius in this northern group of philosophers, died in 1797, leaving behind him in published form only an incomplete account of his doctrines, but having impressed on the minds of his friends a profound admiration of the originality and grandeur of his conceptions of the history of our globe. It was fortunate for his fame, and not less so for the onward march of science, that one of these friends had gained so full and clear a knowledge of the master's teaching, and at the same time possessed such pre-eminent literary gifts, as to be able to present Hutton's doctrines in the remarkable volume to which I have now to ask your attention.

This loyal and accomplished friend, John Playfair, was born in 1748. The eldest son of a Scottish parish minister, he was educated for the Scottish Church at the University of St. Andrews. But during his college career he showed such high mathematical and philosophical attainments that, when only 18 years of age, he was encouraged by his professors to compete for the vacant Chair of Mathematics in the University of Aberdeen, and after a prolonged examination came out third in the list of candidates. Failing in this application, he eventually entered the Church, and was appointed to succeed his father in his Forfarshire parish. Amidst the quiet of a remote country manse and in the duties of a parish minister he spent ten years of his life, supporting his mother and educating his younger brothers. But at the end of that time he resigned his living, and as his scientific tastes remained as strong as ever, he obtained in 1785 the appointment of Joint-Professor of Mathematics in the University of Edinburgh. His gentle and kindly nature, his high mental endowments, and his social charm soon gained for him an honoured place in the circle of philosophers, men of science, and of letters who at that time shed such lustre on the Scottish capital. Among the friendships which he specially cherished there was that of Hutton, who in the Spring of the same year (1785) read to the Royal Society of Edinburgh the first sketch of his famous "Theory of the Earth." Playfair's philosophic mind appears to have been early fascinated by the breadth and profundity of Hutton's views of Nature. As he used to accompany the geologist on his excursions in Scotland, and had abundant opportunities of listening to his enthusiastic disquisitions, Playfair enjoyed special facilities for gaining a fuller appreciation of Hutton's doctrine than could easily be gathered from the master's own writings, which, from their cumbrous and obscure style, had met with less recognition than their intrinsic originality and importance deserved. When, therefore, Hutton died, his admiring disciple determined to draw up a popular and perspicuous sketch of his friend's geological system. After working at the task for five years he published in the Spring of 1802 his well-known "Illustrations of the Huttonian Theory." Playfair's subsequent career was as uneventful as the years that had already passed. In 1805 he was transferred to the Chair of Natural Philosophy in Edinburgh University, an appointment which he continued to fill up to the end of his life. He contributed many articles and memoirs to the current literature of the day, and in his later years undertook many journeys at home and abroad in pursuit of geological studies. But an internal ailment brought his life to a close on 19th July, 1819, at the age of 71.

Playfair's loyalty to his great teacher, and his earnest desire to set the Huttonian system in a clear and attractive guise before the world, led him to keep himself in the background and to take little heed that men should notice the fresh observations, deductions, and illustrations which he himself contributed towards the confirmation of Hutton's doctrines. Hence less credit has perhaps been assigned to him than he deserved as an independent and original observer. The extraordinary merit of his volume was at once recognised, and it gave a powerful impulse to the acceptation of Hutton's views. Its admirably ordered presentation of facts, its luminous and persuasive conduct of argument, its restrained caution in the statement of theoretical propositions, its caustic yet courteous treatment of Hutton's adverse critics, and its pervading grace and elegance of diction have long since given to Playfair's treatise a place among the choicest classics of English scientific literature. It consists of two parts. Of these the first contains a broad and interesting outline of the whole geological system propounded by

Hutton; the second part is composed of a series of valuable notes, further explaining and developing various parts of that system, and containing original observations and deductions of Playfair's own, together with discussions of those published by other writers. This volume brought Hutton's "Theory of the Earth" within the comprehension and appreciation of even the most unscientific reader. It not only revealed to mankind what a genius had passed away in Hutton, but it traced out with admirable clearness some of the chief routes along which geology has since travelled, and it imparted to the infant science much of the impulse which has carried it to the position which it now holds in the circle of human studies.

In Playfair's glowing pages the excellences and the defects of his master's system are faithfully reflected. Never before had so eloquent and convincing a sketch been given of the co-operation of underground and superficial agencies in the decay and renovation of land, and in the perpetuation of the conditions that make this planet a habitable globe. No previous writer had set in so clear a light the sculpture of the land by the flow of rain and rivers across its surface. Nor had the proofs of the presence of abundant intrusive igneous rocks in the crust of the earth ever been so convincingly marshalled, and this too at a time when the doctrine of Freiberg everywhere prevailed that all these rocks have been deposited either as precipitates or as sediments on the floor of the sea.

His close personal association with Hutton had given Playfair a keen appreciation of the vivid interest of geological questions and of the nature of the evidence required for their solution. His own philosophical temperament enabled him to form a calm judgment of the relative value of the various lines of proof, and to trace with precision the limits within which deductions might be logically drawn from them. Moreover, his excursions into the field under the guidance of his master had given him a quickness and accuracy of observation which in the end made him an excellent field geologist, so that in his exposition of Huttonian principles he is able from time to time to appeal in their support to evidence which he has himself collected. His "Notes" are thus full of personal interest in their revelation of his extensive acquaintance with actual concrete examples of the phenomena described.

It was Playfair who first pointed out that "for the moving of large masses of rock, the most powerful engines without doubt which Nature employs are the glaciers," and who first maintained, in opposition to De Saussure's invocation of some great debacle, that the erratic blocks, scattered in such numbers over Switzerland, have been dispersed by glaciers and rivers (§§ 348–353). His reasoning against the appeal to some great cataclysm in explanation of such phenomena enabled him to sustain with much force Hutton's protest against the tendency to have recourse to "accidental and unknown causes." In a convincing argument he reviewed the hypothesis of Buffon and Pallas as to the distribution of abundant remains of large mammals over the plains of Siberia, and he showed that these remains cannot have been brought either by an inundation of the sea or by a deluge on land, but that the species of elephant, rhinoceros, and other animals inhabited these northern regions, where by their natural constitution they were fitted to endure the severity of the Siberian climate. "The rhinoceros of Wilui," he remarks, "certainly lived on the confines of the Polar Circle, and was exposed to the same cold while alive, by which, when dead, its body has been so long and so curiously preserved" (§ 417). He concluded his argument by suggesting that the crowded aggregates of these mammalian remains may have been connected with the migrations of the animals.

Another subject which has been much discussed since Playfair's time—the origin of lakes—did not escape his keen scrutiny of the surface of the land. It received from him a candid and cautious handling, which has not always been imitated by his successors in the discussion of this question. He recognised that "a lake is but a temporary and accidental" feature in topography, seeing that it is obviously being filled up by the unceasing transport of sediment into it from the surrounding ground, and hence that it must be "but modern compared with many of the revolutions that have happened on the surface of the earth" (§§ 319, 326). But when he tried to picture to himself the natural process whereby the lake has been formed, he had frankly to admit the difficulty of the problem. "Some cause," he remarks, "seems to act, if not in the generation, yet certainly in the preservation of lakes, with which we are but little acquainted" (§ 325). He suggests two possible modes of their origin. In the first place, they may arise from the solution and removal of such a soluble material as rock-salt, and he foretells that this must eventually happen in the salt district of Cheshire. He adds that some effect of the same kind may have taken place on the site of the Lake of Geneva, near to which salt-springs rise to the surface. In the second place, he points out that lakes may be produced by the unequal elevation and subsidence of land, whereby hollows arise on the surface which become water-filled basins (§ 327). There can be no doubt that both these suggestions indicate *veræ causæ* which have at different times and places given rise to lakes. Playfair evidently could not conceive that any natural agency can excavate basins out of solid rock. Though he had recognised the great transporting power of glaciers, he did not perceive that they also possess an erosive capacity which enables them to grind down, smooth, and polish the hardest rocks, and under peculiar conditions to hollow them into basin-shaped cavities, which on the retreat of the ice become tarns or lakes.

Like Hutton, Playfair exaggerated the influence of underground heat in the formation and consolidation of rocks. Thus he adopted and stoutly maintained his master's contention that flints and agates have been introduced in a molten condition into the rocks among which they are found. He never grasped the idea of the great solvent power of water and the permeability of rocks by aqueous solutions. Hence he deliberately rejected the proposition that consolidation of rocks may be brought about by infiltration (a proposition so well enforced by Lamarck), and he continued to invoke the action of subterranean heat, amounting sometimes to the point of fusion, even for such deposits as rock-salt.

Another serious defect in the Huttonian theory was strenuously upheld by its illustrator. Hutton had done good service by insisting upon the igneous and intrusive nature of many rocks in the crust of the earth, though some of the evidence on which he relied was fallacious. Having convinced himself that the sparry structure of limestone and other rocks and minerals points to the action of great heat within the terrestrial crust under so vast a pressure as to prevent the escape of the carbonic acid of the carbonates, he inferred that the kernels of zeolite, calcite, and chalcedony in the cavities of amygdaloids are a proof that these rocks have been injected in a molten condition into the crust, and never reached the surface. Playfair called them 'unerupted lavas,' and believed them to be distinguishable from superficial or truly 'erupted lavas' by their enclosed kernels of calcite and other minerals, which are absent from lavas poured out at the surface. He would not admit that any of these older masses could be true superficial lavas which might have been discharged over the sea-bottom and buried under later marine sediments. He quoted, only to reject, the just observation of Spallanzani that the amygdaloids of the Euganean Hills are true superficially ejected lavas, the steam cavities of which have been filled with minerals deposited by infiltrating water (§ 234). He was evidently much impressed by the singularly interesting and suggestive account given by Dolomieu of the intercalation of successive sheets of lava among the limestones of Sicily, but he would not admit that these lavas were poured out over the sea-bottom as "imagined" by Dolomieu. He did not see that by admitting the probability of ancient "submarine volcanoes" he would in no way have invalidated the proofs of intrusion demonstrated by Hutton, but would have obtained a new argument in favour of his master's doctrine of the continuity and antiquity of Nature's operations (§§ 242–244).

To Playfair belongs the merit of having first exposed the gross error of those Neptunists who, in support of their opinion that basalt is a rock which was deposited from solution in water, cited the basalt of Port Rush in the north of Ireland as containing fossil shells. His practised eye soon detected the source of the blunder, a dark shale containing ammonites having been mistaken for the basalt which had invaded and greatly indurated it.[1]

One of the most memorable "Notes" to the "Illustrations of the Huttonian Theory" is that in which the author, discussing the causes of the apparent changes in the level of the sea, maintains that on the whole it is the land which rises or sinks, and not the surface of the sea (Note xxi). It would be difficult to exaggerate the importance of this contribution to geological literature. Although

[1] Playfair's examination of the specimens from Port Rush was made in company with Lord Webb Seymour and Sir James Hall ("Illustrations," § 253).

Playfair's generalisation was no doubt too unqualified, seeing that he failed to recognise other influences which more or less affect the level of the sea, there can be no doubt that his argument, so cogently and temperately urged, at once introduced simplicity into the consideration of many geological problems which had up till then been involved in much confusion, and that in this way it greatly helped the onward advance of the science.

After the publication of his geological volume Playfair made many journeys in the British Isles and abroad for the purpose of visiting places of geological interest and of gathering materials towards the preparation of a new edition of that work. In particular, after the conclusion of peace, he undertook a prolonged journey on the Continent, and though then 68 years of age, he travelled through France, Switzerland, and Italy, as far as the volcanic region of Naples. He was absent from Scotland for seventeen months, and in his journeys travelled a total distance of some 4,000 miles. The quotations from his notebooks given in the brief biographical notice of him prefixed to the collected edition of his works are so replete with original and important observations as to fill us with the deepest regret that he never lived to embody them in an amplified re-issue of his admirable volume. Had he been able to accomplish his design, there can be little doubt that he would thereby have given a further impulse to the progress of the science which he loved and to which he devoted so large a part of the last years of his life.

In concluding this address I should like to point out how well the lives of the two distinguished men which we have now been tracing illustrate many of the distinctive aspects of scientific research. They show the fascination exerted by the study of Nature, and the devoted enthusiasm of those who give themselves up to this study and pursue it with a self-abnegation almost heroic in its indifference to everything but the establishment of the truth. Lamarck and Playfair were engaged in the investigation of the same problems, and had the political conditions of Europe at that time been more favourable they would doubtless have made themselves conversant with their mutual researches, and in all likelihood would have entered into correspondence with each other, if not into the personal relations which the Peace of Amiens had for a few months made possible.

Among the changes in the last century resulting from the remarkable development of facilities for travel, one specially worthy of remark has been the continual growth of sympathy and friendship among men of science in every part of the world. By their community of interest in the study of Nature these men are linked in a brotherhood of peaceful and serious work. For science belongs to no country, or rather she is the common heritage of every country. She knows no politics, and pursues her calm career under the most autocratic despotism as well as under the most democratic republic. She does not employ only one language, but makes her voice heard in the native tongue of every civilised land. Hence it has come about that those who cultivate science are perhaps the most cosmopolitan men in our modern world. They come from all corners of the globe to organise themselves in congresses for the purpose of discussing and promoting the subjects in which they have a common interest and in regard to which they can render each other mutual assistance. Their learned societies and academies rival each other in their generous recognition of the labours of foreign fellow-workers. If the Académie des Sciences in Paris inscribes in its roll of honour, as correspondents and associates, the names of the most distinguished men of science of all countries, the Royal Society of London does not lag behind in the choice of its foreign members and in the bestowal of its medals without respect of nationality.

Hence there cannot be any doubt that the desire to draw together the cultivated society of France and Great Britain in friendly and personal relations (which is the aim of the "Alliance Franco-Britannique, littéraire, scientifique, et artistique") has already long ago been accomplished by men of science. If these men on the two sides of the Channel are rivals, it is in the warfare against ignorance and in the noble task of building the vast temple of science which by their joint labours and those of their associates in other lands is slowly but surely rising in the midst of mankind.

Seeing, then, that as men of science we have experienced the inspiration and the pleasure of mutual co-operation with our fellow-labourers abroad in the same pursuits, we welcome with the heartiest cordiality the establishment and growth of sympathy and friendship between the peoples of France and of Great Britain. Most sincerely do we hope that the same spirit of mutual respect and active brotherhood which has so long reigned in the scientific world may spread through all ranks of society, until the two united nations shall be able to speak to the world with one single voice in the cause of liberty, of progress, and of peace.

To render even a feeble service towards the promotion of this great international movement of our time must be regarded as at once a duty and a pleasure. For myself, I am proud that permission has been granted to me to speak in behalf of such a cause in the halls of the Sorbonne, for so many centuries a favourite home of Philosophy and Science, and I am happy to avail myself of this opportunity of offering my tribute to the memory of the illustrious men who within these walls have created one of the intellectual centres of the world and have linked mankind together in ties of gratitude and admiration for the genius of France.

II.—On the Occurrence of the Genus *Dimyodon*, Mun.-Chalm., in the Mesozoic Rocks of Great Britain.

By Dr. K. A. Grönwall, of the Geological Survey of Denmark, Copenhagen.

When looking through the number of the Quarterly Journal of the Geological Society for August, 1905, I saw the paper by Mr. Richardson on the Rhætic deposits of Glamorganshire and his figure of *Plicatula intusstriata*, Emmr. At the first glance it struck me that this fossil was closely allied to a group of bivalves, well known to me as occurring in the Chalk, where it is represented by the genus *Dimyodon*, Munier-Chalmas.

In 1842 von Hagenow[1] described, under the name *Ostrea Nilssoni*, a bivalve shell found in the White Chalk of Rügen, attached to several other fossils, e.g., belemnites, oysters, and sea-urchins. Although he gave parallel diagnoses of this shell and *Ostrea hippopodium*, Nilss., he did not see the generic difference between his fossil and the oysters.

Later on, 1891, J. Böhm[2] referred *Ostrea Nilssoni* to the genus *Dimyodon*, Mun.-Chalm., and in the same year Stolley[3] described a new species, as also did I myself in the year 1900,[4] then figuring the three Danish species that all occur rather commonly in the Chalk of North-Western Germany and Denmark, *D. Nilssoni*, von Hag., *D. Böhmi*, Stoll., and *D. costatus*, Grönw.

This group of fossils also occurs in the British Chalk. *D. Nilssoni* was in the year 1864 described by S. P. Woodward[5] under the name *Plicatula sigillina*, S. P. Woodw. H. Woods, in his recent monograph of the British Chalk Bivalves,[6] having in the description of 1901 (Pt. iii, p. 143; pl. xxvi, figs. 19–22) used S. P. Woodward's name, in an addition of 1903 (Pt. v, p. 225) altered it into the current name, *Dimyodon Nilssoni*.

When writing the note on *Dimyodon* in 1900 I found in the collections of the Museum of Copenhagen some British specimens of *D. Nilssoni*, v. Hag., and also one of *D. Boehmi*, Stoll., fixed on a *Micraster cor-testudinarium*.

During a visit to England in the Summer of 1905 I saw in the British Museum, besides several specimens of *D. Nilssoni* from various localities, one specimen of *D. Boehmi*, or a closely allied form, fixed on an *Echinocorys* from the Upper Chalk of Gravesend, Kent, and of Grays, Essex.

In the collections in Copenhagen I had also seen some specimens of this genus from the Jurassic fixed on other fossils of greater importance and themselves never determined. In the Geological Museum of Bath some specimens of *Dimyodon*, growing on a *Lima* from the Lower Lias, attracted my attention. They were labelled *Plicatula intusstriata*, and the localities were Shepton (Somerset), Southerndown and Bridgend (Glamorganshire). There was also a smaller species of *Dimyodon* fixed on a *Lima* from the Upper Lias. I had no opportunity of an examination, but only surveyed them as they were exhibited in the show-case.

Later on, in the paper of Mr. Richardson[7] I met with the excellent figure of the *Plicatula intusstriata*, Emmr., clearly proving

[1] Neues Jahrb. f. Min., 1842, p. 546.
[2] Palæontographica, vol. xxxviii (1891), p. 89, pl. iv, fig. 7.
[3] Mitth. Min. Inst. Univ. Kiel, vol. i (1891), tome vii, p. 243, pl. vii, fig. 8.
[4] Medd. dansk geol. Foren., No. 6 (1900), pp. 73–80, pl. ii, figs. 1–8.
[5] Geol. Mag., Vol. I (1864), p. 112, Pl. V, Figs. 1–5.
[6] A Monograph of the Cretaceous Lamellibranchia of England (Palæont. Soc., 1899–1903).
[7] Q.J.G.S., vol. lxi (1905), p. 423, pl. xxxiii, fig. 1.

that this fossil belongs to *Dimyodon*, as this genus is represented by the above-mentioned Cretaceous species.

As it is obvious that this series of forms is widely distributed in the Jurassic rocks of Great Britain, as well as in the Cretaceous, I wish to call the attention of British geologists to these fossils. It would be a promising task to subject the genus and such allies as may hide among the numerous obscure *Plicatulæ* and *Ostreæ* to a thorough revision, but as I have neither the necessary time nor material and literature at my disposal I will only give some hints on this matter.

The genus *Dimyodon* was established by Munier-Chalmas in the "Manuel de Conchyliologie" of Fischer, 1887, p. 937, and its type is *D. Schlumbergeri*, Mun.-Ch. (l.c., fig. 705), from the Bathonian of Hérouvillette. Fischer considers *Dimyodon* as a subgenus of *Dimya* Rouault, but Zittel[1] seems to regard these two genera as identical.

I am inclined to place the following species in the genus *Dimyodon*, but, as already mentioned, this enumeration in no way claims to be complete.[2]

A.—Jurassic.

1. *D. intusstriatus*, Emmr. A very widely distributed species in the Rhætic and the Lower Lias. In the Alps it was first found and therefrom described by Emmrich[3] (the "Kössener Schichten" of the Northern Alps). Its distribution in France is unknown to me, but Mr. Jean Miquel, of Barroubio par Aiguesvives, has kindly communicated to me a specimen from Villespanans (Hérault) from the *Avicula contorta* zone. As to its distribution in Great Britain, I am indebted to Mr. Richardson for very minute records; *D. intusstriatus* has its maximum in the White Lias, but ranges from the *Avicula contorta* zone to the *Bucklandi* zone. Mr. Richardson has found it in Devon, Somerset, S. Gloucestershire, and Glamorganshire. According to R. F. Tomes[4] it occurs also in Warwickshire.

2. *D.* (?) *retifer*, Eudes-Deslongchamps. Mr. Miquel communicated to me a specimen of this fossil (which I only refer to this species on the faith of his determination) from the Upper Bathonian of France, "falaise de St. Aubin sur mer, Calvados." It was determined as a *Plicatula*, but there is no doubt of its belonging to *Dimyodon*.

3. *D. Schlumbergeri*, Munier-Chalmas. This species, the genotype, is found in the Bathonian of Hérouvillette, France, and is figured in Fischer's "Manuel de Conchyliologie" (l.c.).

4. *D. striatissimus*, Quenstedt,[5] from the Malm of Germany, White Jura γ.

[1] "Grundzüge d. Paläontologie," Zweite Auflage, 1903, p. 292.

[2] Besides that some species may be concealed among *Plicatulæ* and *Ostreæ*, I may here mention that Mr. Munier-Chalmas in 1897 told me, in a letter, that there were still some undescribed Jurassic species of *Dimyodon*.

[3] Jahrb. d. k. k. geol. Reichsanst., vol. iv (1853), p. 376.

[4] Q.J.G.S., vol. xxxiv (1878), p. 182.

[5] "Der Jura," 1858, p. 628, pl. lxxviii, fig. 4. The author also figures a *Plicatula* sp. (pl. lxxviii, fig. 5) from the White Jura β; it belongs to *Dimyodon*.

B.—Cretaceous.

5. *D. Boehmi*, Stoll.[1] This widespread species occurs in the Senonian of Northern Germany, Denmark, and England, and is also found in the Danian at Faxe, Denmark.

6. *D. costatus*, Grönw.[2] Common in the Senonian of Denmark, Sweden, and Northern Germany; also found in France, at Meudon. In the Danian there is found a form that in some points differs from that of the Senonian.

7. *D. intusradiatus*, Gümbel.[3] Upper Chalk of the Bavarian Alps.

8. *D. Nilssoni*, v. Hag.[4] This species has a very great extension vertically as well as horizontally. It ranges from the Upper Gault of Folkestone to the Danian of Denmark. It occurs abundantly in the Chalk of England, Northern France, North-Western Germany, the Northern Alps, Denmark, and Sweden.

As to the systematic position of the genus *Dimyodon* as here defined, authors are not quite in agreement, mainly because these fossils occur in a rather imperfect state of preservation, and because the free valve is but rarely found. The cardinal parts of the shell are commonly—as a rule in the young ones—inconspicuous and obliterated, while the muscular impressions, in the Cretaceous forms at least, are almost unknown. The ridge-formed teeth, however, sufficiently prove the hinge mechanism to be isodont and these fossils to be allied to the Spondylidæ.

Some authors [5] have considered *D. Nilssoni* to belong to the genus *Cyclostreon*, Eichwald,[6] the type of which is the *Ostrea plicatuloides* of Leymerie.[7] According to the rather obscure description, the genus *Cyclostreon* is characterized by the absence of proper cardinal teeth and muscular impressions, in place of which there is a horseshoe-shaped impression which serves for the reception of ligament and the junction of the valves.

This interpretation may be the right one for the original species, *O. plicatuloides*, Leym.; but for the fossils here mentioned I may deny the possibility of assigning them to the genus *Cyclostreon* as defined by Eichwald. Frauscher [8] has in the genus *Cyclostreon* associated some most heterogeneous species, among which two species of *Dimyodon*, *D. intusstriatus*, Emmr., and *D. intusradiatus*, Gümb., are to be found.

The Cretaceous species of the genus *Dimyodon* form a well circumscribed and strictly defined group, and, so far as I know the Jurassic species, it seems to me that the same will apply to them.

[1] Stolley: loc. cit. Grönwall: loc. cit., fig. 8.
[2] Grönwall: loc. cit., figs. 4–7.
[3] Palæontographica, vol. xxxviii (1891–2), p. 88, pl. iv, figs. 2*a*–*e*.
[4] Grönwall: loc. cit., figs. 1–3. Woods: loc. cit.
[5] Vogel, 1895: in Sammlungen d. geol. Reichsmuseum zu Leiden, neue Folge, herausgegeben v. K. Martin, vol. ii, tome 1, p. 14, pl. i, figs. 4–7. Wegner: Zeitsch. d. deutsch. geol. Gesellsch. Jahrg., 1905, p. 175.
[6] Lethæa rossica, vol. ii, pp. 406–7.
[7] Mém. Soc. géol. France, sér. ii, tome iv (1851), p. 195, pl. ix, figs. 17*a*–*e*.
[8] Denkschr. k. Akad. Wiss., Math. Nat. Cl., vol. li; Wien, 1886.

III.—On the Relation between the Older and Newer Palæozoics of West Cornwall.[1]

By J. B. Hill, R.N., of the Geological Survey.

(PLATE XIV.)

Introductory.

The author, who has long been engaged on the Palæozoics of West Cornwall, divided the killas extending westward from Gerrans Bay into four groups that formed a natural sequence.[2] Moreover, as they included definite Lower Silurian horizons, as characterized by the fossiliferous quartzite of Carne, these divisions were linked with the Lower Palæozoics. They consist of the Veryan, Portscatho, Falmouth, and Mylor groups. On the latest issues of the old Survey maps the area occupied by the first of these divisions is coloured as Silurian, and the region occupied by the remainder as Devonian. That colouring, however, was not adopted by De la Beche, who surveyed the region, nor was it the result of any subsequent survey of the area. In the original Geological Survey map of Cornwall the killas was separated by De la Beche into two divisions, viz., a grauwacke group and a carbonaceous series. Thus, the former lying below the Culm-measures was undifferentiated for the reason, as explained in his Report,[3] that the progress of geology at that time only warranted the broadest generalizations. He moreover expressed the opinion that the terms Cambrian and Silurian should be restricted to the areas that gave rise to the prolonged researches of Murchison and Sedgwick, and deprecated the extension of that nomenclature to districts that had not received the same detailed investigations. In a later and undated issue of the map the grauwacke group is divided into Devonian and Silurian, presumably by the authority Sir Roderick Murchison. The Devonian colour was not only applied to fossiliferous strata in East and Mid Cornwall, but was extended over the unfossiliferous strata in the west. The Silurian tint, on the other hand, was restricted to a zone that had yielded organic remains. Murchison, however, was of opinion that the older zone extended far beyond those limits into the barren strata coloured as Devonian,[4] and it is evident that the latter tint was adopted as a matter of convenience, as no re-examination of the area seems to have been undertaken. The known Silurian region was confined to the coastal belt between Chapel Point and Gerrans Bay, a boundary connecting those localities admitting of the ready isolation of that zone from the rest of the country. That such a broad generalization, however, was only regarded as provisional may be inferred from the absence of a line on the map between the two divisions. It will be seen, therefore, that the subdivision of the killas, as the result of the

[1] Communicated by permission of the Director of the Geological Survey.
[2] Summary of Progress, 1898, p. 97, and Trans. Roy. Geol. Soc. Cornwall, vol. xii (1901), pt. 6.
[3] "Report on the Geology of Devon, Cornwall, and West Somerset," pp. 38–41.
[4] Trans. Roy. Geol. Soc. Cornwall, vol. vi, p. 322.

recent survey, neither invalidates the map published by De la Beche nor the subsequent conclusions of Murchison. It has, on the other hand, not only brought their generalizations within more definite limits, but has carried the investigation a step farther by demonstrating the relations between the older and newer Palæozoics of Cornwall.

As the lithological characters, the structural features, and the mutual relations of the divisions into which the killas has been differentiated have already been the subject of former communications, both to the Royal Geological Society of Cornwall[1] and to the Summaries of Progress of the Geological Survey,[2] they will only be treated briefly in this paper. They will, moreover, be fully described in the Survey memoirs, but, as the results of recent investigations constitute an important advance in the elucidation of the geology of the West of England, it will be convenient to present at once an outline of these conclusions, as the official publications will not be immediately forthcoming.

The main object of this paper is to demonstrate the existence of an important unconformity dividing the Upper and Lower Palæozoic formations of West Cornwall. Evidence will also be submitted pointing to the natural sequence of the four divisions of the Lower Palæozoics, and to the Lower Devonian age of the conglomeratic series of Manaccan and Grampound.

Lithology of the Lower Palæozoic divisions.

The lithological characteristics of the divisions will now be briefly touched upon.

Veryan Series.—This group consists of blue and grey slate with sandy alternations, thin dark limestones, and dark-coloured cherts. Notwithstanding the occurrence of chert and limestones the sandy interlaminations are frequently coarse, but being largely composed of soft grains are readily cleaved. This series, which also includes the Carne quartzite, is further characterized by the presence of manganese, which stains the slate.

Portscatho Series.—These consist of blue and grey clay slates, alternating with harder beds showing every gradation from a sandy slate to a fairly strong grit. The latter are characterized by the predominance of quartz and the comparative abundance of clastic mica. The marked feature, however, which distinguishes them from the Veryan Series is the absence of limestone, except at their mutual junctions. This dearth of calcareous material also applies to the Falmouth and Mylor divisions.

Falmouth Series.—This series consists of argillaceous and fine sandy alternations, varying in colour from green to grey and buff, although blue argillaceous beds sometimes appear. The contrasting tints produce a variegated appearance common to this group. Their mode of decomposition is equally characteristic. The sandy seams become readily friable, are unctuous to the touch, and weather into

[1] See paper already cited.
[2] From 1897 onwards.

a deep buff colour. The material is of finer texture than the Portscatho Beds, and the coarse structure often seen in the latter is not represented. The presence of zones of strongly contrasted purple and green slate is likewise a distinctive characteristic of this group.

Mylor Series.—This division consists of blue argillaceous and fine-textured sandy beds. The latter are often very siliceous, and occasionally thin quartzites are developed. The most distinguishing feature of this series is its striped and ribbon-like appearance, due to fine alternations of siliceous and argillaceous material, or to argillaceous laminæ varying in composition and colour. This composite structure, while a marked characteristic of this division, is frequently developed both in the Portscatho and Falmouth divisions. In this series it has often contributed to the production of pseudo-conglomerates, following conditions of stress.[1]

Natural sequence of the Lower Palæozoic divisions.

The four divisions already referred to pass uninterruptedly into one another without any stratigraphical break. The junction between the Veryan and Portscatho groups is well exposed at Pendower in Gerrans Bay. Although the two groups there occupy adjoining horizons, and the former are coloured as Silurian and the latter as Devonian in the old map to which attention has been drawn, their natural sequence is demonstrated by the gradual dying out of the Veryan limestones to the west, and which are still represented in an attenuated form within the Portscatho Series, thus serving as a connecting link between the two groups. Not only do the Veryan Series pass uninterruptedly into the Portscatho group, but these latter also graduate imperceptibly into the Falmouth Series, which in their turn merge insensibly into the Mylor Beds. Notwithstanding the comparative absence of palæontological data the researches of Mr. Howard Fox and Dr. Hinde on the Radiolaria tend to confirm the unbroken sequence of these deposits. The Radiolarian remains have been determined by Dr. Hinde from localities scattered throughout these divisions, but these organisms have not been detected on any known Devonian horizon. Besides Radiolaria, Crinoidal and other fragments are occasionally found in these divisions,[2] but their occurrence is extremely rare. The quartzite of Carne in Gerrans Bay, which has yielded Caradoc fossils, was included within the Veryan Series, as it appeared to fall naturally into that division.[3] The detailed investigation of that area has been subsequently undertaken by Mr. Reid, whose results do not invalidate that sequence.

Relations of the Newer and Older Palæozoics in the Manaccan area.

Having now given a brief outline of the Lower Palæozoic divisions, in so far as they have been investigated by the author,

[1] An account of these structures will be found in the Trans. Roy. Geol. Soc. Cornwall, vol. xii (1901), pt. 6.
[2] Excluding the Carne quartzite.
[3] J. B. Hill: Trans. Roy. Geol. Soc. Cornwall, vol. xii (1901), pt. 6.

their precise relations with the Devonian formation will now be discussed. While engaged last season on the survey of the tract bordering the Helford basin, the killas was carried south to Porthallow and westward as far as Tregidden. At Porthallow a fault divides the killas on the north from mica-schist on the south. The rocks lying to the south of that disturbance are not dealt with in this paper.

The sedimentary divisions from the Carnmenellis granite, on the north-west, to Porthallow on the south-east, occur in the following topographical order:—

Mylor Series.
Falmouth Series.
Portscatho Series.
Manaccan Series.
Veryan Series, including the Quartzite.

Of these groups the Manaccan Series represents the Newer Palæozoic,[1] and the remainder are confined to the Older Palæozoic. The strike of the latter is about north-east and south-west, while that of the former is slightly oblique and approximates to an east and west direction.

The Mylor Series, through which the granite has intruded, occupies a band gradually widening in a south-westerly direction from Porthnavas to Gweek. Excellent coast sections across the entire band are afforded by Polwheveral Creek, showing the whole metamorphic aureole as well as the zone beyond.

The Falmouth division that succeeds to the south-east forms a narrow band, but widening likewise in a south-west direction. It extends from Mawnan Smith to Mawgan Creek, and is almost entirely confined to the north side of Helford River. Besides the main zone, infolded lenticles occur in the vicinities of Helford, Durgan, and Bream Cove. Excellent transverse sections are exhibited along the coast at Calamansack.

The Portscatho Series succeeds the Falmouth group to the south-east and forms the coastline as far south as St. Anthony. To the westward it practically monopolises the southern side of Helford River, and the northern shore as far as Porthnavas Creek. It also reappears as a small strip at Porthallow, where it is separated from metamorphic rocks of the Lizard type by a fault.

The Manaccan Series.—The natural sequence represented by these three Lower Palæozoic groups is now broken, and another assemblage makes its appearance, which may be designated the Manaccan Series. It rests unconformably on the Portscatho and the Veryan divisions (including the Carne quartzite), and is largely made up of their detritus. The group occupies a band extending westerly from the coast at Nare Point, whence it has been mapped, as far as St. Martin. Passing to the north of Manaccan it is seen along the shores of Gillan Creek, and around the Nare Point to a little beyond the Nare Head. Its southern margin from the coastline to Treglossack skirts the Veryan Series, and thence to the

[1] The evidence in support of this assumption will be given later.

westward is in contact with the Lizard group. Besides this main outcrop small infolds also occur amongst the Veryan Series. Lithologically, the group consists of conglomerate, sandstone, and clay slate, the two latter being often calcareous, and they are all so clearly interbedded that their natural sequence is obvious. The most important member is undoubtedly the conglomerate, from the evidence it affords of the derivation of the group. Its character and main constituents have been given in a former publication,[1] since which it has yielded chert, mica-schist, and possibly serpentine. The latter ingredient, however, being obtained from a road section, the evidence is possibly not conclusive. At its northern margin, where the conglomerate is in close relation with the Portscatho Series, it is almost entirely composed of fragments derived from that group. This is admirably exhibited at Gillan harbour, where the magnitude of the boulders, often exceeding a foot in size, enables their ready identification with the Portscatho Beds in their immediate vicinity, in which practically every type of the latter is seen to be incorporated. The fact, moreover, that the fragments were veined with quartz prior to such incorporation sufficiently indicates the magnitude of the break represented by this unconformity. The conglomerate is likewise seen in contact with the Portscatho Beds on the coastal shelves at Men-aver Point and Nare Point. It has been remarked that the conglomerate varies with the nature of the underlying rock from which it is derived. Whereas at Gillan Creek, where it rests on the Portscatho Series, fragments of that group preponderate, as the Veryan Series and quartzite horizons are approached it partakes more of the character of those types, and the foreign fragments derived from the Lizard rocks increase in a similar direction. The conglomerate is by no means continuous, but the base of the formation is frequently of fine texture. This is shown by the protruding bosses of quartzite, some of which are encircled by the sandstone beds of the Manaccan Series. There is, moreover, a tendency for the coarser deposits to die out in a westerly direction, as was long ago recorded by De la Beche,[2] the frequent absence of which presents difficulties in the demarcation of the Manaccan Series from the older Palæozoics that underlie them, and especially where good sections are not available.

The Manaccan Series present a less advanced type of metamorphism than that of the Lower Palæozoic divisions amongst which they occur. This difference in deformation between the older and newer Palæozoics, although not always of a very marked type, was early recognized by the author as a significant factor, more especially in the comparison of the killas of Mid Cornwall with that occupying the western regions, which pointed to the conclusion that the latter represented conditions of stress that were either not experienced by the former or prevailed in a less vigorous degree. In the Manaccan area this contrast is admirably illustrated by the comparatively unaltered condition of the clay slates associated with the

[1] J. B. Hill: Trans. Roy. Geol. Soc. Cornwall, 1901.
[2] "Report on the Geology of Cornwall, Devon, and West Somerset," 95.

conglomerate and the more advanced type of deformation represented by the adjoining Portscatho and Veryan divisions. Mr. John Pringle has obtained numerous plant remains from these rocks, together with a few corals and brachiopods, but beyond indicating a marine fauna they throw no light on their geological age. The argillaceous members were searched for graptolites, but without success.

The Manaccan Series is also characterized by the presence of a basic lava that occupies a well-marked horizon between Roskruge and Tregidden. Its contemporaneous nature is clear, not only from its having been involved with the coarser deposits, and frequently partaking of a conglomeratic margin, but scoriaceous boulders clearly derived from it have been incorporated with the adjacent conglomerate. The rock is a very fine-grained basalt, often andesitic, and belongs to the 'pillow lava' class. As this rock is the sole greenstone in West Cornwall that can be definitely separated from the intrusives, it is possible that the contemporaneous greenstones are restricted to the Devonian.[1] Moreover, its comparatively undeformed condition still further illustrates the less advanced metamorphism presented by the Devonian rocks to that of the Lower Palæozoics.

The Veryan Series of Meneage.—The quartzite is almost entirely hidden beneath the Manaccan Series, through which it emerges in numerous lenticles from Penare on the east to Trevaddra on the west. Besides being veined with quartz it is often extremely brecciated, but in this condition loses nothing in compactness, the interstices being filled up with silica. This character was attained prior to the formation of the overlying conglomerate.

The Veryan Series is exposed along the coast from a little north of Nare Cove to Porthallow Cove, whence it extends inland as far as Treglossack, and is there overlain by the Manaccan Series. This small tract is highly disturbed, while local thrusts and brecciation with production of pseudo-conglomerate are prevalent, and it is, moreover, not solely confined to the Veryan group. The quartzite appears between Nelly's Cove and Porthallow Cove. Thin limestones are seen from Nelly's Cove to Nare Cove. Radiolarian cherts are distributed over the section, and are strongly developed at Nelly's Cove. The Portscatho Series and strips of the overlying conglomerate can also be detected, more especially at the south of Porthallow Cove, where the former is contiguous to the Lizard group. It is probable also that this highly disturbed tract may contain representatives of other zones,[2] but the Veryan Series undoubtedly preponderates. At Gallentreath, between Nelly's Cove and Porthallow Cove, a greenstone of pillow lava type is seen that recalls the pillow lava of Mullion Island. Another highly silicified igneous rock that is closely adjacent resembles a similar band mapped by Mr. Reid at Perhaver. Like the rock at Mullion Island, the Gallentreath

[1] The evidence pointing to the Devonian age of the Manaccan Series will follow.

[2] Geol. Mag., 1904, No. 481, in which Mr. C. D. Sherborn has referred fossils obtained from this district to Ludlow age.

greenstone is in close proximity to Radiolarian cherts, but the evidence is insufficient to decide whether it is intrusive or contemporaneous.

The Devonian base on the Grampound and Probus horizons.

The evidence obtained from the Manaccan area, where the Upper Palæozoic rocks occur as a great outlier amongst the Lower Palæozoic group, has thrown light on the nature of the junction further to the north that marks the main boundary between those formations. The fine-grained conglomerate of Grampound and Probus was recognized in 1902 as the equivalent of the conglomerate of the Manaccan Series. This inference was amply confirmed by microscopical determination undertaken by Dr. Flett. It contains a similar assemblage of rock fragments, resembling one another so closely as practically to preclude the possibility of their derivation from different sources, or from the same source at widely different periods. It was at the same time recognized that it might represent an unconformity between the Silurian and Devonian rocks of Cornwall, an inference which the recent detailed investigation of the Manaccan area has shown to be correct. This fine-grained conglomerate is associated with slightly calcareous sandstones and clay slates, and the whole assemblage is precisely equivalent to that represented by the Manaccan Series, except that in the latter, besides the fine-grained conglomerates like those of Probus and Grampound, these beds frequently present an extreme coarseness, many of the included boulders exceeding a foot in size. As already remarked, the conglomerate of that area is by no means continuous, but the base of the formation is frequently of fine texture. There is, moreover, a tendency for the conglomerate to die out in a westerly direction, so that the demarcation of the Manaccan Series from the older Palæozoics is attended with difficulty in the cultivated areas. These conditions are exactly reproduced in the Probus horizon. The coarse conglomerates, analogous to those of Manaccan, occurring only in the district further to the east, where they have been mapped by Mr. Reid in the Gorran Sheet (353), while in the western direction towards the Bristol Channel even the fine-grained conglomerates of Probus and Grampound disappear. The rock series of Probus likewise corresponds in strike with that of Manaccan, having a general east and west trend and oblique to that of the adjoining Lower Palæozoic strata. The southern boundary extends from Porth Towan on the west to Probus on the east, whence it has been traced by Mr. Reid to the north of Tregoney, where it sweeps to the south, and thereafter follows an irregular course to the coast at St. Michael Caerhayes.

The Grampound and Probus Beds have hitherto yielded no organic remains except at Ladock, where an indeterminable brachiopod has recently been discovered. To the north, however, the work of Messrs. Reid and Scrivenor shows that they link on with Lower Devonian fossiliferous horizons in the Newquay district. They, moreover, have close affinities to the Devonian, not only in their prevailing strike, but also in lithological type and metamorphic condition. For these reasons they are taken to represent the basement beds of that formation.

Relative deformation of the Older and Newer Palæozoics.

It has already been pointed out that the Lower Palæozoic rocks exhibit a greater degree of deformation than do the overlying Devonian. It can be shown by the included boulders in the Devonian conglomerate that the Caradoc quartzite was brecciated and the interstices cemented by silica prior to their incorporation in that deposit. It has likewise been shown from the same evidence that the Portscatho Beds had been welded into solid rock and veined with quartz before the formation of that conglomerate. The Lower Palæozoic beds, therefore, must have been buried deep within the crust and compressed into solid rock, and subsequently upheaved to form the floor of the Devonian seas. At the close of the Carboniferous period these rocks, in common with the overlying Devonian, were again brought within the influence of crustal disturbance, by which they were folded, fractured, and cleaved. As a result of this twofold experience in the subterranean depths almost all traces of organic life appear to have been obliterated. So far as the Mylor, Falmouth, and Portscatho divisions are concerned, and even the Veryan Series if we exclude the quartzite, the sole relic of life that has survived, except an occasional crinoid fragment, is confined to the Radiolaria, the preservation of their casts being in no small measure due to the minuteness of these tiny creatures, and to the siliceous nature of the cement in which they are usually encased.

Age of the Lower Palæozoic divisions.

The age of the Lower Palæozoics cannot be precisely defined. The Quartzite is of Lower Silurian age, and palæontologists are agreed that the fauna is Caradoc.[1] If its inclusion in the Veryan group be correct—and there is no evidence at present pointing to a discordance in the sequence—there is a natural succession from the Quartzite on the one hand to the Mylor Series on the other. The discovery of Upper Silurian fossils by Messrs. Upfield Green, Sherborn, and Reid in areas closely adjoining to the Caradoc Quartzite would appear to indicate a downward succession, of which the Mylor Series represents the base, and that the Lower Palæozoic divisions referred to in this paper are Lower Silurian. As the survey, however, of the older Palæozoics in the Meneage peninsula has not yet been completed, it will be safer to defer further consideration of this subject until the evidence has been exhausted. It will be sufficient for the present to have demonstrated the limits of the Devonian, and to have shown that the killas of West Cornwall is chiefly restricted to the Lower Palæozoics, of which at least one member is of Caradoc age.

[1] The Lower Silurian age of this quartzite was proved by the late Mr. Charles W. Peach, to whose palæontological researches Cornish geology owes so much. Murchison noted that the Gorran fossils were Upper Caradoc, and those of Gerrans Bay (Carne quartzite) were even younger (Trans. Roy. Geol. Soc. Cornwall, vol. vi).

Work of other observers in the district.

The geological literature of West Cornwall is so voluminous that it would be impossible within the compass of this paper to do justice to the work of previous observers. In 1821 the Nare Point conglomerate was referred to by Sedgwick, who noted its mechanical origin and its passage into the ordinary grauwacke of the district.[1] It is evident from a perusal of De la Beche's Report, that had he differentiated the Silurian strata from the Devonian, he would have included among the former some of the killas in the Meneage peninsula. As already remarked, Murchison expressed the opinion in 1846 that much of the strata between Gerrans Bay and Falmouth would prove to be of Silurian age. The killas of West Cornwall has formed the subject of various papers by Mr. J. H. Collins, whose researches, extending over many years, prove the zeal and enthusiasm with which he attacked this thorny problem. In 1881 Mr. Collins published a sketch-map with his paper on the Geology of Central and West Cornwall,[2] in which he not only divided the killas into numerous units, but assigned them respectively to the Devonian, Upper Silurian, Lower Silurian, and Cambrian formations, that were separated from each other by unconformities. Although Mr. Collins' general conclusions cannot be sustained, he subsequently correlated the conglomeratic series of Meneage with the Ladock Beds (the latter being, in part at least, equivalent to the Grampound and Probus grits), and assigned them to the Lower Devonian.[3] He recognized also that the killas of West Cornwall was mainly of Lower Palæozoic age, and had he confined himself to that broad generalization his paper would have ensured a more lasting recognition. He also placed the Ponsanooth Beds, which to some extent represent the Mylor Series, at the base of the killas, which may probably be correct. Mr. A. Somervail[4] controverted some of Mr. Collins' conclusions, but agreed with him as to the Pre-Devonian age of a large part of the killas, and assigns a Lower Silurian age to the slates from Gerrans Bay to the vicinity of Penryn, most of which had been similarly classified by Mr. Collins, and Mr. Somervail suggested that they were of Llandeilo age. In 1891 Mr. Ussher published a sketch-map with his paper,[5] dealing with the Devonian rocks as described by De la Beche and supplemented by his own researches on that formation. In that map Mr. Ussher has likewise shown the western killas (now representing the Mylor, Falmouth, and Portscatho Series) as (?) Pre-Devonian, and has placed the Grampound grits at the base of the series classed as undoubted Devonian. Mr. Upfield Green has claimed the beds represented by the Mylor, Falmouth, and Portscatho Series as Lower Devonian, of which the Dartmouth slates represent the upper member, while the base is marked by the conglomerate

[1] Trans. Cambridge Phil. Soc., vol. i.
[2] Journ. Roy. Inst. Cornwall, vol. vii, p. 17.
[3] Journ. Roy. Inst. Cornwall, vol. viii, p. 186.
[4] Journ. Roy. Inst. Cornwall, vol. vii, pp. 262–273.
[5] Trans. Roy. Geol. Soc. Cornwall, 1891.

of Meneage, etc.[1] Mr. Green's conclusions were criticized by Mr. Ussher, who contended that the superposition of the Dartmouth slates to the Mylor, Falmouth, and Portscatho Series was not supported by proof.[2] Mr. Ussher recalled that although he formerly correlated the Grampound grits with the Gedinnien, he would now hesitate to do so, the inference apparently being that they might occupy a higher horizon. In that paper Mr. Green refers to the Portscatho and associated series as consisting "chiefly of grits varying much petrologically, but mostly felspathic," and correlates them with arkose or felspathic grits that occur next to the conglomerate on the Continent. As the conglomerate is now shown to be unconformable to the Portscatho Beds, it is of little importance to point out that the latter are more properly defined as siliceous grits, in which felspathic constituents play only a subordinate part, so that their correlation with the Continental arkose referred to cannot be supported on petrological grounds. In 1894 Mr. Clement Reid pointed out that towards Gorran Haven "shore conglomerates, belonging probably to upper part of Lower Devonian, rest directly on Ordovician or still older rocks."[3]

Finally, the researches of Mr. Howard Fox on the Radiolarian cherts of West Cornwall, and the assistance he has received in their determination by Dr. Hinde, must be referred to. Mr. Fox has shown that not only are these organisms confined to the horizon of the pillow lavas, which indicates such a remarkable association with Lower Silurian horizons in the south of Scotland and elsewhere, but he has proved their existence throughout the Silurian sequence of West Cornwall. The fact, moreover, that the most patient search has failed to detect their presence in the Devonian strata has furnished additional evidence in support of the differentiation of those systems in this region. On the assumption that the Old Red Sandstone was deposited in great inland basins it is possible that the British Devonian rocks, being so closely adjacent to the Welsh lake basin, were laid down in a partially enclosed sea like the Mediterranean, from which the oceanic organisms might have been almost entirely excluded.

Summary and Conclusion.

The main conclusions may be epitomised as follows :—

1. The Lower Palæozoic divisions, including the Veryan, Portscatho, Falmouth, and Mylor groups, form a natural sequence.
2. The Upper Palæozoic, represented by the Manaccan Series, rests unconformably on the Lower Palæozoics, and its constituents have been largely derived from the Veryan and Portscatho groups.
3. The Veryan and Portscatho groups were consolidated and veined with quartz, prior to their denudation and incorporation in the Manaccan conglomerate.

[1] Geol. Mag., 1904, p. 403.
[2] Geol. Mag., 1904, p. 590.
[3] Summary of Progress of Geological Survey for 1904, pp. 22–23.

4. The Manaccan Series are repeated on the horizons of Probus and Grampound, from which they extend across the county to either coast.

5. The Manaccan Series represent the basement beds of the Lower Devonian, and the Lower Palæozoic groups include Lower Silurian of Caradoc age, but whether the succession is ascending or descending has not been definitely proved, although the evidence suggests a descending sequence.

Before concluding, it may be remarked that the facts, herein presented, involved such a complete change in the colouring and interpretation of the old geological maps that a special investigation of the evidence on which the conclusions are based was undertaken at the request of the Director by Mr. H. B. Woodward and Mr. Clement Reid. As the result of that investigation they were satisfied that the conglomerate was partly derived from the underlying Veryan and Portscatho Beds, and that those groups, together with the associated Falmouth and Mylor Series, are of Pre-Devonian age. The conclusions, therefore, which form the subject of this communication not only embody the opinions of the author, but command the support of his official superiors of the Geological Survey.

EXPLANATION OF PLATE XIV.

Sketch-map to illustrate the geology of the Manaccan district.

IV.—Fossil Echinoidea from Sinai and Egypt.

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(PLATES X and XI.[1])

THE collections of Echinoidea described in the following report were made by Messrs. Barron, Beadnell, and Hume during their work for the Egyptian Geological Survey, and were entrusted to me for description by the Director, Captain Lyons, R.E.

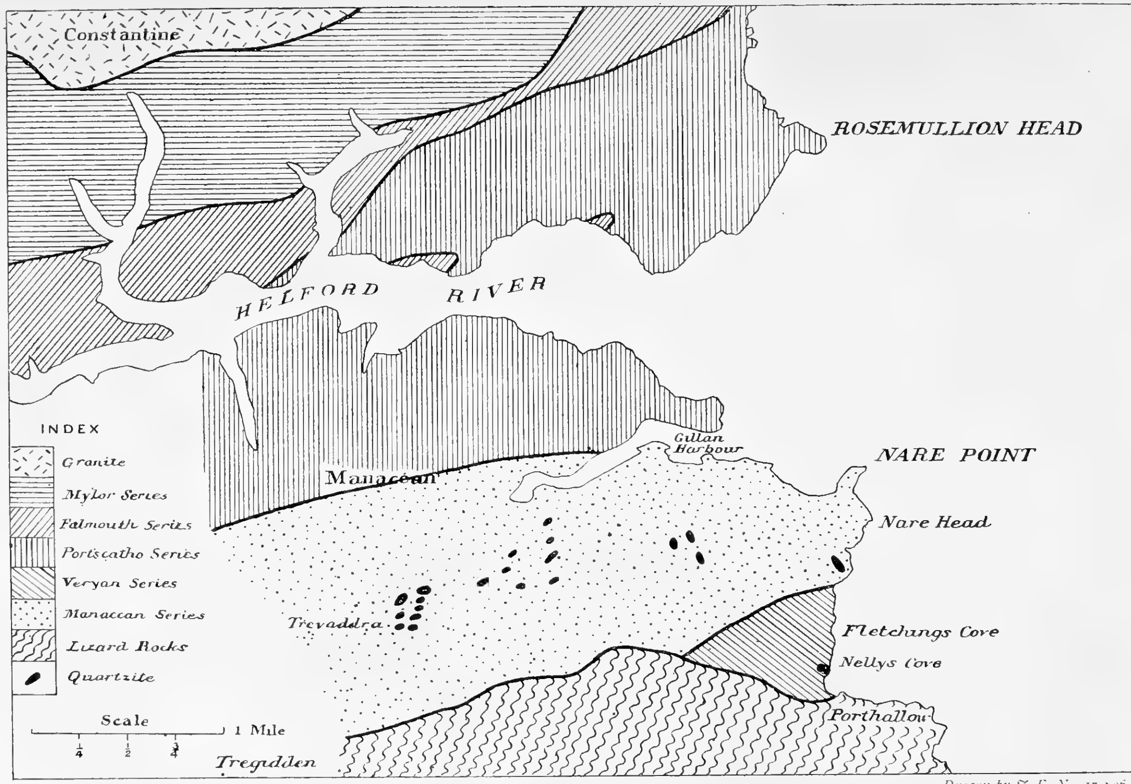
The collections belong to three main series—(1) Cretaceous, (2) Eocene and Miocene, and (3) Pleistocene. The Cretaceous Echinoids come from the massif of Abu Roash, and from Sinai. The specimens from Abu Roash were collected by Mr. H. J. L. Beadnell, and mostly came from the eastern end of the massif near the village of Abu Roash. The best known fossil from this horizon is *Coptosoma abbatei* (Gauth.), and the bed from which it comes has been assigned to both the Cenomanian and the Turonian. The sections published by Fourtau[2] show that the beds belong to the older part of the Cretaceous massif of Abu Roash; but he places the *C. abbatei* beds in the Turonian[3] or Lower Senonian.[4] Walther,

[1] [Plate XI will appear with the second part of Professor Gregory's paper in the June Number of the Geological Magazine.—Editor.]

[2] Fourtau: Notes E'ch. foss. E'gypte, 1900, p. 17.

[3] Fourtau: ibid., p. 21; and Crét. massif Abu Roash, C.R., vol. cxxxi (1900).

[4] Fourtau, Révision E'ch. foss. E'gypte: Mém. Inst. E'gypt., vol. iii, fasc. 8 (1899), pp. 607, 623.



Geological Sketch-map of the district bordering the Helford Basin.

Schweinfurth, Blanckenhorn,[1] and Beadnell,[2] on the other hand, place these beds in the Cenomanian; so also does Dacqué.[3] But the Echinoids from these beds appear to me to be Turonian rather than Cenomanian. The Echinoids from this massif are few in number, and they are mostly species new to the locality, so that their evidence is by no means decisive. But the affinities of the Abu Roash Echinoids known to me are Turonian. The collections give no evidence of the occurrence of a Cenomanian Echinoid fauna at Abu Roash. Of course, Cenomanian beds may occur, from which Echinoids were not collected.

In Sinai, on the other hand, the bulk of Echinoids are of Cenomanian affinities, as shown in the table of species (*infra*). The Sinai Echinoids include two Turonian species and a new species, of which the nearest ally known to me is Turonian. This fact may represent either that the species lived in both epochs or that the beds of the two series occur at the same localities in Sinai.

The Cainozoic fauna in this collection, excluding the Pleistocene, is very small, and the specimens are not well preserved. The most puzzling form is an *Echinolampas* allied to *E. crameri*, Lor., which is reported as having been found in the raised beaches of Wadi Feiran; it is quite unlike any living *Echinolampas*. Professor Jeffery Bell, the best British authority on recent Echinoids, kindly examined the specimens, and tells me that they are unlike any living species. The affinities of these species are Miocene or earlier; possibly they were derived from blocks of limestone that may have fallen from an old cliff into a recent beach.

The Pleistocene fauna from both shores of the Gulf of Suez has purely Erythrean characters. Most of the specimens are identical with living species. A few specimens, however, which are badly preserved, may be of an earlier age, as they may be either recent or extinct species. All the well-preserved material is identical with the existing Red Sea species. There is nothing to suggest any considerable antiquity for these raised beaches. Seven specimens are somewhat doubtful, and two of them may be Pliocene or Miocene. Nos. K 1660 and J 1624 are both imperfect specimens, and cannot be identified; and K 1660 from the level of 380 feet in the Wadi Abu Shigeli is perhaps *Brissus egyptiacus*, Gauthier, which is assigned by its author[4] to the Miocene.

The three specimens referred doubtfully to *Schizaster gibberulus* are so imperfect that the determination is of no value. They may be crushed casts of that species, but their generic characters are not known.

The *Echinodiscus* is quite unlike any Pleistocene species, and the fragment of the *Clypeaster* (L 4204) described as coming from the

[1] Max Blanckenhorn, Neues zur Geol. & Pal. Aegyptens: Zeit. deut. Geol. Ges., 1900, p. 33.

[2] Beadnell, Cret. Reg. Abu Roash: Rep. Geol. Surv. Egypt, 1900, pt. ii (1902), pp. 18, 19, 20, etc.

[3] Dacqué, Mitth. Kreidecomplex Abu Roash: Palæontogr., vol. xxx (1903), p. 354.

[4] Fourtau, Révision E'ch. foss. E'gypte: Mém. Inst. E'gypt., vol. iii, fasc. 8 (1899), p. 718, pl. iii, figs. 11, 12.

beach deposits of Wadi Feiran may be a fragment of a Miocene species. The only species from that locality which is satisfactorily determinable is an *Echinolampas*, which is a Lower Cainozoic or Miocene species. Hence it may be that the three species of Echinoids from the beach deposits of Wadi Feiran are *remanié* from a Miocene or Lower Cainozoic horizon.

I must express my best thanks to Captain Lyons for having allowed me to keep the collection so long, in spite of the unavoidable delays in the preparation of a report upon it.

I. CRETACEOUS.

Subclass *REGULARIA ECTOBRANCHIATA*.

Suborder *DIADEMINA*.

Family DIADEMATIDÆ.

HETERODIADEMA, Cotteau, 1864.

HETERODIADEMA BIGRANULATUM,[1] n.sp. (Pl. X, Figs. 1*a–f*.)

Diagnosis.—Test small, low; well flattened above and below; the ambitus is tumid.

Apical area large, its length is half the diameter of the test; and the ratio of breadth to length is 7 to 9 (it is 21 : 29 in *H. libycum*). In shape it is nearly pentagonal; the three anterior sides are straight, while the two posterior sides are somewhat convex. Peristome small.

Ambulacra, 13–14 compound plates in each vertical series; the passage from the large tubercles on the ambitus, to the smaller ones near the apex, is less sudden than in *H. libycum*.

Interambulacra, 10 compound plates in each vertical series; the scrobicular areas are not confluent, but occasionally the scrobicular circles become very thin, and the granules somewhat scanty; there are two granules in each of the horizontal rows (instead of the four in *H. libycum*) between the base of the boss and the median suture.

Dimensions:

Diameter	21 mm.
Height	8·5 mm.
Width of apical area	9 ,,
Length of apical area	11 ,,
Width of ambulacrum at ambitus	5·5 ,,
Width of interambulacrum at ambitus	8 ,,

Distribution.—Cenomanian: southern slope of Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume, 1899.

Figures.—Pl. X, Fig. 1*a*, from above, nat. size; Fig. 1*b*, from the side, nat. size; Fig. 1*c*, a compound ambulacral plate showing the granulation, by 4 diam.; Fig. 1*d*, a worn ambulacral plate showing the sutures, by 4 diam.; Fig. 1*e*, interambulacral plates showing

[1] From its double rows of granules around the bases of the ambital interambulacral tubercles.

the ornamentation, by 4 diam.; Fig. 2, *Heterodiadema libycum* (Desor), two interambulacral plates, after Cotteau.

Affinities.—This echinoid is a typical *Heterodiadema*; it differs from *H. libycum* (Desor),[1] the well-known type-species, by its non-confluent scrobicular areas, and by having only two instead of four granules in each row on the interambulacral plates.

Family DIPLOPODIIDÆ.

ACANTHECHINOPSIS,[2] n.gen.

Diagnosis.—Diplopodiidæ with the ambulacra diplopodous abactinally, where the plates are long, thin, simple primaries; but with uniserial epipodia on the actinal surface and near the mouth. The ambital plates are of five primaries, one of which may be reduced to a demiplate.

There is a bare depression in the median line of the abactinal part of the interambulacra.

Tubercles crenulate and perforate.

Type Species.—*A. humei*, n.sp.

Distribution.—Cretaceous: Sinai and Southern Tunis.

Affinities.—This species is most nearly allied to *Acanthechinus*, but it differs therefrom by its perforate tubercles.

ACANTHECHINOPSIS HUMEI, n.sp. (Pl. X, Figs. 3*a*–*e*.)

Test of medium size; subpentagonal; flat below, somewhat turban-shaped when seen from the side.

Ambulacra broad above, where the epipodia occur in long narrow primaries. The ambital plates have five primaries, one of which may be reduced to a demiplate, by being just crushed out from the middle line.

Interambulacra, about 16 plates in a vertical series. The tubercles begin as a single series, separated from the series on the opposite side of the interambulacrum by a bare depressed area. On the seventh plate from the top a second line of tubercles begins, and the ambital plates have three rows of tubercles in a somewhat oblique series.

Dimensions:

Diameter	36 mm.
Height	15 mm.
Diameter of peristome	12·5 mm.

Distribution. — Cenomanian: southern slope of Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.

Figures.—Pl. X, Figs. 3*a* and *b*, test from above and from the side, nat. size; Fig. 3*c*, ambulacral plates near the apex, by 4 diam.; Fig. 3*d*, ambital ambulacral plates, by 4 diam.; Fig. 3*e*, ambital interambulacral plates, by 4 diam.

[1] *Pseudodiadema libycum*, Desor, 1858: Syn. E'ch. foss., p. 72. *Heterodiadema libycum*, Cotteau, 1864: Pal. franç., Terr. crét., vol. vii, p. 522, pl. 1124. Cotteau, Peron, & Gauthier, 1879: E'ch. foss. Algér., fasc. 5, p. 201, pl. xv, fig. 5. Gauthier, 1889: E'ch. foss. S. Hauts-Plat. Tunisie, p. 68.

[2] Like *Acanthechinus*.

Affinities.—This species is most nearly allied to a specimen, described by Gauthier as *Diplopodia semamensis*, Gauth., from the Cenomanian of Jebel Semama in Southern Tunis, to which it is certainly a near relation. Gauthier referred to the abnormal characters of what he truly described as this "remarkable species." He had only one imperfect specimen; its dimensions are diam. 35 mm., height 12 mm., and diam. of peristome 11 mm.

A. humei differs from *A. semamensis* (Gauth.), as that has more abundant interambulacral tubercles.

	Acanthechinopsis humei.	*A. semamensis.*
Ambital plate has	a slightly oblique series of three tubercles.	a zigzag row of four tubercles.
The series of tubercles which begins at the top of interambulacral area	becomes the middle row at the ambitus.	remains the innermost line throughout.
The second vertical series of tubercles begin on the	fifth plate.	hird uppermost plate from top of 1*a*.
On the ambital plates	a large second tubercle appears inside the long row of primary tubercles.	no conspicuous secondary tubercle inside the main series.

Family PEDINIDÆ.

MICROPEDINA, Cotteau, 1867.

MICROPEDINA BIPATELLIS.[1] (Pl. X, Figs. 4, 5*a–f*.)

Test, the average size for this genus; well rounded, subspheroidal, but with depressed actinal surface, tumid ambitus, and the upper surface much more raised and tapering than the lower.

Circular in section.

Apical area and peristome both small.

Ambulacra: the epipodia appear conspicuously biserial, especially near the mouth, but at the ambitus they may be recognized as triserial.

The ambulacral plates on the ambitus consist of a large primary, with small adoral and aboral demiplates; the aboral and middle epipodia are in the same vertical line, near the interradius; the adoral epipodium occurs at about the middle of the lower edge, giving the biserial aspect to the ambulacrum.

Near the peristome the aboral plates may be a primary, and the adoral is nearly so. The ambital ambulacral plates are ornamented by two small granules. Interambulacra of long narrow plates with an irregular line of very small granules, which may be as many as seven in number. In some plates the line of granules becomes doubled near the ambulacrum.

[1] Having two small plates (or patella) in the compound ambulacral plates.

Dimensions:

	L 3482.		L 4323.		*M. olisipponensis.*		*M. cotteaui.*
Diameter	40 mm.	...	33 mm.	...	13–40 mm.	...	25 mm.
Height...	28 mm.	...	26 mm.	...		...	22 mm.
Ratio of height to diam.	70 : 100	...	78 : 100	...	64 : 100 to 88 : 100	...	88 : 100

Distribution.—Egypt. Cenomanian: Jebel Gunneh (L 4323); northern side of Jebel um Raiyig, north-eastern Sinai (L 3482). Both collected by Dr. W. F. Hume.

Figures.—Pl. X, Fig. 4, a small specimen from the side, nat. size, from Jebel Gunneh, L 4323; Figs. 5*a–f*, plates from L 3482 from Jebel um Raiyig; Fig. 5*a*, ambulacral plate from near the apical area, by 4 diam.; Fig. 5*b*, an ambulacral plate from the ambitus, by 4 diam.; Fig. 5*c*, an ambulacral plate from the actinal surface, by 4 diam.; Fig. 5*d*, an ambulacral plate from near the peristome; Figs. 5*e* and 5*f*, ambital interambulacral plates, by 4 diam. Pl. XI, Fig. 15, the ambital ambulacral and interambulacral plates of *M. cotteaui*, Coq., after Cotteau.

Affinities.—The nearest ally of this species is *M. olisipponensis*, Lor.,[1] from the Cenomanian of Portugal, which differs by having three regular granules on the ambulacral plates, and somewhat larger granules on the interambulacrals. It differs from the type-species, *M. cotteaui*, Coquand,[2] by having an adoral demiplate, instead of both the lower plates in the ambital ambulacral plates being primaries. In this respect it resembles *M. olisipponensis*, which agrees with *M. cotteaui* in the granulation of both the ambulacral and interambulacral plates.

Family CYPHOSOMATIDÆ.

CYPHOSOMA, Agassiz.

Cyphosoma beadnelli, n.sp. (Pl. X, Figs. 6, 7*a–d*, and 8.)

Diagnosis.—Test of medium size, subcircular and low.

Ambulacral plates composed of six constituents; each plate has one large tubercle, and a median row of coarse scanty granules down the middle line of each area. The scrobicular circles are confluent. Interambulacra, 10 plates in a vertical series; each bears one large tubercle, round the base of which is an incomplete scrobicular circle, a line of about 5 large granules on the inner and outer sides of the scrobicular circle, which is incomplete above and below in the ambital plates, so that the scrobicular areas are confluent.

Dimensions:

	Largest.		Another specimen.		Another specimen (Fig. *b*).
Diam. max. ...	28 mm.	...	23·5 mm.	...	24 mm.
Diam. min. ...	26 mm.	...	22 mm.	...	—
Height	9·5 mm.	...	7 mm.	...	10 mm.

[1] P. de Loriol: Crét. Fauna Portugal, vol. ii (1887), E'chinodermes, p. 62, pl. x, figs. 3–6.
[2] Cotteau: Pal. franç., Terr. crét., vol. vii (1867), p. 823, pl. 1197.

Figures.—Pl. X, Fig. 6, abactinal view of a specimen, nat. size; Fig. 7*a*, another specimen from the side, nat. size; Fig. 7*b*, abactinal end of an ambulacrum of the same, by 4 diam.; Fig. 7*c*, an ambital ambulacral plate of the same, by 4 diam.; Fig. 7*d*, interambulacral ambital plates of the same specimen, by 4 diam.; Fig. 8, actinal surface of another specimen, nat. size.

Distribution.—Cretaceous (Cenomanian or Turonian): east end of Abu Roash village. L 1376. Collected by H. J. L. Beadnell, Esq.

Affinities.—The species is allied to the Turonian *Cyphosoma coquandi*, Cott.,[1] of Batna, Algeria, in which the granulation is more abundant, the scrobicular areas are not confluent, and there are only five components in the compound, ambital, ambulacral plates.

THYLECHINUS, Pomel, 1883.

1. THYLECHINUS QUINCUNCIALIS,[2] n.sp. (Pl. XI, Figs. 8*a*–*c*.)

Diagnosis.—Test above medium size; circular; depressed.

Peristome moderate in size; circular with well-developed buccal slits.

Ambulacra: about 16 compound plates in each vertical series. The scrobicular circles are very incomplete; they may be represented only by a series of granules round the edge of the boss, but there may be a line above and below the boss, along the horizontal edge of the plate.

Interambulacra: about 13 plates in each vertical series. The plates are slightly bent, the abactinal margin being concave. The ambital tubercles are quincuncial in arrangement, and there are three vertical series on each side of an interambulacrum at the ambitus. The three plates nearest the peristome have one tubercle each.

Dimensions:

Diameter	30–31 mm.
Height	12–13 mm.

Distribution.—Cenomanian: Sinai, marls at the head of Wadi Ethal. L 3872. Collected by the late T. Barron, Esq.

Figures.—Pl. XI, Fig. 8*a*, a specimen from the side, nat. size; Fig. 8*b*, part of the ambitus, showing the plan of the interambulacral tubercles, by 3 diam.; Fig. 8*c*, two compound ambulacral plates from the same, by 4 diam.

Affinities.—This species resembles by its quincuncial tubercles one of the two echinoids included by Gauthier[3] in *T. sancti-arromani* (Gauth.), from the Dordonian (Upper Senonian) of Bir Maguer, Southern Tunis. It appears to me probable that the specimen illustrated by Gauthier's figs. 9–11 is a distinct species from his figs. 8, 12, and 13, which may be selected as the type of the species. This *Thylechinus quincuncialis* differs from *T. sancti-arromani* by the presence of only one tubercle, instead of a row of smaller ones on the plates next the peristome.

[1] Cotteau: Pal. franç., Terr. crét. (1864), p. 587, pl. 1139, figs. 7–12.

[2] From the plan of the tuberculation.

[3] *Cyphosoma sancti-arromani*, Gauthier, 1889: E'ch. foss. Sud Hauts-Plateaux Tunisie, pp. 81–82, pl. v, figs. 8, 12, 13, *non* figs. 9–11.

2. THYLECHINUS TRIGRANULATUS, n.sp. (Pl. XI, Figs. 9*a–d.*)

Test low and small; circular; it is flat below, is tumid at the ambitus, and somewhat pointed above. Apical area small. Peristome decagonal, with broad buccal slits.

Ambulacra, about 11 compound and 5 abactinal primary plates, in a vertical series. The uppermost, or the two uppermost, compound plates are smooth, and have only a low granule. Each ambital plate has a single prominent tubercle, but little smaller than those of the interambulacra. The boss occupies nearly the whole of the non-poriferous part of the plate, and is surrounded by a thin single row of small granules on its border.

Interambulacra.—There are about 11 plates in each vertical series. The plates are long and low; the abactinal side is slightly concave. The base of the tubercle is surrounded by a circle of low granules, so that the scrobicular areas are non-confluent. Each plate typically has three prominent granules, one in each of the two adambulacral corners and one on the abactinal interradial corner.

Dimensions:

Diameter	22 mm.
Height	9 mm.
Diameter of apical area	5–6 mm.
Diameter of peristome	8–9 mm.
Width of ambulacrum at ambitus	5 mm.
Width of interambulacrum at ambitus	8·5 mm.

Figures.—Pl. XI, Fig. 9*a*, test from below, nat. size; Fig. 9*b*, from the side, nat. size; 9*c*, upper part of an ambulacrum showing the structure of the plates, by 4 diam.; 9*d*, part of an interambulacrum at the ambitus, by 4 diam.

Distribution.—Cenomanian — Cretaceous Marls: head of Wadi Ethal, Sinai. L 3872. Collected by the late T. Barron, Esq., 1899.

This *Thylechinus* is represented by one specimen; it is somewhat distorted, but the characters are well shown. The ornamentation reminds me most of *Cyphosoma baylei*, Cott. (Pal. franç., Terr. crét., vol. vii (1864), pl. 1138, fig. 12), which, however, is a true *Cyphosoma.*

COPTOSOMA, Desor, 1858.

1. COPTOSOMA ABBATEI (Gauthier), 1899.

Cyphosoma abbatei, Gauthier, in Fourtau, 1899: Rév. E'ch. foss. E'gypte, Mém. Inst. E'gypt., vol. iii, fasc. 8, p. 620, pl. i, figs. 2–6.
Cyphosoma abbatei, Fourtau, 1900: Notes E'ch. foss. E'gypte, p. 21.
Cyphosoma abbatei, Dacqué, 1903: Mitth. Kreidecomplex Abu Roash, Palæontogr., vol. xxx, p. 357.
Pseudodiadema, sp., Walther, 1887: Apparition craie, Bull. Inst. E'gypt., 1887, p. 7.

This species, well described by Gauthier, is represented by a good series of specimens. They show that the ambulacra are not diplopodous abactinally, so the species is a *Coptosoma.*

Distribution.—Cenomanian or Turonian: eastern end of the village of Abu Roash. I 3792. Collected by H. J. L. Beadnell, Esq.

2. Coptosoma gunnehensis,[1] n.sp. (Pl. XI, Figs. 10*a*–*d*.)

Diagnosis.—Test of medium size; subpentagonal in form. Flat base; somewhat tapering below. The middle area of the interambulacra is depressed near the apical system.

Apical system apparently somewhat small, pentagonal.

Peristome large, subdecagonal, with broad buccal slits.

Ambulacra: 13 compound plates each with one well-developed tubercle. Scrobicular circles confluent; a well-developed double series of granules down the middle line of each area. Four constituents in each ambital ambulacral plate.

Interambulacra: 12–13 plates in each vertical series. At the ambitus each plate bears two well-developed tubercles; the plates are bent into a step-like form, the central tubercles being half the width of the plate nearer the actinal surface.

Granulation scanty; the two scrobicular areas of each plate are confluent, but they are not confluent with those of the plates above and below it; usually two granules on the side of the plate near the ambulacrum.

Dimensions:

Diameter	27 mm.
Height	8 mm.
Diameter of apical area	9–13 mm.
Diameter of peristome	13 mm.
Width of ambulacrum at ambitus	5·5 mm.
Width of interambulacrum at ambitus	11 mm.

Distribution.—Cenomanian (?): Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.

Figures.—Pl. XI, Fig. 10*a*, type-specimen from above, and Fig. 10*b*, from the side, nat. size; Fig. 10*c*, a compound ambital ambulacral plate, by 4 diam.; Fig. 10*d*, ambital interambulacral plates, by 4 diam.

Affinities.—This well-marked form has the doubly-bent, step-shaped, interambulacral plates found in various Cyphosomoid echinoids of the Middle and Upper Cretaceous, as in *Cyphosoma alcantarense*, de Loriol.[2] Its nearest ally is the Turonian *Coptosoma major* (Coquand),[3] which has a more granulate test, the two scrobicular areas on each plate being separated by a line of granules, and according to Cotteau's figures[4] the ambulacral plates consist of five primaries. Gauthier[5] included in his *Cyphosoma sancti-arromani* a specimen shown in his figures 9, 10, and 11, which is another ally of this species; it has the step-shaped interambulacral plates, but the secondary tubercles are on a somewhat different plan. *C. sancti-arromani* is from the Dordonian (i.e. Maastrichtian or uppermost Senonian) of Southern Tunis.

[1] From Jebel Gunneh, the locality of the type-specimen.

[2] P. de Loriol: Faune Crét. Portugal, vol. ii (1887), E'chinod., p. 52, pl. ix, fig. 4, from Up. Carentonian.

[3] *Phymosoma major*, Coquand, 1863: Géol. et Pal. Constantine, Mém. Soc. E'mul. Provence, vol. ii, p. 256, pl. xxvii, figs. 16, 17.

[4] Cotteau: Pal. franç., Terr. crét., vol. vii (1864), pl. 1143, fig. 5.

[5] Gauthier: E'ch. foss. Sud Hauts-Plateaux Tunisie, pl. v, figs. 9–11, *non* figs. 8, 12, 13.

Subclass *IRREGULARIA.*

Order 1. GNATHOSTOMATA.

Suborder *HOLECTYPINA.*

Family PYGASTERIDÆ.

HOLECTYPUS.

1. Holectypus cenomanensis, Guéranger, 1859.

Holectypus cenomanensis, Guéranger, in Cotteau & Triger: E'ch. Dep. Sarthe (1859), p. 173, pl. xxx, figs. 5–10.
Holectypus cenomanensis, Duncan, 1865: Ech. Coast Arabia, Quart. Journ. Geol. Soc., vol. xxi, p. 354.
Holectypus cenomanensis, Fourtau, 1899: Rév. E'ch. foss. E'gypte, Mém. Inst. E'gypt., vol. iii, fasc. 8, p. 625.

Distribution. — Cenomanian: Algeria, France, etc.; Jebel um Raiyig, north-eastern Sinai. L 3483. Collected by Dr. W. F. Hume. Cretaceous Marls: Jebel el Araba, Wadi el Araba, Sinai. L 4220. Collected by the late T. Barron, Esq.

Dimensions:

	L 3483.	L 4220.	*jullieni.*	*cenomanensis.*
Diameter ...	— ...	— ...	24 mm. ...	45 mm.
Length	40·5 mm. ...	22·5 mm. ...	35 mm. ...	31 mm.
Width	39 mm. ...	22·25 mm. ...	11 mm. ...	31 mm.
Height	21 mm. ...	10 mm. ...	15 mm. ...	15 mm.
Length to width ...	100 : 96·3 ...	— ...	— ...	100 : 48·4
Length to height ...	100 : 51·8 ...	— ...	100 : 45 to 42·8 ...	Diam. in this species is up to 45 mm.[1]

Affinities.—The characteristics of this species are its comparatively large size (up to 45 mm. in diam.), the subpentagonal or subcircular form, the very low, conical form, and the great size of the periproct, which is acuminate at both ends, and extends from the peristome to the margin.

It differs from the *Echinoconus egyptiacus*, d'Orb.,[2] by its low height; from *H. excisus*, Cott.,[3] by the fact that the periproct does not notch the posterior margin of the test. *H. serialis*, Deshayes,[4] is much smaller, and has less numerous tubercles on the interambulacral plates; and so also has *H. jullieni*, P. & G.[5] The latter is a Turonian and Senonian species, and in spite of its somewhat lower height is a near ally of *H. cenomanensis.*

2. Holectypus turonensis (Desor), 1847.

In Agassiz & Desor: Cat. rais., Ann. Sci. nat., ser. III, vol. vii, p. 146.
Cotteau: Pal. franç., Terr. crét., vol. vii (1861), p. 56, pl. 1018.
Cotteau, Peron, & Gauthier: E'ch. foss. Algér., fasc. 6 (1879), p. 87.

[1] Cotteau, Peron, & Gauthier: E'ch. foss. Algér., fasc. 5 (1879), p. 172.
[2] D'Orbigny: Pal. franç., Terr. crét., vol. vi, p. 544, pl. 1005, figs. 7–9.
[3] See e.g. the figure in Cotteau & Triger: E'ch. Dep. Sarthe, p. 368, pl. lxii, figs. 1, 3.
[4] See Desor: Syn. E'ch. foss., p. 174, pl. xxiii, figs. 6–9.
[5] Peron & Gauthier: E'ch. foss. Algér., fasc. 6 (1880), p. 85, pl. vi, figs. 3–7; fasc. 7 (1881), p. 91.

Distribution. — Turonian : S. France, and Tebessa, Algeria. ? Cenomanian—Cretaceous Marls : Sinai, Wadi Ragga (L 4123); and head of Wadi Ethal (J 3873).

This species is represented by three specimens, of which the two from the Wadi Ragga show all the characters very well. They resemble the Cenomanian *H. crassus*, of which it is possible that they are young specimens.

Their dimensions are :—

		J 4233.		*H. crassus, fide* Cotteau.
Diameter ...	...	15–23 mm.	...	51½ mm. by 31 mm.
Height ...	...	7–10 mm.	...	17 mm.

The ornamentation and shape agree with *H. turonensis* better than with *H. crassus*. The periproct notches the hinder margin, as much as in the French specimens, whereas the Algerian specimens are said by Cotteau, Peron, & Gauthier (op. cit., p. 88) only rarely to do so.

3. Holectypus larteti (Cotteau), 1867.[1]

Cotteau, Notice E'ch. foss. recueillis par Lartet pendant voyage duc de Luynes: Bull. Soc. géol. France, ser. II, vol. xxvi (1869), p. 537.
Lartet: Explor. géol. Mer Morte, Paris (1877), p. 155, pl. xiv, figs. 1–5.

Distribution.—Cretaceous : Mt. Hor (coll. Lartet). Cretaceous Marls : head of Wadi Ethal, Sinai. L 3873. Coll. T. Barron, Esq.

This species, by its small periproct, has some resemblance to *Discoidea*, but the peristome is typically that of *Holectypus*. The largest of the three specimens is 23 mm. in diam., and 12·25 mm. in height.

According to Lartet's figure the diameter of the type-specimen is 25 mm. and its height 13 mm. The nearest Algerian species is *Holectypus chauveneti*, P. & G.,[2] in which the diameter and height are 18 mm. and 8 mm. respectively.

Family GALERITIDÆ.

GALERITES, Lamarck.

Galerites thomasi (Peron & Gauthier), 1878.

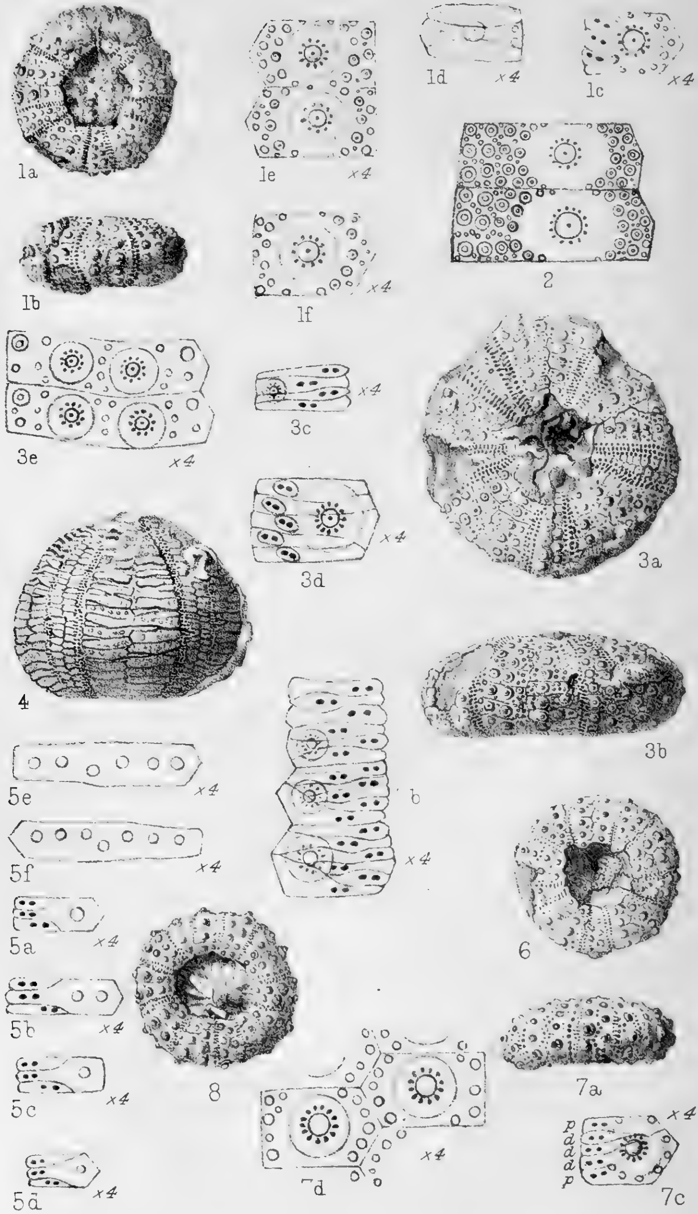
Echinoconus thomasi, Peron & Gauthier, 1878 : E'ch. foss. Algér., fasc. 5, p. 162.

Distribution.—Cenomanian: Algeria (Berouaguiah); head of Wadi Ethal, Sinai. ? L 3873. Coll. T. Barron, Esq.

This species was founded on a very imperfect specimen which showed neither periproct nor peristome, so that the identification is doubtful.

L 3873 includes only one imperfect, worn specimen, which has the tumid margin, a slight actinal flattering, a large subpentagonal peristome, which is large for this genus, and a submarginal periproct. The apical system agrees with that of *Galerites thomasi*.

[1] Compt. Rend., vol. lxxviii (1867), p. 198.
[2] Peron & Gauthier: E'ch. foss. Algér., fasc. 5, p. 172, pl. xii, figs. 3–6.



E. Drake del. et lith. West, Newman imp:

Fossil Echinoidea from Sinai & Egypt.

EXPLANATION OF PLATE X.

FIG. 1.—*Heterodiadema bigranulatum*, n.sp. Cenomanian: south slope of Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.

1*a*, type-specimen from above. Nat. size.
1*b*, from the side. Nat. size.
1*c*, a compound ambulacral plate showing the granulation. × 4 diam.
1*d*, part of a worn ambulacral plate, showing the structure of the compound plates. × 4 diam.
1*e*, two interambulacral plates, showing the ornamentation. × 4 diam.
1*f*, another interambulacral plate. × 4 diam.

FIG. 2.—*H. libycum* (Desor). Interambulacral plates after Cotteau.

FIG. 3.—*Acanthechinopsis barroni*, n.sp. South slope of Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.

3*a*, *b*, the test from above and from the side. Nat. size.
3*c*, ambulacral plates near the apex. × 4 diam.
3*d*, ambital ambulacral plates. × 4 diam.
3*e*, ambital interambulacral plates. × 4 diam.

FIGS. 4–5.—*Micropedina bipatellis*, n.sp. Cenomanian: Sinai. Collected by Dr. W. F. Hume.

4, a small specimen from the side. Nat. size. Jebel Gunneh. L 4323.
5*a–d*, ambulacral plates from L 3482. × 4 diam.
5*a*, a plate near the apical area.
5*b*, a plate from the ambitus.
5*c*, a plate from the actinal surface.
5*d*, a plate near the peristome.
5*e*, *f*, ambital interambulacral plates from L 3482. × 4 diam.

FIGS. 6–8.—*Cyphosoma beadnelli*, n.sp. Cenomanian or Turonian: east end of Abu Roash. Collected by H. J. Beadnell, Esq.

6, abactinal view of a specimen. Nat. size.
7*a*, another specimen from the side. Nat. size.
7*b*, abactinal end of an ambulacrum of the same. × 4 diam.
7*c*, ambital ambulacral plate of the same. × 4 diam.
7*d*, interambulacral ambital plates of the same specimen. × 4 diam.
8, actinal surface of another specimen. Nat. size.

(*To be concluded in the June Number.*)

V.—NOTES ON THE CORRIES OF THE COMERAGH MOUNTAINS, CO. WATERFORD.

By F. R. COWPER REED, M.A., F.G.S.

(*Concluded from the April Number, p.* 161.)

BETWEEN Crotty's Lough and Coumshingaun a long spur of the Comeraghs juts out eastwards for about a mile and a half with an average height of 1400–1500 feet. On the south side this projecting ridge descends rather steeply to a stream at its base, which heads at a height of over 2,400 feet on the lofty plateau between Coumgorra and Coumshingaun; it runs down the mountain-side in a narrow gully over bare rock and reaches the foot in a series of picturesque waterfalls. No glacial débris occurs in this ravine, but on the lower ground the stream flows over the margin of the moraines belonging to Coumshingaun and runs eastward as the River Ire to join ultimately the Clodiagh.

We now come to *Coumshingaun*, the principal and best known corrie in the Comeraghs and containing the largest lake. The corrie has the form of a somewhat elongated horseshoe and faces west. It is situated only about one-third of a mile south of Crotty's Lough, with the above described ravine of the River Ire between them. The mouth of the corrie measures about 500–600 yards across, being narrowed by the approach of the enclosing spurs, but towards its head it expands considerably, so that the opposing cliffs are as much as 1,100 yards apart, measured from edge to edge. The lower half of the cliff at the head is composed of two successive precipices, which descend almost vertically to the water's edge and correspond to massive rock-beds. There is only a small talus slope as the foot, and above the main precipices the cliff is composed of the straight edges of many thinner beds of sandstone, which form a series of small scars and ledges on which rest small grassy talus slopes. The total height of this cliff in one place amounts to 1,288 feet in a horizontal distance of 400 yards, giving a mean slope of 46½° (Geol. Surv. Mem., p. 6). To anyone standing at the mouth of the corrie and looking west the cliffs appear nearly perpendicular, and

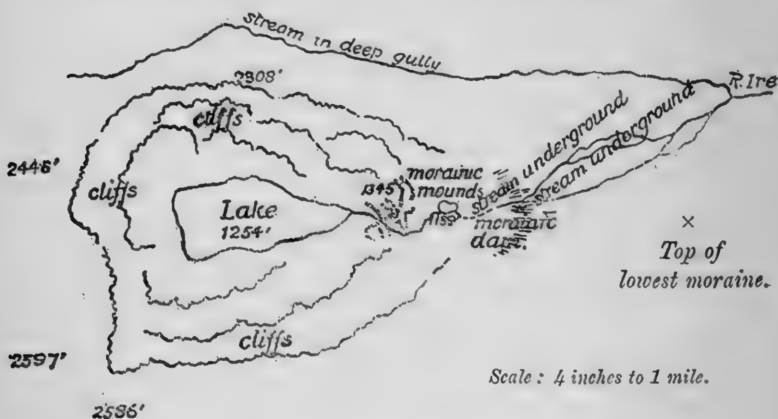


Fig. 6.—Sketch-map of Coumshingaun and Lake.

the beds, whose truncated edges form them, are seen to have a slight dip to the south. The north and south sides of the corrie are only precipitous in their middle or upper parts, all their lower half being covered with steeply inclined grassy screes. The spur on the southern side is prolonged eastwards as a narrow ridge with regularly sloping sides, and has the typical appearance of a valley-side plastered with lateral moraine. The northern spur is shorter and rounded more abruptly, and the solid rock crops out in many places on its surface.

The level of the lake itself is 1,254 feet above the sea, and a small clear stream issues from its southern corner close under the southern spur and finally joins the River Ire after a course of about two miles. The lake is of an elongated oval shape, with its longer axis running the length of the corrie and measuring about 750 yards; its breadth near the middle is about 300 yards, and it practically covers the whole floor of the corrie from one precipice to the other with no level ground round its edges. The eastern end of the lake is obviously shallow, but local report credits the middle with being of great or even unfathomable depth. No accurate soundings are, however, on record, so far as I know.

The existence of morainic dams across the mouth of the cwm is strikingly apparent to any casual observer, and on ascending from the level of the high road up to the lake three distinct transverse moraines may be recognised. The lowest has a steep but irregular face, and its surface forms a more or less level broad shelf, across which meander many small streams. Huge angular masses of rock and more or less rounded boulders are scattered over it, and several examples of perched blocks—all of red sandstone or conglomerate—are noticeable. At a level of about 800 feet there is another and well-marked step in the slope, which indicates that we have reached the face of the second moraine. The face is steep and rough, and many springs issue from its foot or at various levels on the slope. We then cross its somewhat irregular surface, which is of less width than the lower one, and as we draw near the lake meet with a series of large and overlapping mounds of morainic material and irregularly distributed large boulders, which form the final barrier and dam to the waters of the lake. The maximum height of these mounds is about 100 feet above the level of the water. The stream which issues from the lake runs between them near the southern spur of the mountain, and expands into several small pools before descending the steeper slopes of the moraines or soaking through them to reappear as springs at a lower level. Its course at first is certainly not over solid rock, and it is clear that the mouth of the corrie is at any rate to a large extent filled up with drift. Its resemblance to a 'hanging valley' is well seen from the opposite slopes of Croghaun Hill (Pl. XIII, Fig. 2).

South of Coumshingaun there is another large corrie in the face of the escarpment looking east and measuring about 850 yards in depth and 600 in width. Though possessing less striking surroundings than Coumshingaun and devoid of a lake on its floor it is essentially of the same character, and the mouth is similarly blocked with transverse moraines. The floor of it is almost entirely occupied with extensive screes which slope down from the cliffs around it and may have filled up a pre-existing lake. A stream issues from this corrie and flows in a south-easterly direction to join the River Mahon after a course of about 4 miles. There is no other definite corrie in this escarpment, but about 2½ miles to the west of it on the southern slopes of the mountains, and only separated from the great corrie of the Stilloges in the Nier Valley by a narrow ridge 300 yards wide and just 2,350 feet high, there is a wide shallow amphitheatre formed by a gently curved line of cliffs, about 750 yards long, beneath which lie two small lakelets, from which issues the Coum Tay stream joining the River Tay below.

We may now turn to the Nier Valley, which possesses some striking elongated corries or rather precipitously walled hanging valleys on its south side. Standing on the Gap in the Comeragh Range between Knockanaffrin and Coumgorra, we look westwards down the Nier Valley and note that the Gap is in reality a low col at the head of the River Nier. On our left we observe several deep tributary valleys entering the main valley from the south, and their generally bare craggy sides and hanging mouths attract attention. The head-stream of the River Nier issues from such a valley immediately on our left, and this valley starts behind Coumgorra and has its mouth spanned by successive banks and mounds of coarse morainic material. It lies at a considerable height above the thalweg of the Nier Valley itself, as in the case of a typical hanging valley, and its sides are rocky and precipitous in places and glaciated close to the present stream (see Geol. Surv. Mem., Sheets 167, 168, etc., p. 80), which has cut a small gorge at the head of the valley in its descent from the summits above, which rise to a height of nearly 2,500 feet.

A long narrow spur, only about 250 yards wide, separates this interesting glen from the large amphitheatre containing the *Comeragh Loughs.* This elongated amphitheatre or short hanging valley appears to be a composite corrie like Coumgorra, and its wide mouth (measuring nearly three-quarters of a mile across) faces nearly due west. Its depth is only about 700 yards, and its sides are precipitous, the lofty cliffs reaching a height of over 700 feet. The mouth of this corrie is blocked in the usual manner by glacial mounds, and the two lakes which it contains are separated also by heaps of morainic material. The inner lake, which measures about 200 yards across, lies at an elevation of 1,650 feet, and the outer and lower one, which is of rather smaller size, at 1,537 feet. The stream which flows out of the inner one is joined by one from the lower one and then runs down to the Nier. No clear evidence of the existence of a true rock-basin is at present available.

The immense corrie or short rocky valley named *Coumstilloge,* which holds the Stilloge lakes at a level of about 1,700 feet above sea-level, is the next one down the Nier. It faces the north-west, with a mouth nearly a mile wide, and with a depth of just over a mile. It appears to be formed by the confluence of three simple corries, two of which seem to have become merged to compose the broad amphitheatre at its head which holds on the east side Loughs Coumstillogemore and Coumstillogebeg, which are in close proximity to each other and lie in line along the stream which runs down to the main valley. To the west of these tarns there lie in the smaller corrie of the head-pair three small unnamed tarns without any surface-outflow. The mass of Coumfea Mountain, 2,340 feet high, projects into the south-western side of the composite corrie and overhangs the third or lateral constituent corrie which holds Lough Couma beneath precipitous cliffs about 600 feet high. This tarn has also no visible outlet.

The minute features of this Stilloge Valley and its group of lakelets have not yet been thoroughly examined, but it appears that glacial dams and mounds have led to the formation of the lakelets, and in general features of cross-section, hanging mouth, and precipitous walls it resembles Coumgorra and the other corries.

The difference between the north and south sides of the Nier Valley is striking, for corries or lateral valleys of the type described are conspicuously absent on the northern flanks.

Origin of the Corries.

In striving to find an explanation of the origin of these corries and lakes in the Comeragh Mountains we are met at the outset by the still unfinished controversy as to the method of formation of all corries and rock-basins. There are current the theories of glacial erosion, subaerial erosion, marine erosion, and tectonic movements.

Thoroughgoing glacialists, like the Rev. Maxwell Close,[1] have ascribed the carving out of the Irish corries themselves, as well as the hollowing out of their floor, to the unaided action of ice. Others believe that the main or preliminary processes in their formation were effected by the ordinary subaerial agencies, and consider that ice has only played a subordinate part, superinducing certain peculiar features by which we can distinguish true cirques from the funnel-like heads of ordinary valleys of erosion.[2] Others maintain that typical cirques occur even in mountain regions which we have no reason to believe were ever glaciated,[3] and that the origin of the corrie was to a large extent independent of and prior to the formation of the hollow holding the lake, whether the latter lies in a rock-basin or a barrier-basin.

Kinahan[4] has urged the primary importance of faults, joints, and local dislocations of the strata producing lines of weakness along which marine erosion has acted; and he compares the cwms to the 'cooses' on the Galway coast, the shape of which has been determined by the intersection of various small faults.

Finally, tectonic movements, causing local subsidences, have been considered sufficient to account for their features, which indeed recall those of calderas[5] and of the breached craters of Auvergne.[6]

The most acceptable theory seems to be that of a modified head of a valley of erosion. The head of an upland glen, be it short or long, tends to have a half funnel shape, owing to the convergence to a central point of the various streams descending its slopes; and, given certain favourable conditions,[7] such a valley head may be converted into a true cirque. One of these conditions is the moderate horizontality of the strata over which the streams fall. Another is that the rocks must be of such a nature as to allow the formation of cliffs, and for this purpose well-jointed bedded limestones or sandstones of considerable toughness and durability are especially

[1] Maxwell Close: Journ. Roy. Geol. Soc. Ireland, vol. ii (1871), p. 236.
[2] Richthofen: "Führer für Forschungreisende," 1886, pp. 255–259.
[3] James Geikie: "Great Ice Age," 3rd ed., 1894, p. 236.
[4] Kinahan: "Valleys and their Relations to Fissures, etc.," p. 126; London, 1875.
[5] Richthofen: op. cit., p. 255.
[6] Howorth: "Ice and Water," vol. i (1905), p. 535.
[7] Bonney: Quart. Journ. Geol. Soc., vol. xxvii (1871), pp. 312–324; ibid., vol. xxix (1873), pp. 382–398.

suitable. Major lines of weakness, such as faults, will also be favourable for the development of cliffs.

It is probable also that in the first instance some suitable configuration of the ground at the head of the glen must have existed, such as the presence of a bare rock-face, more or less vertical, which may have been caused by a landslip due to the bursting out of springs at or near the base of a steep terminal slope. A cliff under the above-mentioned conditions would tend to be preserved, and by eating its way backwards into the slope would increase in height and extent under the action of weathering, particularly of frost, as is the case in Norway. The aspect of such a cliff with respect to the four quarters of the compass would have also some effect in determining its preservation and growth; and the fact that the majority of corries face north or north-east, and are rare on the other slopes of mountains and on escarpments facing in other directions, has been noticed throughout Europe.[1] Their position has sheltered them from the moisture-laden winds from the south-west and from the consequent rapid denudation which takes place under their influence. If ice and snow have, moreover, played a considerable part in the development of the peculiar characters of corries, it is on the northern sides of mountains that ice and snow would linger longest.

If we regard cirques to be of the nature of valley-heads formed under special conditions we have not even then surmounted all the difficulties connected with them. For we still have to explain their shortness in proportion to their width, their flat or excavated floors, their U-shaped cross-section, their frequent horse-shoe shape, and their occurrence as niches or recesses high up on the lateral flanks of main valleys or on escarpments, with their floors nearly level or even hollowed out, and the ground from their mouths sloping down steeply to the base of the mountain-side. The problem is of the same essential character as that of 'hanging valleys,' and some geologists regard them as merely hanging valleys of a special type and with a special history. Their niche-like position has been accounted for by supposing the main valley to have been widened and over-deepened by ice or water, while erosion in the lateral valleys was checked. It has been contended by Professor Davis that the glacier of the main valley has ground out its channel, deepening it and widening it at the expense of the lower parts of the lateral valley, which were occupied by small glaciers joining the main glacier at the level to which its mass rose against the lateral slopes. The main ice-stream in this way passed transversely across the lower ends of these tributary valleys, planing them down and truncating them abruptly. The corries in Skye have been thus explained,[2] and the hanging valleys of the Rhone. But this theory meets with much opposition. In the case of the Alps a general post-glacial or inter-glacial uplift has been suggested, when the main valleys would tend to be rapidly excavated by

[1] Penck: Morphol. d. Erdoberfl., ii (1894), p. 310.
[2] Harker: Trans. Roy. Soc. Edinb., vol. xl, pt. 2 (1901), pp. 221–252.

torrential rivers arising from the rapid melting of the ice and snow, but the glaciers in the upper parts of the side valleys would still persist and protect their beds from erosion.[1] The result in either case would be the same; the heads of the lateral valleys would be left hung up above the main thalweg when the period of excessive erosion was ended. Such may have been the first stage in the evolution of the Comeragh corries. Any new descent of the snow-line on the return of colder conditions would cause the lateral glaciers to advance and lead to the accumulation of mounds or dams of glacial débris in or beyond the mouths of the lateral 'hanging valleys.'

It is not without significance that the vertical distribution of hanging valleys along the sides of a main valley has in certain instances been found to bear a definite relation to the thalweg. Similarly, in many districts corries have been observed to possess a certain uniformity of level; but this is held by some geologists to indicate a former snow-line. Successive tiers of corries in belts (which are not unknown in some regions) are accordingly regarded as marking successive stages in the retreat of the snow-line.[2]

In the Comeraghs there is only one belt or zone of corries recognisable, and this lies between the contour-lines of 1,250 and 1,500 feet. Carvill Lewis (op. cit.) noticed that these mountains were glaciated up to a height of about 1,000 feet, and we may perhaps imagine the mountain-mass above this level to have stood up as a nunatakkr above the great ice-sheet during the period of maximum glaciation.[3] A lobe of the ice may have forced its way over the low col by Coumgorra and descended the Nier Valley. The heads of the lateral valleys which were not invaded by the ice would be modified during this period by the action of frost; their rocky sides would be splintered into cliffs, helped by the bedding, lie, vertical divisional planes and character of the rocks.

When the maximum cold and the ice which swathed the lower hill-slopes departed, these rock-walled niches were found left as the sole representatives of the former lateral valleys. Some were short and wide, others were long and complex, their size and shape having been determined by the various local conditions which affected the flow, pressure, and height of the ice-stream which crossed their mouths. On the return of the cold, though in a less severe form, an ice-cap probably formed on the mountains[4] and sent tongues down into the incipient corries on its flanks. The corrie-glaciers thus originating would produce the modifications in the already formed hanging valley-heads which were needed to convert them into true cirques. The U-shaped cross-section which we notice in them is characteristic of glaciated valleys. The frequent widening towards their head, though begun before the formation of the corrie-glaciers, was increased by the scouring out of the accumulated

[1] Bonney: Q.J.G.S., vol. lviii (1902), pp. 590–701. Garwood: id., pp. 703–714.
[2] Penck: op. cit., pp. 307–309 and references.
[3] Maxwell Close: Journ. Roy. Geol. Soc. Ireland, vol. i (1867), p. 228.
[4] Hull: Phys. Geol. Geogr. Ireland, 1878, pp. 103, 263.

screes against their cliffs and of the débris on their floor. Ice-falls from the edge of the ice-cap would assist the radial recession of the cliffs at the head, and tend to develop a horse-shoe shape to the corrie. A concentration of the erosive energy of the glacier must be produced at some central point in the floor, and, in the opinion of many geologists, its effects would be apparent by the excavation of a rock-basin. Even Kinahan (op. cit., p. 131) admitted that ice could thus enlarge and deepen a corrie. But the controversy as to the power of a glacier to scoop out a basin in solid rock is still raging, though no other agent capable of producing hollows, such as those in which the Snowdon lakes lie,[1] has been discovered, and apart from ice-erosion we have to imagine special local subsidence. The fact that infra-glacial corrosion does take place under certain conditions in modern glaciers during their advance seems now indisputably established. But in the case of the Comeragh lakes it has not been definitely proved that any of them lie in true rock-basins, and in all which I have examined the morainic dams which stretch across the mouths of the corries seem sufficient to account for their existence. Detailed soundings are, however, not available at present, and we must not forget Marr's[2] warning as to the inconclusiveness of the evidence furnished by the nature of the surface over which the stream flows as it issues from the lake. The glacier occupying the corrie could scarcely fail to scour out and remove all the abundant débris in the shape of screes and loose material strewn on the floor, and would deposit them outside in successive heaps and dams of moraine. Stages and halts in the dwindling away of the glaciers and in the retreat of the snow-line while glacial conditions passed away are marked by the remains of such dams; and their present preservation is due to the weakness of the erosive power of the streams issuing from the corries or draining off the overflow of the lakes held up by them. The frost and snow of every winter splits off fragments from the unprotected face of the cliffs, and the jointing of the rocks tends to preserve their vertical character, while the growth of scree material at their foot is an index of their waste since the glacier departed.

EXPLANATION OF PLATE XIII.[3]

Fig. 1.—Mouth of Coumshingaun (Comeragh Mountains) from surface of lowest moraines, showing steep face of middle morainic dam.

Fig. 2.—Coumshingaun (Comeragh Mountains) from Croghaun Hill, showing the lower morainic slope strewn with boulders, and the steep-faced middle dam bearing irregular morainic mounds near edge of lake. Crotty's Rock on skyline near right margin of view.

Fig. 3.—Coumgorra (Comeragh Mountains), showing mouth of inner corrie, from top of lowest shelf of moraine. Outer amphitheatre on right of view.

[1] Jehu: Trans. Roy. Soc. Edinb., vol. xl, pt. 2, No. 20 (1902), pp. 419–467 and references.

[2] Marr: Q.J.G.S., vol. li (1895), p. 35; ibid., vol. lii (1896), p. 12.

[3] [This Plate appeared in the April Number with the first part of Mr. Cowper Reed's paper.—Edit. Geol. Mag.]

REVIEWS.

I.—Geological Survey of Canada. By Robert Bell, M.D., F.R.S., etc., Acting Director. Report on the Klondike Goldfields. By R. G. McConnell, B.A. Part B of Annual Report, vol. xiv. 8vo. Ottawa, 1905.

THIS report is based on field-work carried on during the season of 1903, and completes a preliminary report published in 1900.

The existence of gold on the Yukon has been known since 1869, first in Alaskan, afterwards in Canadian territory. The Klondike district came into notice in connection with gold-mining in the year 1894. The goldfields have an area of about 800 square miles, and are situated east of the Yukon River in latitude 60° North. The streams flowing through the area are all gold-bearing to some extent, but only a limited number have proved remunerative. The Klondike and Indian Rivers, bordering the district on the north and south respectively, are comparatively small streams; both drain into the Yukon. The smaller streams and creeks draining the interior of the district are the sources of the gold.

The geological features of the country may be summarized as follows:—The rocks have a wide range in age, and present great variations in structure and composition, owing to igneous intrusions at different periods and enormous pressure from earth-movements. The oldest and most important formations consist of ancient schists, partly of clastic, partly of igneous origin.

The schists are divided into three series, viz., the Nasina Series (clastic), the Klondike Series, and the Moosehide Series (diabase). The unaltered sedimentary rocks belong to Early Tertiary (Kenai?) and Late Tertiary (Flat-creek Beds). The massive igneous rocks comprise granite, diabase, andesites, quartz porphyries, and serpentine. These rocks are fully described in the report.

A description of the gold-producing creeks with illustrative sections is given, showing the position of the auriferous gravels and their relations to the underlying 'Klondike schists.' The methods used for extracting the gold are either by sinking and drifting or by open-cut work. The gravels, being everywhere frozen, require to be thawed before they can be extracted, and this is done, except in remote districts, by means of steam thawers or by pumps. The gold production of the Yukon territory since the discovery of the Klondike goldfields in 1896 is estimated by the Geological Survey at over 96,000,000 dollars (1896–1903). Nearly the whole of this immense amount was obtained from the various Klondike creeks and benches.[1] It is stated that 'placer' mining will undoubtedly be supplemented, sooner or later, by hydraulic mining on a large scale.

This report is well illustrated with views of the workings and with two maps of the Klondike mining district on a scale of two statute miles to one inch. A. H. F.

[1] Benches represent fragments of older valley-bottoms partially destroyed by the excavation of the present valleys.

II. — UNITED STATES GEOLOGICAL SURVEY. Bulletin No. 268: Series C, Systematic Geology and Palæontology. CHARLES D. WALCOTT, Director. MIOCENE FORAMINIFERA FROM THE MONTEREY SHALE OF CALIFORNIA: WITH A FEW SPECIES FROM THE TEJON FORMATION. By RUFUS M. BAGG, jun. pp. 1–55, plates i–xi. 8vo. Washington, 1905.

THE Miocene Foraminifera described in the above Bulletin were collected by Professor J. C. Branner from the Monterey Shale near Asuncion Station, on the Southern Pacific Railway, in San Luis Obispo County, California.

The Monterey Shale is between 2,000 and 2,500 feet thick here, and forms one broad fold with many small faults. The shale contains layers that are more or less sandy and even flinty. An abundance of well-preserved Foraminifera occur in the softer parts of the shale, the bulk of which is made up of diatoms. The Monterey Shale rests in this region upon sandstones which are referred to the Chico Group; and it is overlain by beds regarded by the author as of Pliocene age, but by Dr. Fairbanks as Upper Miocene.

The result of a study of the fossils yielded an interesting fauna of sixty-six species, including a few varieties, and seventeen genera. The latter comprise *Bulimina, Bolivina, Lagena, Nodosaria, Cristellaria, Uvigerina, Sagrina, Globigerina, Orbulina, Pullenia, Discorbina, Truncatulina, Anomalina, Pulvinulina, Rotalia, Nonionina,* and *Polystomella.* Among these it will be noted that there are no arenaceous genera and species, nor warm water Miliolidæ; that there is only one member of the Nummulitic group, but a large number of rotaline types.

The majority of the forms represented are identical with such as are abundant in the North Atlantic Ocean at the present time, and the author considers that the conditions of oceanic temperature and depth at which the California beds were laid down are fairly represented in that sea. The fossils were probably deposited in waters the depth of which was less than 500 fathoms.

The fauna as a whole is remarkably similar to that of the older Pliocene beds of Monte Bartolomeo (Lake of Garda) described by Johann Egger in 1895, a fact already pointed out by Chapman (1900) in his report on the California Foraminifera (Proc. California Acad. Sci., ser. III, vol. i).

An interesting table is given showing the limits of depth of existing representatives of the fossil Foraminifera found in the Miocene of California. The depths vary from shoal water to upwards of 3,000 fathoms. The habitats of some species are limited to special localities; others have a worldwide oceanic distribution.

The table is followed by a list of the described species, systematically arranged, after which comes a bibliography in which many well-known works are enumerated; finally, the descriptions of the species, and a full index. A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 7th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair. The following communications were read:—

1. "On the occurrence of Limestone of the Lower Carboniferous Series in the Cannock Chase portion of the South Staffordshire Coal-field." By George Marmaduke Cockin, F.G.S.

Silurian limestone underlies the Coal-measures in the southern part of the South Staffordshire Coalfield, and a rock, probably similar, was found in a borehole at No. 2, Cannock Chase Colliery. A shaft was sunk some 30 years ago, about 5 miles north of the latter locality, at No. 1, Fair Oak, but was abandoned, as no workable coal-seam was found. Before the undertaking was abandoned, an exploration heading was driven for 44 yards in the direction of the dip, and from it heads along the strike for 150 yards. In the waste-heaps, which have remained undisturbed since 1875, a number of fossils belonging to the Lower Carboniferous Limestone have been found. A fault must be presumed to bring Carboniferous Limestone into such a position as to be reached by the headings. About 1½ miles north-west of Fair Oak, rocks (determined by Mr. Walcot Gibson as Millstone Grit) were reached by a boring at 396 yards. An account of the strata pierced by the Fair Oak boring is appended.

2. "Liassic Dentaliidæ." By Linsdall Richardson, F.G.S.

Among the fossils collected in the cuttings on the new Honeybourne and Cheltenham Railway were many belonging to the family Dentaliidæ; and as the majority are new, the author has investigated the Liassic members of the family contained in his own collections and in those of numerous museums. The growth of the Scaphopod shell is effected by additions at the anterior end, while the posterior end suffers by wear and absorption. The members of this class are essentially marine, inhabiting deep water, and feeding principally on Foraminifera. The word *Dentalium* is used in the broad sense, and not in the restricted sense of a shell with strong longitudinal costæ. Eight new species are described, and eight species already known are discussed.

II.—March 21st, 1906. — Aubrey Strahan, M.A., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "The Chalk and Drift in Möen." By the Rev. Edwin Hill, M.A., F.G.S.

In 1899 Professor Bonney and the writer published a paper on Möen and Rügen: the present contribution contains results of further studies.

The problem of Möen is to account for portions of Drift, isolated, and seemingly included, in cliffs of Chalk. It has been generally assumed that these portions occupy dislocations, and that the dislocations were either simultaneous with, or subsequent to, the deposition of the Drift. But, in this paper, cases are described where Drift is seen to occupy cavities in dislocations, which had been water-worn, and consequently had been produced, before the advent of the Drift. The assumption hitherto generally made is, therefore, incorrect: the Chalk had been disturbed in pre-Glacial times. A probable assumption that there were pre-Glacial hills and cliffs similar to the present, with similar clefts and furrows in the cliffs, which were covered in Glacial times with a mantle of Drift now in course of removal by denudation, explains every variety of Drift inclusion. These varieties are described, and proofs are given of such an overlying mantle of Drift, even now over 100 feet thick on the flanks of the hills, and rising to their summits.

Differences from the Rügen phenomena are noted and explained. An apparent upward succession of Boulder-clay, shingle-beds, sand, and scattered boulders is discussed.

Slopes of uniform inclination which rise from the beach, often 60 feet and more, to the bases of the vertical cliffs, appear to be talus-slopes. In reality they are everywhere solid Chalk, with only a skin of débris: this suggests post-Glacial changes in sea-level.

Certain weathered-out hollows in cliff-faces indicate a way in which isolated portions of Drift might, when denudation had commenced, be long protected from destruction.

One instance of a Chalk boulder included in Drift emphasizes the general contrast, not likeness, between Möen and Cromer. The position of the Drift in Möen is similar to that of the Boulder-clays at Flamborough and along the Yorkshire coast. Had the Yorkshire Chalk been dislocated as that at Swanage or Lulworth, probably we should have in England similarities to Möen.

The author, with the Chairman's approval, read the following extract from a letter which he had received from Sir John Evans:—

"It is, I do not know how many, years ago that I visited the island of Möen, in company with the late Professor Steenstrup. The impression left on my mind by the abnormal contortions of the Drift was that they might, to a great extent, be due to the corrosion and erosion of the Chalk below, by the infiltration of water charged with carbonic acid. The surface of the Chalk in Hertfordshire is remarkably irregular, with deep indentations and numerous pinnacles. Within less than 100 yards of each other shafts may be sunk through Drift, and the Chalk in one shaft may be 30 or 40 feet below the surface, and in another only 10 or 15 feet. In a shaft about 6 feet in diameter, that I have lately had sunk near Berkhamsted Common, the surface of the Chalk on one side of the shaft is about 6 feet higher than it is on the other.

"On the Great Northern Railway, near Knebworth, there are pipes eroded to a great depth in the Chalk, which must have been formed since Pleistocene times, inasmuch as in the gravels let down in the pipes there are palæolithic implements. If I remember rightly, a similar pipe in the Valley of the Somme, cited by Prestwich, is 90 feet deep."

2. "On the Relations of the Chalk and Boulder-clay near Royston (Hertfordshire)." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.G.S.

On the uplands south of Royston, Mr. H. B. Woodward, F.R.S., has described three sections,[1] which in his opinion indicate that a great ice-sheet, as it advanced from the north, sheared off large masses of Chalk and mixed them up with its ground- or englacial moraine (the Chalky Boulder-clay).

The author points out that this interpretation rests on an hypothesis—namely, that the latter deposit is the direct product of land-ice—which, as it involves some serious difficulties, cannot yet be taken for granted. For instance, this clay in many parts of England contains chalk pebbles, more or less well-rounded, and often striated. But it is improbable that fragments of rock in either a ground- or an englacial moraine would be shaped into ordinary pebbles; and they would be brought into contact so seldom, and for so brief a time, that they would be but little scratched. But these chalk pebbles resemble those formed by water, either in a river-bed or (more probably) on a sea-beach. How, in the latter case, they could be striated Colonel H. W. Feilden showed twenty-eight years ago.

That ice is capable of shearing off and thrusting before it large masses of rock, is also an hypothesis, for which the author, after doing his best to study ice-work in the field, can find no valid evidence. He maintains that these sections do not suggest the above explanation. Passing over that "north of Reed" as unimportant, we come to the Pinner's Cross Pit. Here the Boulder-clay is not, strictly speaking, 'banked up' against the Chalk, as stated by Mr. Woodward, but occupies a hollow in the Chalk, as described by the late Mr. Penning. The Chalk has a fairly high dip, but there is little other sign of mechanical disturbance. In the pit south-west of Newsell's Park, a shear-plane can indeed be seen in one face, which, however, is explicable by ordinary faulting; and on the same face there are (or were) some small clayey patches. A few yards farther to the south-east, Boulder-clay appears above the floor of the pit, filling an arched cavity. This is, no doubt, a singular position, but there is nothing to show that the Chalk has been thrust over the Clay. The author suggests that, as in Möen and occasionally in Rügen, the Clay has been carried down from above into cavities already formed in the Chalk, and quotes a case from the latter island of a clay-filled cavity, which was connected with the surface and might have yielded a section like that in the above-named pit. Penning's diagram shows (probably nearly over this spot) Boulder-clay resting upon the Chalk. So the author maintains that, even if the fundamental hypotheses be true, they are not applicable to these sections.

3. "Brachiopod Homœomorphy: *Pygope, Antinomia, Pygites.*" By S. S. Buckman, F.G.S.

[1] Quart. Journ. Geol. Soc., vol. lix (1903), p. 362.

This paper deals with the diphyoid Terebratulæ, of which so many species have borne the name *Terebratula diphya* (Colonna). It is pointed out that this name is pre-Linnean, and can only date from the time when it was revived by L. von Buch in 1834. Prior to that several names had been given to these shells. The first were *Terebratula cor* and *T. pileus* given by Bruguière in 1792 in the *Journal d'Histoire Naturelle,* his paper in which has been entirely overlooked by workers on these shells. Bruguière's names indicate a perforate and an imperforate species respectively. Consideration is then given to the synonymy of certain diphyoid species:—*T. triangulus,* Valenciennes, in Lamarck, which was actually founded on Bruguière's own figures of his *T. pileus*; *T. triquetra,* Parkinson, which includes two species, a perforate and an imperforate; and *T. antinomia,* Catullo, which covers various species. These and others all antedate *T. diphya,* L. von Buch.

It is pointed out that *Terebratula diphya* is not the type of the genus *Pygope,* as all text-books say; for Link, the author of the generic name, referred only to *T. antinomia,* Catullo. Reasons are given for taking as the type of *Pygope* one of the forms of *T. antinomia* which is considered to be the same species as *T. deltoidea,* Val. Then the latter generic name *Antinomia,* Catullo, is discussed. The genus was founded on five species, and one of them is now selected as the type—the genolectotype. This is *A. dilatata,* Catullo, supposed to be equivalent to *Terebratula antinomia,* Catullo, that is, to what is now selected to be the type of that species. In that case the species would bear the name *Antinomia antinomia* (Cat.). The two generic names *Pygope* and *Antinomia* are employed, because they are supposed to indicate two independent parallel genetic series, whose members differ in size and position of the perforation, and in characters of the lateral margin. But there is yet another series of diphyoids, typified by *Terebratula diphyoides,* d'Orb. It is pointed out that, although the species covered by the name *diphyoides* are very like *Pygope* as now used, yet they all differ in having particular characters in the preperforate stage—a dorsal ridge and a ventral sulcus. For this series de Haan's MS. name *Pygites* is used; and it is supposed that there are three genetic series of diphyoids which have developed independently, and that the remarkable perforate form, with its two lobes joined, has been evolved three times over. A genetic plate is given, figuring for comparison many of the species in the three series, showing their development from the glossothyridoid, to the bifidate, to the perforate (ordinary *T. diphya*) stage; and that then they finish by losing all trace of the perforation, the lobes completely coalescing (the imperforate stage), represented by *Terebratula pileus,* Brug.=*T. triangulus,* Val. in Lamarck.

Synonymies and short notices of the species in the three genera have been given. In compiling them there have been found two papers overlooked by Brachiopod bibliographers—one by E. Newman in the *Zoologist,* naming *T. Duvali,* and one by Catullo.

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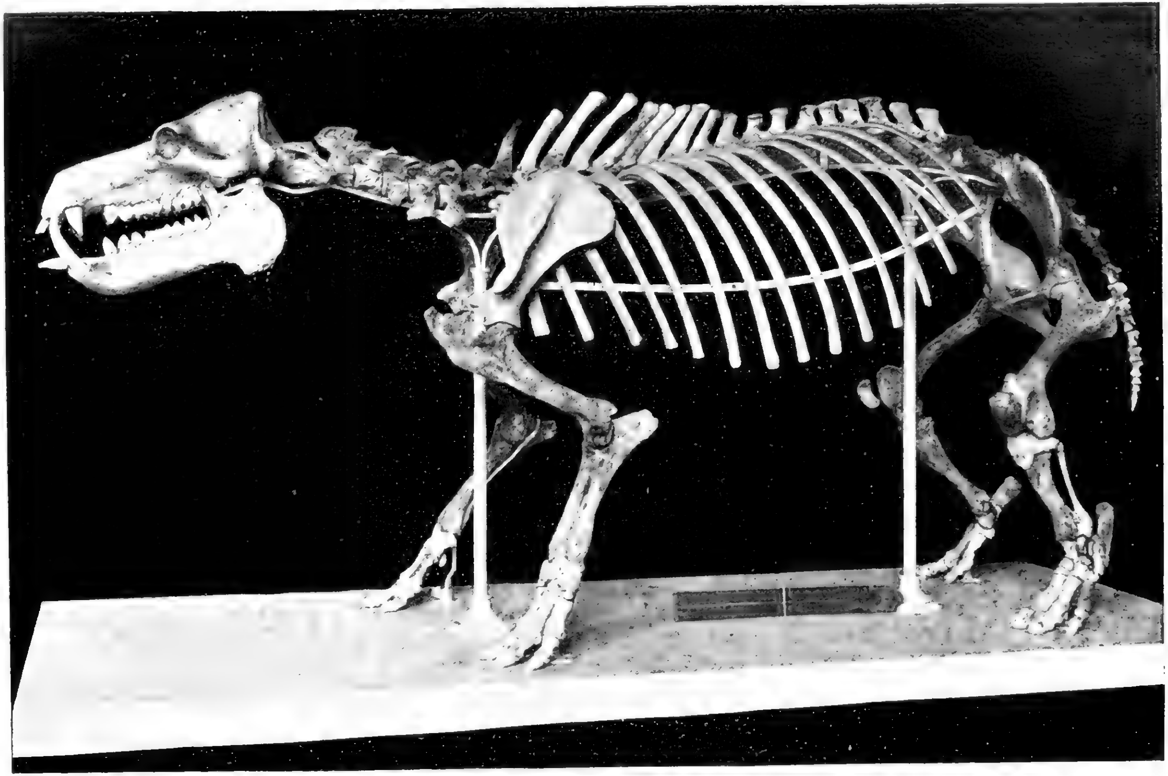


Reconstructed skeleton of *Hippopotamus minutus*, Blainv., from the caves of Cyprus.
Extreme length of specimen, $55\frac{1}{2}$ inches ; height at withers, $26\frac{3}{4}$ inches.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. III.

No. VI.—JUNE, 1906.

ORIGINAL ARTICLES.

I.—The Pigmy Hippopotamus of Cyprus.

By Dorothea M. A. Bate.

(PLATE XV.)

THE accompanying Plate represents a restoration of the skeleton of *Hippopotamus minutus*, Blain., which has lately been completed in the Geological Department of the British Museum (Nat. Hist.). The vertebral column and limbs are almost entirely composed of the actual bones, while the model of the skull has been built up according to the various parts obtained separately. No ribs were preserved in their entirety, neither were perfect specimens of the scapulæ or innominate bones procured. A large amount of material, including that from which the reconstruction of this skeleton has been made, was brought from Cyprus as the result of excavations carried on there by me at different times in 1901–2. The specimen was mounted and the skull modelled with great skill by Mr. F. O. Barlow, Formatore in the British Museum (Nat. Hist.).

As already recorded,[1] a number of Pleistocene deposits containing remains of this pigmy hippopotamus were discovered, five of which were situated in caves in the sea cliffs of Cape Pyla, which has a coastline of about five miles. In one of these, which is known as that of Haghios Saronda, the ossiferous breccia attains a thickness of seven feet, while indications are not wanting to suggest the belief that originally it was of even greater dimensions. In the other caves in the vicinity remains were present in much smaller quantities, this being in most cases evidently partially the result of incursions of the sea subsequent to their deposition. Seven other deposits occur on the south side of the Kerynia Mountains, all within a distance of a few miles, and are situated in low and insignificant cliffs which lie parallel with the axis of the range. Owing to the Upper Eocene formation overlapping the limestone to a greater

[1] Trans. Royal Soc. B., vol. 197 (1904), pp. 347–8.

extent on the northern slopes, this secondary cliff-line is absent on that side, which may account for the fact that no osseous remains were found or heard of on the seaward aspect of these hills.

It has been previously noted[1] that several of the deposits found in the north of the island are now no longer enclosed in caves, the walls and roofs of which have partially or entirely disappeared, probably on account of the very rapid atmospheric erosion which takes place in barren limestone districts in this climate.[2] In each of these, with one exception, there is at least one cave-wall still remaining. The exception is found in that of Haghios Chrysostomos, below the peak of Buffa Vento, which is more isolated from the main mountain mass than any of the others, and is situated in an irregular line of limestone rocks which crest a spur projecting into the overlying formation, which is locally known as the "Hummocks." Herr Alfred Bergeat, who studied the geology of Cyprus, mentions, in a paper published in 1891,[3] the mammalian remains near the monastery of Haghios Chrysostomos, which he considers occur, not in a cave-deposit, but in a breccia[4] of large extent. This opinion was probably due to the almost entire disappearance of the limestone cliff-line which formerly rose above the Kythræan formation, but both the presence of very similar examples in the vicinity, and also the stalagmitic nature of the deposit, which was demonstrated during the excavations made here, appear to leave no doubt as to its original deposition in a cavern.

The finding of the remains of this the smallest of the Hippopotami proved, as Dr. Forsyth Major has already pointed out,[5] to be the re-discovery of an almost forgotten species, first noticed by Cuvier[6] as long ago as the early part of last century, though the locality from which it came was not previously known. Although adding to the number of the pigmy Hippopotami of the Mediterranean islands, *H. minutus* rather unexpectedly proves to have apparently little affinity with these, but to be instead more closely allied to the still surviving Liberian species, which has been considered by several authorities, notably the late Sir William Flower,[7] to be sufficiently distinct to form a separate genus (*Chœropsis*), in which the Cypriote form would now probably have to be included, for, as Dr. Forsyth Major anticipated,[8] the further material obtained since the publication of his paper has shown it to be likewise tetraprotodont.

[1] Op. cit., p. 348.

[2] The same phenomenon has been found to occur among the Pleistocene cave deposits of Crete. See Geol. Mag., Dec. V, Vol. II, May, 1905, pp. 193–202.

[3] "Zur Geologie der Massigen Gesteine der Insel Cypern": Tschermak mineralogische und Petrographische Mittheilungen, Band xii (1891), pp. 278–9.

[4] Included in the Kythræan Series of Messrs. Bellamy & Jukes-Browne. See "The Geology of Cyprus," W. Brendon, Plymouth, 1905.

[5] Geol. Mag., Dec. IV, Vol. IX, May, 1902, pp. 198–9, and Proc. Zool. Soc., 3rd June, 1902, pp. 107–111.

[6] "Ossements Fossiles," 2nd ed., i, pp. 322–331 (1821).

[7] Proc. Zool. Soc., 1887, p. 612.

[8] Proc. Zool. Soc., 3rd June, 1902, pp. 107–111.

On comparing the mounted skeleton of *H. minutus* with that of *H. liberiensis*,[1] it was found that in height and antero-posterior length they agree very closely: the height at the withers in each case being about 2 feet $2\frac{3}{4}$ inches, and the length of the vertebral column (along the ventral curve) about 4 ft. $6\frac{1}{2}$ ins. These measurements are, however, if taken by themselves, decidedly misleading, for, in spite of this apparent similarity in size, the Cypriote species has a much smaller skull, must have been longer in the leg, and altogether the slighter animal of the two. This is especially remarkable in the bones of the limbs and feet, which, when compared, are found to be all noticeably very much more slender in *H. minutus* than in the Liberian species. The same diminutiveness also obtains in the dentition: the antero-posterior length of the upper cheek teeth of one side, taken from specimens in a similar stage of wear, is in *H. liberiensis* 142 mm. and in *H. minutus* 132 mm. Three considerably worn molars in a right mandibular ramus of the latter measure antero-posteriorly 77 mm., while the space occupied by the corresponding, though less abraded, teeth of *H. liberiensis* is 85 mm. In the molars from Cyprus there is even less approach than in those of *H. liberiensis* to the trefoil pattern so characteristic of the worn teeth of the larger Hippopotami, and it may also be mentioned that the upper canines of the West African species are so deeply grooved that the surfaces of wear become practically bilobed in outline, whereas in those of the Cypriote race they are as indicated in Fig. 1, p. 244. The width of the palate is, relatively speaking, similar in the two species.

Dr. Forsyth Major has pointed out[2] one or two peculiarities in the skull of *H. minutus*, and we may add that the outline of its anterior half, when viewed from above, is more regular and uniform than is the case in that of *H. liberiensis*, owing to the maxillæ being less constricted and the premaxillæ further extended and more closely connected with the anterior portion of the maxillæ as shown in Figs. 2 & 3, p. 244, this being especially noticeable when the two skulls are seen side by side. The comparative length of those borders of the maxillæ which adjoin the nasals is considerably greater in *H. minutus* than in the recent pigmy species. Another striking difference is that in the former the upper surface of the skull between the orbits is slightly concave, this hollowed appearance being intensified by the projection of the post-orbital processes of the frontals, which in a slight degree assume the tubular form so conspicuous in *H. amphibius*, but which seems to be altogether absent in *H. liberiensis*.

Darwin has declared[3] that a luxuriant vegetation is not necessary for the maintenance of large species of mammals, but in that case undoubtedly an extensive tract of country must be available to contribute to their support. It is pretty generally supposed that many of the small forms found in islands are the direct result of

[1] Presented to the National Collection by Dr. Büttikofer in 1887.
[2] Proc. Zool. Soc., 1902, pp. 107–111.
[3] "Voyage of the Beagle," 12th ed., Ward, Lock, & Co. (1897), p. 98, etc.

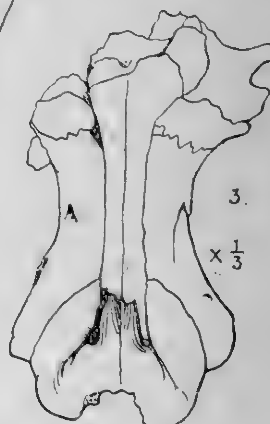


FIG. 1.—Worn surface of left upper canine of *Hippopotamus minutus*, Blainv. Nat. size.

FIG. 2.—Skull of *H. liberiensis*, after Leidy.[1] One-third nat. size.

FIG. 3.—Imperfect skull of *H. minutus*, after Dr. C. I. Forsyth Major.[2] Reduced to one-third nat. size.

[1] Journ. Acad. Nat. Sci. Philadelphia, 1853, ser. II, vol. ii, pl. xxi, fig. 2.
[2] Proc. Zool. Soc., June, 1902, pl. x, fig. 5.

isolation in a limited area by the sea and the consequent shortage of suitable food. On the other hand, pigmy species are not necessarily found in a restricted island habitat, as proved at the present day by the existence of *H. liberiensis*, and perhaps Prjevalsky's Horse might also be cited as an example of this. However, in both these it seems most probable that their diminutive size is rather a primitive than a highly specialised characteristic, and it also seems likely that the same may be true to a great extent in the case of the Cypriote Hippopotamus; the isolation of this last in an island may rather have been chiefly the means of preserving a survivor of an earlier age. As already mentioned, some of the primitive characters, both in the pattern of the teeth and in the structure of the skull of this species, have been noted by Dr. Forsyth Major.[1]

To satisfactorily account for the extinction of the pigmy Hippopotamus and Elephant of Cyprus is a task of extreme difficulty, as there seems to be no evidence that either still existed contemporaneously with man, and, on the other hand, in earlier historical times the island was famed and coveted by different nations, chiefly on account of its great fertility and the extent of its forests. This extinction appears all the more inexplicable when we consider that it must have taken place, comparatively speaking, not so very long after the specialisation in size had been accomplished, for, according to Messrs. Bellamy and Jukes-Browne,[2] Cyprus was still connected with the mainland in early Pleistocene times, since which period *Elephas cypriotes*, at all events, would apparently have attained its later minute proportions. Torrential inundations and other destructive agencies have been suggested as the ultimate reason for the extermination of some of the species peculiar to the Mediterranean islands, and this may be true in some instances, possibly in Malta, but in Cyprus there seems to be no indications of the occurrence of such violent phenomena during the Pleistocene period. It is more likely that some climatic change, and its consequent alteration of the vegetation, was the indirect cause of the disappearance of this pigmy Hippopotamus, which, belonging to an ancient and effete race, was unable in a new direction to "undergo sufficiently rapid variation to enable it to avoid getting so far out of harmony with its surroundings that further existence became impossible."[3]

[1] Op. cit.

[2] See Key to Geological Map of Cyprus, p. 15 (by the former), London, Stanford, 1905; and these two authors on the Geology of Cyprus, Brendon & Son, Plymouth, 1905, pp. 55–6, and fig. 9. With reference to this last, it is interesting to find that Bishop Graziani, writing early in the seventeenth century, says of Cyprus: "'Tis thought she was heretofore a peninsula joining that side of Asia, being separated by the violence of a flood" ("The Sieges of Nicosia and Famagusta," edited by Claude Delaval Cobham, London, 1899).

[3] Dr. C. W. Andrews, "Some Suggestions on Extinction": Geol. Mag., Dec. IV, Vol. X, January, 1903, p. 2.

II.—Fossil Echinoidea from Sinai and Egypt.

By J. W. Gregory, D.Sc., F.R.S., F.G.S.,
Professor of Geology, Glasgow University.

(PLATE XI.)

(*Concluded from the May Number, p.* 227.)

Order ATELOSTOMATA.

Suborder *ASTERNATA*.

Family NUCLEOLITIDÆ.

1. Nucleolites waltheri (Gauthier), 1900.

Echinobrissus waltheri, Gauthier, in Fourtau: Notes E'ch. foss. E'gypte, Cairo (1900), p. 21, pl. L, figs. 8–10.

Distribution.—"Santonian": Berak el Gazal, near Abu Roash (Fourtau). "Eocene": Abu Roash district. L 1379. Coll. H. J. L. Beadnell, Esq. A young broken specimen, east end of the Cretaceous area, near Abu Roash village. I 3796. Coll. H. J. L. Beadnell, Esq.

2. Nucleolites daglensis (Gauthier), 1889.

Echinobrissus daglensis, Gauthier, 1889: E'ch. foss. Sud Hauts-Plateaux Tunisie, p. 41, pl. ii, figs. 24–26.

Distribution.—Cenomanian, "and perhaps also Lower Turonian": Southern Tunis. Marls: lower half of Jebel el Araba, Wadi el Araba, south-westward of Camp 23. L 4120. Coll. by the late T. Barron, Esq. Jebel um Raiyig, north-eastern Sinai. L 3481. Collected by Dr. W. F. Hume.

Dimensions :

				daglensis (Gauthier).					*luynesi* (Lartet's figure).
	mm.	mm.		mm.	mm.	mm.	mm.		mm.
Length ...	19·5	19	...	13	14	16	19	...	18
Breadth ...	18	17	...	10	11·5	13	16	...	15
Height ...	9	8	...	6	7	9	11	...	9·5

It is necessary to compare this species with *N. luynesi*, Cott.,[1] from Mt. Hor, which differs by the more undulating lower surface, and the more anterior position of the highest point in the test.

3. Nucleolites gibbosa (Peron & Gauthier), 1879.

Echinobrissus gibbosus, Peron & Gauthier: E'ch. foss. Algér., fasc. 5 (1879), p. 148, pl. x, figs. 1–4.

The collection includes three specimens, which agree most closely with the above species; but they appear to me to be possibly only variations of *N. daglensis*.

[1] Cotteau, E'ch. foss. recueillis . . . Lartet . . . voyage . . . duc de Luynes: Bull. Soc. géol. France, ser. II, vol. xxvi (1869), p. 535, fig. p. 534. Lartet: Explor. géol. Mer Morte (1877), p. 153, pl. xiii, figs. 15–19.

Distribution.—Middle Cenomanian: Algeria (Bou Saada). Cretaceous Marls: lower half of Jebel el Araba, Wadi el Araba, south-west of Camp 23. L 4120. Collected by the late T. Barron, Esq. Jebel um Raiyig, north-eastern Sinai. L 3481. Collected by Dr. W. F. Hume.

4. NUCLEOLITES MESLEI (Peron & Gauthier), 1881.

Echinobrissus meslei, Peron & Gauthier, 1881: E'ch. foss. Algér., fasc. 7, p. 157, pl. xvi, figs. 7–12.

Distribution.—East end of Abu Roash village. I 3791. Collected by H. J. L. Beadnell, Esq. Fragment from the same locality. I 3796. Collected by H. J. L. Beadnell, Esq.

This collection of 18 specimens of a large *Nucleolites* includes two types; the common type agrees in all respects with the above species except that it is a little lower, as shown by the following table:—

Dimensions:

	I 3791. *a.*	*b.*	*c.*	Average of the three.	*fide* P. & G.	
	mm.	mm.	mm.	mm.	mm.	mm.
Length	31·5	28·5	31	30·33	31	30
Width	28	25·75	27·5	27·08	28	25
Height	14	14	14·5	14·17	15	15
Ratio of length to width	—	—	—	100 : 89	100 : 90	100 : 83
Ratio of length to height	—	—	—	100 : 46·5	100 : 48	100 : 50

Some of the specimens (as number *a* in the above table) are somewhat longer and more pointed at the posterior end; but this seems to me due to the fold on the posterior margin being produced backward instead of downward.

Order STERNATA.

Family SPATANGIDÆ.

Section **Prymnadetinæ.**

HEMIASTER, Desor, 1847.

1. HEMIASTER PSEUDO-FOURNELI, Peron & Gauthier, 1878.

E'ch. foss. Algér., fasc. 4 (1878), p. 113, pl. iv, figs. 5–8.

Distribution.—Cenomanian: Algeria, Batna, etc.; southern side of Jebel Ejjibi, near Ain el Hudhera, Sinai. L 3480. Collected by Dr. W. F. Hume. Cephalopod bed, head of Wadi Ethal. L 3918. Collected by the late T. Barron, Esq.

Dimensions:

	L 3480.	Peron & Gauthier's (figured specimen).
Length	31·5 mm.	33 mm.
Width	30·5 mm.	31 mm.
Height	22 mm.	23 mm.

2. HEMIASTER FOURNELI, Deshayes.

For synonymy, etc., see Fourtau: Révision, p. 631.

Coptosoma abbatei beds, Abu Roash. Three broken specimens. Collected by Mr. Beadnell (I 3787).

3. Hemiaster blanckenhorni, Gauthier, 1900.

In Fourtau: Notes E'ch. foss. E'gypte, p. 23, pl. i, figs. 11, 12.

I 3796 includes one crushed specimen from the eastern end of the Cretaceous area, near Abu Roash village.

4. Hemiaster africanus, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 247, pl. xxv, figs. 10–12.
Cotteau, Peron, & Gauthier: E'ch. foss. Algér., fasc. 6 (1879), p. 58.

Distribution.—Turonian: Batna, etc., Algeria. Cenomanian: Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.; also side of Jebel Ejjibi, near Ain el Hudhera. L 3480.

5. Hemiaster nicaisei, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 326, pl. xxv, figs. 22, 23.

Distribution.—Cenomanian: Algeria (Aumale, Berouaguiah). Cenomanian (?): Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.

6. Hemiaster chauveneti, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 135, pl. viii, figs. 1–5.

Distribution.—Cenomanian: Algeria. Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

7. Hemiaster saadensis, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 125, pl. vi, figs. 1–4.

Distribution.—Cenomanian—Algerian: Bou Saada. Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

8. Hemiaster jullieni, Peron & Gauthier, 1878.

E'ch. foss. Algérie, fasc. 4, p. 124, pl. v, figs. 8–11.

Distribution.—Cenomanian (Rhotomagian): Algeria (Krenchela). Marls at Wadi Ragga, Sinai. L 4223. Collected by the late T. Barron, Esq.

9. Hemiaster battnensis, Coquand, 1862.

Géol. Pal. S. Prov. Constantine: Mém. Soc. E'mul. Provence, vol. ii, p. 248, pl. xxvi, figs. 6–8.
Synonymy, see Cotteau, Peron, & Gauthier: E'ch. foss. Algérie, fasc. 4 (1878), p. 118.

Distribution.—Cenomanian: Algeria. Cephalopod bed, head of Wadi Ethal, Sinai. L 3918. Collected by the late T. Barron, Esq.

LINTHIA, Merian, 1853.

1. ? Linthia roachensis (Gauthier), 1900.

In Fourtau: Notes E'ch. foss. E'gypte, p. 24, pl. i, figs. 13–15.
Linthia roachensis, Dacqué, 1903: Palæontogr., vol. xxx, p. 357.
Hemiaster lusitanicus, de Loriol, 1883: ibid., vol. xxx, p. 39.

Three broken specimens, labelled "Eocene," Abu Roash (I 1379), are not unlikely to be this species, but sand-polishing has removed all the tubercles, and they are badly crushed.

? I 3796. Two specimens, probably of the same form, but both differently crushed. The peripetalous fasciole is distinct, but not the lateral: otherwise they might be *L. roachensis.*

2. Linthia oblonga (d'Orbigny), 1854.

Periaster oblongus, d'Orbigny, 1854: Pal. franç., Terr. crét., vol. vi, p. 275, pl. 900.
Linthia oblonga, Peron & Gauthier, 1880: E'ch. foss. Algérie, fasc. 6, p. 79.
Linthia oblonga, Fourtau, 1899: Rév. E'ch. foss. E'gypte, Mém. Inst. égypt., vol. iii, fasc. 8, p. 631.
Linthia oblonga, R. B. Newton, 1904: *L. oblonga* from Sinai, Geol. Mag. (1904), pp. 441–445, Pl. XV.

The collection of Spatangoids includes a large series from the Cephalopod bed in Wadi Ethal (L 3918), the determination of which has been the most difficult problem in dealing with this collection.

I have not adopted the easiest course in dealing with them, though that, perhaps, would be the right one. That course would be to 'lump' most of them in one species and label it *Linthia oblonga* (Orb.), and also include therein *Hemiaster luynesi,* Cott., and some Algerian echinoids described as *Hemiaster.*

The specimens from Wadi Ethal show the peripetalous fasciole very clearly; and in some of them there are obscure traces of the lateral fasciole. The latter specimens can be safely identified as *L. oblonga,* as has been done by Mr. R. B. Newton. But the majority of the specimens have no lateral fasciole. In many the tuberculation is so well preserved and the peripetalous fasciole is so distinct, that the absence of the lateral fasciole is not due to imperfect preservation. If these specimens are to be included in *Linthia,* the diagnosis of that genus must be amended to the effect that the lateral fasciole may be absent from many specimens of a species. In that case there is no constant difference between *Linthia* and *Hemiaster.*

This conclusion may be the right one, for there is a remarkable parallelism between species of *Hemiaster* and of *Linthia.* Thus the *Hemiaster luynesi* and *H. meslei* and *H. pseudofourneli* may be forms of *L. oblonga* without a recognizable lateral fasciole. *H. pseudofourneli* would be a somewhat thick variety; but the following dimensions given by Newton show that there is a considerable variation in the form of *L. oblonga,* his second specimen being decidedly narrower in proportion to its width than the others:

Dimensions :

Length	...	31 mm.	...	28 mm.	...	30 mm.
Width	...	27 mm.	...	21 mm.	...	27 mm.
Height	...	20 mm.	...	18 mm.	...	19 mm.

[1] Cotteau, E'ch. foss. voyage duc de Luynes: Bull. Soc. géol. France, ser. ii, vol. xxvi (1869), p. 535, fig. p. 534. Better figures are given by Lartet: Explor. géol. Mer Morte (1877), pl. xiv.

The relations of those species of *Hemiaster* and *Linthia* having forms similar to *L. oblonga* can only be satisfactorily determined by a careful study of the specimens from the Mediterranean Cenomanian and Turonian series. This study would show whether the many accepted species of *Hemiaster* in that fauna are mutations or individual variations.

Distribution.—Cenomanian and Turonian: Algeria, Palestine, near Suez, Cephalopod bed, head of Wadi Ethal. L 3918. Collected by the late T. Barron, Esq.

List of Mesozoic Echinoids described in the foregoing paper, giving their Distribution in the various localities.

	Egypt.	Sinai.						
	Abu Roash.	Jebel Ejjibi.	Jebel Gunneh.	Jebel um Raiyig.	Wadi Ethal.	Jebel el Araba.	Wadi Ragga.	
Heterodiadema bigranulatum, n.sp.	...		×					Cenomanian.
Acanthechinopsis humei, n.sp....	...		×					Cen.
Micropedina bipatellis, n.sp. ...	...		×	×				Cen.
Cyphosoma beadnelli, n.sp. ...	East end							
Thylechinus quincuncialis, n.sp.	...				×			
T. trigranulatus, n.sp.	...				×			
Coptosoma abbatei (Gauth.) ...	E. end.							With *H. fourneli*.
C. gunnehensis, n.sp.	...		×					Turonian.
Holectypus cenomanensis, Guér.	...			×		×		Cen.
H. turonensis (Desor)	...				×		×	Tur.
H. larteti (Cott.)	...				×			Mt. Hor.
? *Galerites thomasi* (P. & G.) ...	...				×			Cen. ?
Nucleolites waltheri (Gauth.) ...	E. end.							
N. daglensis (Gauth.)	...			×		×		Cen. & ? Tur.
N. gibbosa (P. & G.)	...			×		×		Cen.
N. meslei (P. & G.)	E. end.							Sen.
Hemiaster pseudo-fourneli, P. & G.	...	×			× {	Ceph. bed		Cen.
H. fourneli, Desh.	E. end.							With *C. abbatei*.
H. blanckenhorni, Gauth. ...	E. end.							
H. africanus, Coq.	...	×			×			Turonian.
H. nicaisei, Coq.	...				×			Cen.
H. chauveneti, P. & G. ...	...						×	Cen.
H. saadensis, P. & G.	...						×	Cen.
H. jullieni, P. & G.	...						×	Ceu.
H. battnensis, Coq.	...				×			Cen.
? *Linthia roachensis* (Gauth.) ...	With *N. waltheri*.							
L. oblonga (Orb.)	...				×			Cen. & Tur.

II. EOCENE AND MIOCENE.

Order ATELOSTOMATA.

Suborder *ASTERNATA.*

Family CASSIDULIDÆ.

Subfamily *ECHINOLAMPINÆ.*

ECHINOLAMPAS, Gray, 1825.

1. Echinolampas globulus, Laube, 1867.

Beitr. Kennt. Ech. vicent. Tert.: Sitz. Akad. Wiss. Wien., vol. lvi, 1, p. 239; and 1868, Denk. Akad. Wiss. Wien., vol. xxix, p. 4, pl. iv, fig. 5.

This species has been twice recorded by M. de Loriol-le-Fort, who, in the later of his excellent accounts of the species, considerably reduced its dimensions.

In his Monograph of 1880[1] he records the length as from 25 to 60 mm., and in that of 1883[2] as from 12 to 26 mm. These specimens (I 1379) from the Eocene of Abu Roash fully agree with the account and figures in his earlier paper. The specimens are of the larger size, 57 mm. long by 41 mm. broad by 34 mm. high. They are nearest, among the larger species, to *E. libycus*, Lor.[3]

2. Echinolampas africanus, de Loriol, 1880.

Op. cit., p. 90, pl. iii, fig. 1; pl. iv, figs. 5, 6; and 1883, op. cit., p. 23, pl. vii, fig. 1.

The following specimens from the Eocene of Sinai were collected by the late Mr. Barron:—

L 4148. Three worn specimens. Nummulite beds, Jebel Wagra, Wadi Feiran, Sinai.

L 3582. Three worn specimens. Top of Nummulite bed, Wadi Khadahid, Sinai.

L 3578. Two worn specimens. Nummulite bed, Wadi Abyad, Sinai.

L 4175. One worn specimen, crushed with depressed petals. Nummulite bed, Jebel el Araba, Wadi el Araba.

Dimensions:

	L 4148.	L 3582.	A crushed specimen. L 3582.	L 3578.	*Fide* De Loriol.
Length ...	84 mm.	74 mm.	90 mm.	86 mm. ... 96 mm.	75 to 100 mm.
Width ...	73·5 mm.	62 mm.	85 mm.	72 mm. ... 78 mm.	—
Height ...	42 mm.	38 mm.	53 mm.	44 mm. ... ?	—
Ratio of length to width ...	100 : 87·5	100 : 84	100 : 95	100 : 84 ... 100 : 81	100 : 85 to 88
Ratio of length to height ...	100 : 50	100 : 51	100 : 59	100 : 51 ... —	100 : 48 to 62; average 50.

[1] P. de Loriol: Mon. E'ch. numm. E'gypte, Mém. Soc. Phys. Nat. Hist. Genève, vol. xxvii (1880), p. 98.

[2] P. de Loriol: Eoc. Echin. Ægypt., Palæont., vol. xxx (1883), pt. 2, p. 27.

[3] Ibid., p. 31, pl. v.

3. Echinolampas fraasi, de Loriol, 1880.

Op. cit., p. 92, pl. v, fig. 1; 1883, op. cit., p. 22, pl. vi.

One specimen with specimens of *Echinolampas africanus*, from the top of the Nummulite beds, Wadi Khadahid, Sinai. L 3582. Collected by the late T. Barron, Esq.

Dimensions:

		Fide de Loriol.
Length	88 mm. (?)	92 mm.
Width	85 mm.	—
Height	53 mm.	—
Ratio of length to width ...	100 : 96 (?)	100 : 84
Ratio of length to height ...	100 : 60 (?)	100 : 67

4. Echinolampas feiranensis, n.sp. (Pl. XI, Figs. 11–14.)

From the locality of Wadi Feiran.

Diagnosis.—Test: the front half is subcircular, but the anterior margin is somewhat flattened; the two sides are well rounded; the posterior end is produced to a blunt rostrum. Hence the slope is subpentagonal. The margin of the actinal surface is flat, but the peristome is in the middle of a broad, fairly deep depression. The upper surface is high; the apex is very excentric anteriorly, and the front slopes steeply forward.

Ambulacra: the petals are long, and reach nearly to the margin of the test. The petals are well developed, and the interporiferous areas are tumid.

Periproct on the rostrum.

Dimensions:

	L 4204 (fig. *a*).					De Loriol. 1880.	1880.
Length ...	38·5 mm.	37 mm.	29 mm.	30 mm.	36·5 mm.	17–30 mm.	18 mm.
Width ...	33 mm.	35 mm.	27·5 mm.	28 mm.	33 mm.		
Height ...	21 mm.	13 mm.	14·5 mm.	11 mm.	17·5 mm.		
Ratio of length to width ...	100 : 91		100 : 95		90	100 : 87–98	100 : 94
Ratio of length to height ...	100 : 54		100 : 50		100 : 48	100 : 56–78	100 : 61
Distance of centre of apex from anterior margin: de Loriol (fig. 4)	14 mm.		10 mm.		14 mm.	12 mm. Length of test, 27·5	
Ratio of length to that distance	100 : 36·3		100 : 34·5		100 : 38·3	100 : 43·6	

Distribution.—Limestone, probably Miocene: south of Wadi Feiran, Sinai. L 4204. Collected by the late T. Barron, Esq.

Figures.—Pl. XI, Figs. 11–14. Fig. 11, a specimen from above, nat. size; Fig. 12, the same specimen from the side, nat. size; Fig. 13, small specimen from the side, nat. size; Fig. 14, base of a third specimen, nat. size.

Affinities.—This species is most nearly allied to *E. crameri*, de Lor.,[1] from which it differs by the subtumid petals, the flatter form, and more anterior position of the apical disc.

The other near ally of *E. feiranensis* is *E. goujoni*, Pomel,[2] from the Lower Eocene of Tunis; but in the form of the peristome that species is much nearer to *E. crameri* than to the new species.

5. Echinolampas aff. insignis, Pomel.

H 2191. Two broken specimens. Near Dara Hill, west of Dara, "close to Miocene, on Eocene and Cretaceous." Eastern side of the Red Sea Hills. Collected by the late T. Barron, Esq.

Two very broken, crushed specimens, length 118 mm., width 117 mm., height 41 mm. (crushed).

III. PLEISTOCENE.

Subclass *REGULARIA ENDOBRANCHIATA.*

Order CIDAROIDA.

Family CIDARIDÆ.

Phyllacanthus imperialis (Lamk.).
Raised beach, Dahab. L 3516.

Subclass *REGULARIA ECTOBRANCHIATA.*

Suborder *ECHININA.*

Family TRIPLECHINIDÆ.

Echinus verruculatus (?).
In Pecten bed, Upper Coral Terrace between Nebk and Sherm, N.E. Sinai. L 4324.

Toxopneustes pileolus (Lamk.).
Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.

Family ECHINOMETRIDÆ.

Echinometra lucunter (Leske).
Raised beach, 20 feet above sea-level. Gharib Lighthouse.

Heterocentrotus mammillatus (Leske).
Shore at Dahab. L 3524.
Many spines. Raised beach, 80 feet above sea-level. Camp 6, Wadi Gueh. K 1558.

[1] De Loriol, 1880: op. cit., p. 100, pl. vi, figs. 4–10. 1883: op. cit., p. 32, pl. iii, fig. 8.

[2] See e.g. Gauthier, Ech. foss. recueillis en 1885 et 1886 dans Hauts-Plateaux Tunisie par Thomas: Explor. Sci. Tunisie, Paris, 1889, p. 94, pl. vi, figs. 12–14.

Raised beach at Dahab. L 3516.
Raised beach, north of Koseir. J 2121–38.
Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.
Lower raised beach, east of Jebel Esh. K 2155.
Raised beach, Camp 4, Wadi Hamrawein. J 1638.
Raised beach, Camp 5, Wadi Gueh. K 1615.

Subclass *IRREGULARIA.*

Order GNATHOSTOMATA.

Suborder *CLYPEASTRINA.*

Family FIBULARIIDÆ.

FIBULARIA VOLVA, Ag.
Raised beach, 20 feet above sea-level. Gharib Lighthouse. J 2058–98.

Family LAGANIDÆ.

LAGANUM DEPRESSUM, Lesson.
Raised beach, Camp 4, Wadi Hamrawein. J 1638.
Pecten bed in cliff between Nebk and Sherm. L 3539.
Raised beach, east of Jebel Esh. J 2154.

Family SCUTELLIDÆ.

ECHINODISCUS sp. (too fragmentary for description).
"Beach deposits," north side of Wadi Feiran. L 4288.

Family CLYPEASTRIDÆ.

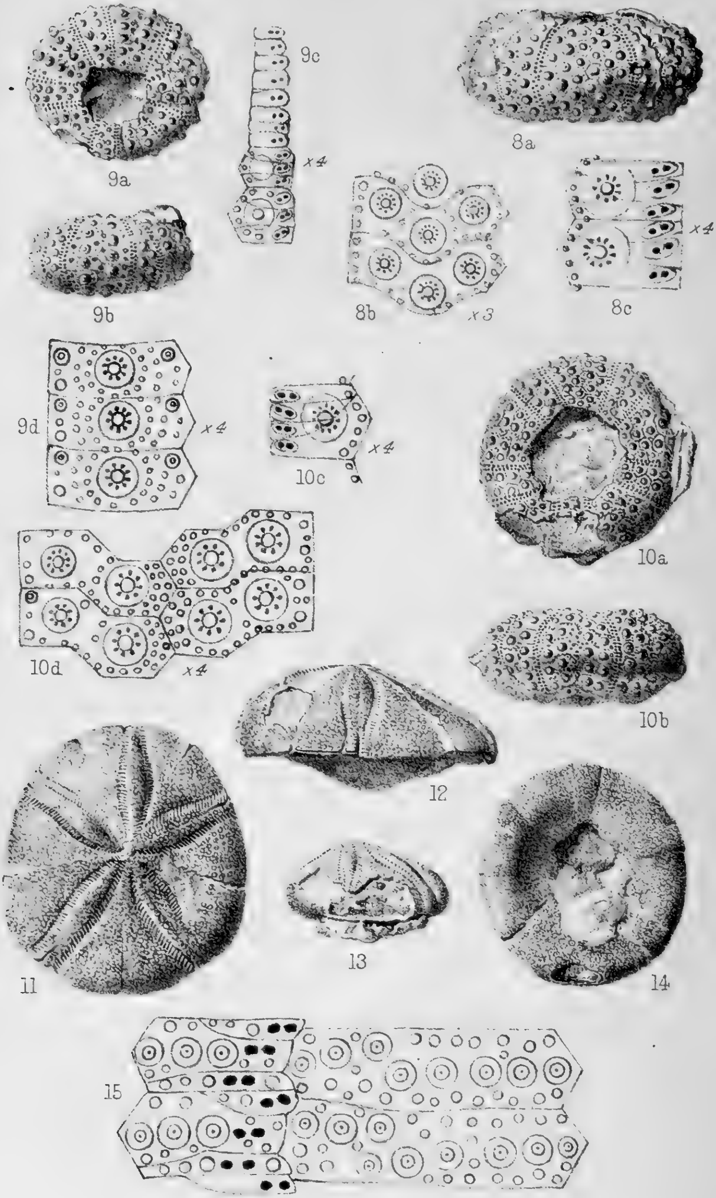
CLYPEASTER SCUTIFORME (Gmel.).
Raised beach, No. 2, west of Camp 7, Wadi Abu Shigeli, north of Kosseir. J 1614.
Raised beach, near Dahab, E. Sinai. L 3494.
Third raised beach between Nebk and Sherm, Sinai. L 3538.

CLYPEASTER HUMILIS (Leske).
Camp 4, Wadi Hamrawein. J 1638.

CLYPEASTER aff. HUMILIS.
Raised beach, Gaa, Camp 23, side of Jebel el Araba. L 3634.

CLYPEASTER sp. young.
Raised beach, Camp 4, Wadi Hamrawein, near Qosseir. J 1638.

CLYPEASTER sp.
Raised beach, north of Qosseir. J 2121–38.
Pecten bed, in cliff between Nebk and Sherm. L 3539.
"Beach deposits," north of Camp 7, south of Wadi Feiran, Sinai. L 4204. Probably fragment of a Miocene species.



E. Drake del. et lith.
West, Newman imp.

Fossil Echinoidea from Sinai & Egypt.

Order ATELOSTOMATA.

BRISSUS CARINATUS (Lamk.).

Raised beach, north of Qosseir. J 2110.

BRISSUS (?) CARINATUS (Lamk.).

Abu Shigeli, 560 feet above sea-level. J 1624.

Wadi Abu Shigeli, 380 feet above sea-level. K 1660.

Indeterminable cast of perhaps a SCHIZASTER, allied to GIBBERULUS, Ag., or perhaps a BRISSOPSIS.

Raised beach, 300 feet above sea-level, Wadi Hamrawein. K 1553.

? SCHIZASTER GIBBERULUS, Ag.

600 feet above sea-level, Camp 4, Wadi Hamrawein. K 1638.

LOVENIA ELONGATA (Gray).

Shore, Dahab. L 3524.

EXPLANATION OF PLATE XI.

FIG. 8.—*Thylechinus quincuncialis*, n.sp. Cenomanian: marls at head of Wadi Ethal, Sinai. L 3872. Collected by the late T. Barron, Esq.

8*a*, a specimen from the side. Nat. size.

8*b*, part of the ambitus, showing the plan of the interambulacral tubercles. × 3 diam.

8*c*, two compound ambulacral plates from the same. × 4 diam.

FIG. 9.—*Thylechinus trigranulatus*, n.sp. Cenomanian: marls at head of Wadi Ethal, Sinai. L 3872. Collected by the late T. Barron, Esq.

9*a*, test from below. Nat. size.

9*b*, from the side. Nat. size.

9*c*, upper part of an ambulacrum, showing the structure of the plates. × 4 diam.

9*d*, part of an interambulacrum at the ambitus. × 4 diam.

FIG. 10.—*Coptosoma gunnehensis*, n.sp. Cenomanian (?): Jebel Gunneh, Sinai. L 3506. Collected by Dr. W. F. Hume.

10*a*, *b*, type-specimen from above, and from the side. Nat. size.

10*c*, a compound ambital ambulacral plate. × 4 diam.

10*d*, ambital interambulacral plates. × 4 diam.

FIGS. 11–14.—*Echinolampas feiranensis*, n.sp. Miocene: south of Wadi Feiran, Sinai. L 4204. Collected by the late T. Barron, Esq.

11, 12, the type-specimen from above and from the side. Nat. size.

13, a small specimen from the side. Nat. size.

14, base of a third specimen. Nat. size.

FIG. 15.—*Micropedina cotteaui*, Coquand. Ambital plates (after Cotteau).

[ERRATUM.—In GEOL. MAG., May number, p. 227, in Explanation of Plate X, Fig. 3, *Acanthechinopsis humei*, n.sp., is, by an error, printed *A. barroni*, n.sp. It is correctly printed as *A. humei* on p. 219, and also in list of species on p. 250.—EDIT. GEOL. MAG.]

III.—SOME NOTES ON ARCHÆAN STRATIGRAPHY.

By F. P. MENNELL, F.G.S.

MUCH has been written concerning the Archæan rocks from a petrographical point of view, but their structural relations have as a rule received little attention. I do not wish to be understood as overlooking the work that has been done in England, and especially in America, of late, and which has added so much to our knowledge of the older rock groups. But when we come to deal with formations of such high antiquity as those which chiefly concern the geologist in South Central Africa, it becomes evident that we can hope to derive little assistance from the observations that have been made in other quarters of the globe. In the European area there is so great a preponderance of sediments whose nature is obvious, and whose structural relations are only just sufficiently complicated to be interesting, that it is far too common to find the schistose rocks indiscriminately lumped together, with the intrusions that invade them, as "igneous and metamorphic," whereas in an Archæan area the basis of all stratigraphical work (if I may use such a term) must be the distinction between the igneous rocks and those which owe their proximate characters to metamorphism, whatever their origin may be. We find, in fact, that even where much time and labour has been spent over these rocks they have resulted in so much controversy and confusion that the geologist in a region like Tropical Africa finds it necessary to discard most of his preconceived ideas and start to frame new generalisations for himself. And how important it is to have clear ideas on the subject will be realised when it is considered that in some countries nearly all the rock groups are of Archæan age. Indeed, as I have already had occasion to point out,[1] the European area is probably unique in its vast development of sedimentary as compared with igneous and metamorphic rocks. In Africa the stratified formations may almost be looked upon in the same light as the drift deposits of England. They merely form a superficial coating through which the 'basement rocks' of the earth's crust constantly protrude except along the coastal fringe. If we look, for example, at the map accompanying Hatch & Corstorphine's recently issued "Geology of South Africa," we find separate colours used for eight different sedimentary formations, which range from 5,000 to over 25,000 feet apiece in thickness. Only one of these is known to be of pre-Archæan date, and what are now admitted to be the Cape equivalents of the seven remaining groups are all officially classed as Archæan by the Cape Geological Survey, and it is certain that none are pre-Silurian. It is perhaps necessary to remind the reader that the once popular correlation of the Transvaal rocks with the Palæozoic strata of the Cape is, as was first pointed out by the writer two years ago, quite untenable, and is now thoroughly discredited.

It may be that the structure of the Central African metamorphic area is simpler than that of similar regions elsewhere, but it is certain that more light is likely to be thrown on some of the most interesting problems of physical geology by the study of its formations than can be thrown upon these last by the results so far obtained in other countries. This may in part be attributed to the great extent and striking lithological features of some of the principal rock groups, and even more perhaps to the clearness of the exposures. Instead of the irritating little isolated patches

[1] "Geology of South Rhodesia," p. 25.

of rock that we are accustomed to in England, we find miles of almost continuous sections along hill-slopes and stream-beds. Even a comparatively bare tract like the Alps is at a disadvantage owing to its ups and downs, whereas the African tablelands afford almost plane surfaces. The remarkable rocks that we used to puzzle over through the microscope are clearly shown in their relations with the other formations, and we are able to form definite conclusions where before we could but guess. The writer has scarcely passed a day for four years without setting foot on Archæan rocks. And he may place on record his deliberate opinion that there is no greater rarity than a "rock of doubtful origin," if we except, perhaps, a few talcose rocks and others usually occurring around mineral deposits, in whose formation hydrothermal agencies have played a great part. There does not appear to be any problem of this nature that combined field and microscopic observation is not competent to solve. The coarsely crystalline schists which have excited so much controversy are found to have been crystalline from the start, as they appear to be invariably of igneous origin, for it can be proved to demonstration in the majority of cases, and must be accepted as an inevitable inference in the rest. Most gneisses are, in fact, igneous rocks of quite recent date in comparison with the sediments into which they can be seen intrusive. These sediments are rarely of a highly crystalline nature, save along contacts, and show their true characters both in their composition and their field relations. Careful search indeed rarely fails to reveal exposures where they are comparatively free from alteration, and show clearly their sedimentary origin even in hand specimens. The groups which have perhaps been the greatest puzzles in other parts of the world are here quickly reduced to order. The banded gneisses, granulites, etc., whose secret seemed so impenetrable when their field relations were imperfectly understood, are no longer a mystery when we can examine them along bare rock surfaces miles in extent. Some are granites modified by movements in consolidation and the local absorption of particular classes of rock; others are schists modified by contact action and impregnation with granitic material; others, again, can be termed neither igneous nor metamorphic, but may be conveniently classed as 'mixed rocks,' having been formed by the interlamination of igneous and other material due to the 'lit par lit' injection processes which characterise the plutonic masses when we get near their roots.

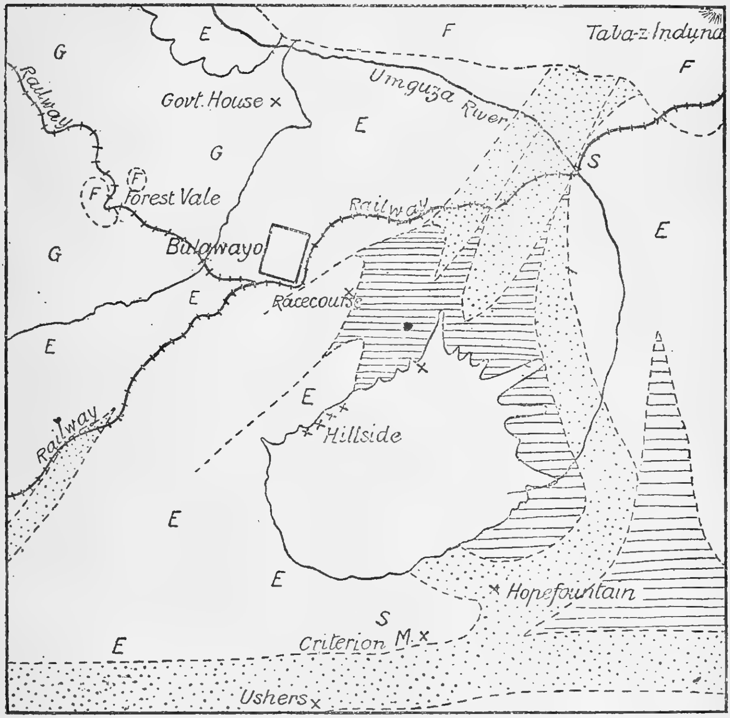
Among rocks such as we have alluded to, the principles of ordinary stratigraphy have little application. Terms like dip and strike become almost meaningless, and the structural relations of the rocks have to be made out from quite other considerations than superposition. The apparent dip is simply that of foliation, and though the strike often coincides, as pointed out by Judd,[1] with the real direction of the strata, this is by no means always the case, as may soon be found out by the simple experiment of following the apparent strike of a band with well-marked lithological characters

[1] Student's Lyell, p. 549.

Definite evidence of the relative ages of different formations is not often easy to obtain. Even if the dips could be relied upon, they are usually vertical or nearly so. There is one point, however, to which attention may be drawn. A little consideration will show that the great granite masses which are so important a feature of these areas must, as a rule, indicate anticlinal or dome-like structures, and we find in fact that where the dips depart from the vertical they are nearly always away from the granites. Where this is the case the relative distances of the different rocks from the granites may be taken as one of the chief aids in determining the succession. For it stands to reason that the oldest beds will be nearest the axis of elevation marked by the granite. Any indication, however, of marked transgression on the part of the igneous rock, such as dip of the foliation *towards* the latter, or the strike of the schists being directly into it, prevents such a criterion being relied on. I may say, however, that even where the dips are reversed the rocks generally occur in their normal succession, as determined elsewhere. An important point to remember is that metamorphosed igneous intrusions figuring amongst the schists may behave as rocks of any date earlier than their real period of formation. This follows naturally from their protrusion from below, and hence it is very difficult in some cases to distinguish between them and the much older rocks on which some of the schists of sedimentary origin (in which they are intrusive) have been laid down. Their intrusive nature has to be inferred from (1) petrological characters, (2) the way in which they make unexpected appearances among the old sediments, (3) such traces as may survive of contact action produced by them, (4) absence of pebbles derived from them in such conglomeratic beds as may occur.

The last reference to conglomerates reminds us of what an important feature they may be in Archæan stratigraphy. Very few developments of Archæan rocks fail to show important conglomerate beds, and they are simply invaluable as datum-lines. Not only are they readily recognised in the field as a rule, but their pebbles afford most important evidence of their age. Thus the relative ages of the two most important sedimentary series in Rhodesia is at once determined by the fact that one of them, the Conglomeratic series as it may be called, contains numerous pebbles of the other, which I have termed the Banded Ironstone series. The two sets of beds, though of enormous thickness, are folded together in the most intricate manner, and though their order of superposition was originally determined by me solely on the strength of the evidence afforded by their general relative distance from the granite, it is very satisfactory to get the additional proof given by the pebbles.

Even where the granites are transgressive in a marked degree, evidence of the order of succession of the metamorphic rocks may sometimes be obtained from carefully considering their relations to the granite. We may take an actual instance from the neighbourhood of Bulawayo. The figure, representing an area about 18 miles across, shows the general structure of the schistose rocks round the Hillside intrusion (consisting chiefly of a remarkable type of augite-microcline syenite). The sketch is rather diagrammatic, owing to the lack of any detailed topographical maps, but though the exact outlines of the various groups may require alteration it may be taken as a fair representation of the facts. The dotted areas are covered by the Conglomerate series, and the lined ones by the Banded Ironstones (altered fine mechanical sediments, characterised by a jaspery appearance, and a banding due to the differences in the iron contents of the various layers), while the unshaded portions are occupied by the schists of igneous origin and other rocks. The



Sketch-plan of Hillside Granite Mass, showing relations to the surrounding rocks. Granite-schist boundaries solid, all others dotted. Banded Ironstone, lined; Conglomerate, spotted. F, Forest Sandstone; E, Epidiorite, etc.; S, Chlorite Schists; G, Granite.

east and west trend seen at the bottom of the figure is due to what may be termed the Matopo system of folds, as it resulted in the rising up of the great Matopo granite mass, while above there is seen a tendency to parallelism with the edge of the granite to the westward. The Hillside intrusion has obviously risen by eating its way upward, and not primarily owing to the folding of the schists, which are not much thrown out of their course in its neighbourhood. But the first impulse must all the same have been due to an incipient fold, and though it is so slight it affords an important clue to the structure of the area. The apparent dip of the beds is vertical, as near as may be, but though this may represent the position on a small scale the *general dip* (or the *true dip*) of the beds cannot be very steep, as may be inferred from the diagram. For slight as has been the disturbance of the beds, the tilting has been sufficient to prevent the conglomerate from anywhere coming into actual contact with the intrusion on the north or east. It is evident from this, first, that the Banded Ironstone is the older rock, and further, since denudation has entirely removed the conglomerate from its surface, even though the uplift has been so slight, that the folds cannot be very sharp. If they were, the conglomerate would not wedge out in the way it does before coming close to the intrusion. On the south side of the intrusion there is probably extensive faulting where the two systems of folds meet, for the Basement schists run as a wedge into the conglomerate, without any intervening Banded Ironstone. This will account for the difference in structure that is shown.

A point of considerable importance in all Archæan areas is the relation of schists and granite. As Professor Bonney points out, the cases of gradation from mica-schist through gneiss into granite are due merely to the fact that a kind of mica-schist is produced through the crushing of gneiss, and the latter itself from the granite.[1] But even this is a rare phenomenon, for true mica-schists are not at all common in my experience, and I know of hardly any so-called gneiss which is not obviously an igneous rock—nearly always a granite which has become somewhat 'streaky' before complete consolidation. To the unaccustomed eye, however, it is not at first by any means a simple matter to determine whether a granite is intrusive or not. I may say that though it was perfectly obvious from the undisturbed condition of the granite, and the much folded state of the surrounding districts near Bulawayo, that the former must be intrusive, I was a long time in bringing to light unquestionable evidence on the point. Indeed, if it had not been for a lucky chance taking me over the magnificent contact section of the Matopo granite, in an out-of-the-way locality near Figtree, it might have been two years instead of only one before I was able to interpret the evidence near Bulawayo. For the evidence is precisely what has led many geologists into recording instances of supposed gradation between schists and granite, or, on the other hand, into denying the intrusive character of the granite. Dr. Hatch, for example, after making a tour through Rhodesia,[2] actually came to the conclusion that the schists were intrusions in the granite (!), though he has since retracted this opinion in consequence of the

[1] Proc. Geol. Assoc., vol. xv, p. 4.
[2] Geol. Mag., 1895, pp. 193, etc.

evidence adduced by me to the contrary.[1] The dome-like structure of the schists round most of the granite masses is readily accounted for on the idea of the greater age of the latter. What has, however, given rise to the greatest confusion is the fact that at their roots granite masses do not show those features which we have learnt to regard as characteristic of intrusion where we have seen them, as is generally the case in Europe, invading normal sediments. Actual dykes are rare, and do not extend far from the main mass of the rock. The characteristic feature of the invasion of crystalline schists is in fact the production by 'lit-par-lit injection' of those very rocks which have aroused the greatest amount of controversy. Once this fact is realised, much becomes clear that before was very far from it. The scantiness of dyke-like protrusions is readily explained. At great depths the formation of open fissures is scarcely possible; eruptive activity is naturally prominent only in the upper part of a mass. The offshoots from the deep-seated portions must corrode a way into the surrounding rocks, or insinuate their material between their laminæ. The last process is the usual one, and even the few large dykes that are seen are mere feeders by which the injection is carried on, and which soon become exhausted in the process. They therefore scarcely ever extend beyond the zone of injection 'lit par lit,' though as this may be over a mile across, that would not prevent them being prominent, and their extreme rarity is rendered the more evident.

The section at Figtree referred to above is one of those rare occurrences which outdo textbook diagrams in clearness. There are excellent exposures along the spruit-beds, and we may see large dykes running into the schists for hundreds of yards, as well as every intermediate stage between such features and the insinuation on a microscopic scale of granitic material between the foliation planes of the schists. Sometimes the granitic and sometimes the schistose material has, owing to slight movements, been broken up into discontinuous threads. Thus we see one rock forming a matrix enclosing a series of lenticles of the other, and subsequent diffusion of material, or possibly actual melting, has in some cases also led to the formation of typical banded gneisses, while epidosites are also found, due no doubt to what Dr. Callaway calls 'secondary injection.' When once a section like that described has been seen, it is easy to interpret more obscure ones in other places. Not that other sections are necessarily obscure at all; in fact, when the unfamiliarity has been overcome, it is an easy matter from the nature of the rocks to predict the proximity of granite when crossing a metamorphic area, or of schists when traversing an igneous one. In a number of localities it is very interesting to trace the gradual changes that take place. Starting, for instance, from beyond the Rifle Kopje at Bulawayo, we begin with coarsely crystalline, unfoliated 'epidiorites,' which, in spite of amphibolisation, etc., retain an ophitic structure, which puts their original nature beyond doubt. Approaching the granite going nearly west,

[1] "Geology of South Africa," 1905, p. 98.

the rocks become more and more foliated in appearance, then igneous material begins to show between the folia, and we come to half-igneous, half-metamorphic 'banded gneisses' at what we may take as the junction. Inside the igneous mass huge fragments of what was originally schist may often be seen, which by fusion and impregnation, in the absence of stirring movements, fully bear out Professor Cole's contention that "masses of quartz-diorite arise as products of admixture where granite intrudes into more basic masses."

Of course, normal contact rocks are seen where the old sedimentaries are invaded, but from what has been said on the question of relative age, it will be inferred that this is comparatively rare. I have nevertheless been able to record from time to time the presence of nearly all the characteristic contact minerals, like andalusite, fibrolite, kyanite, cordierite, etc., chiefly from 'Banded Ironstone' junctions. But the granite masses have kept as a rule well within bounds, and rarely break through their covering of the old Basement schists or those of igneous origin. But in the absence of actual invasion by a granite mass, it is fairly obvious whether or no the latter must be regarded as intrusive. The usual intense folding of the schists leaves little room for doubt as a rule, for rocks involved in movements which have left the granite undisturbed must necessarily be of greater age.

I am afraid some of the points discussed above may be regarded as of a rather obvious nature. My excuse for putting them into writing must be that they are seldom referred to in geological works and are almost persistently overlooked in dealing with the structure of metamorphic areas.

IV.—The River Cefni in Anglesey.

By Edward Greenly, F.G.S.

Many years ago, when discussing the origin of the Menai Straits, attention was drawn by Ramsay to the existence of several other valleys running in the same direction, north-east and south-west. Not only is this the case, however, but the valleys of the dominant system that traverses the plateau of Anglesey have the same trend, ridge and trough alternating with wonderful regularity, as far, at any rate, as Llanerchymedd, a distance of some 12 miles from the Straits.

Much less conspicuous, for the most part, though more numerous than at first sight appears, are certain valleys running at right angles to those of the dominant system, and therefore north-west and south-east. They may drain either to north-west or south-east. They are unlike those of the dominant system in almost every particular. Those are long and straight: these are short and sharply winding. Those are broad and relatively shallow, these narrow and relatively deep. Those are generally bounded by gently sloping sides, these by steep and even precipitous sides. Much the largest is that through which the railway has been taken, just beyond the little market town of Llangefni.

The River Cefni is the name given to a very complicated system of streams, which, with all its branches, drains some 60 square miles of the interior of Anglesey. Entering the great hollow of the Malldraeth Marsh, which, as is well known, belongs to the dominant system, on its north-west side, at a point about a mile below Llangefni, the combined waters then turn round to the south-west, and find their way out to sea in Malldraeth Bay.

The Malldraeth Marsh is practically at sea-level, and until the year 1788[1] was flooded by the sea at spring tides. It was then reclaimed, and the river embanked and straightened for a distance of some six miles from its mouth; but the deserted meanders of the old river can be traced in many places as a series of stagnant, crescent-shaped pools along the alluvial plain.

Between the Marsh and Llangefni the river runs a little east of south in a comparatively open valley, chiefly cut in Carboniferous rocks. But at Llangefni it emerges, rather suddenly, from a ravine, which is excavated in schists and quartzites of the ancient complex, with a general N.E.–S.W. strike. This ravine extends for about 1¼ miles, almost exactly north-west, and is the most striking valley of the kind in the island. It is 140 feet deep at the wood's end by Pandy,[2] and in places less than 400 feet wide at the top, with precipitous and rocky sides, and it describes bold and sweeping curves in its course. In short, it is a perfectly typical water-cut valley, and differs in the most striking manner from the valleys of the dominant type.

But, at its upper end, instead of proceeding from an upland hollow in the same direction, we find that it issues, almost at right angles, from the side of a N.E.–S.W. valley of the dominant type, which extends for several miles to right and left of the exit.

Now this hollow, which may be called the Trefollwyn Valley, after a farmhouse in it near the railway, does not open out to the south-west like the Straits, the Malldraeth, and most others of the class. It is a closed oval basin, and its waters all converge to the head of the Cefni Ravine, and pass out that way at a point midway along its south-east side.

The further upper waters are very complex, and raise problems of their own, which cannot be dealt with in this paper, and which, indeed, I do not feel that I understand. But the anomalous system here described seems to throw some light on the relation of the two types of valley and their mode of origin. For the Trefollwyn Valley could not have been in existence when the Cefni Ravine was in course of excavation. Its south-west barrier, at Tai Mona, on the Holyhead Road, is less than 150 feet above sea-level,

[1] Information kindly supplied by Mr. Thomas Prichard, of Llwydiarth Esgob, Anglesey, from the records of the Drainage Commissioners.

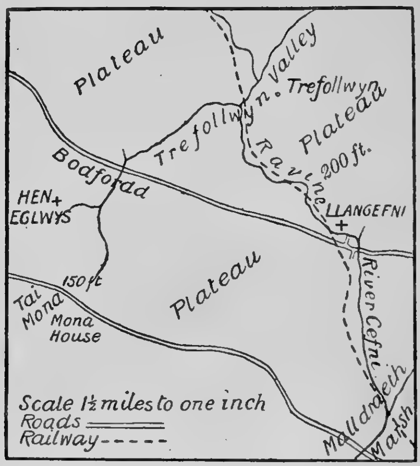
[2] I am indebted for this measurement to the kindness of Mr. Tobias Clegg, F.G.S., of Llangefni County School, who very ingeniously determined it by means of a kind of extemporized theodolite.

whereas the highest part of the plateau trenched by the Ravine is about 200 feet (see Map), so that the waters of a lake lying in the basin would have chosen the south-west exit and deepened that channel.

Nor can we postulate in this case an ice-dam such as those that have been appealed to with such striking success in Cleveland and other regions. There is not the smallest evidence of such a dam, the glaciation being steadily from north-east to south-west, with mere local variations of direction.

All the evidence goes to show that the Trefollwyn Valley is the later.

Now, nearly opposite to the exit at the Ravine's Head, a small stream enters the Trefollwyn Valley on its further side, after a course of about a mile from the north-west. It has no name on the maps, but the railway has been carried quite near to its south-west banks. It is cut in rock, not merely in drifts.



Sketch-map of part of course of River Cefni.

This channel is in the natural position for the apparently vanished upper portion of the Cefni. The fall would be slight, but there would be a fall, enough to make such a continuation possible, and ample if we allow for cutting back as well as cutting down of the lower part of the course. How, then, did it come to be so strikingly severed from its lower portion by the broad valley of Trefollwyn?

Admitting that 'subsequent' tributaries of the Cefni may have initiated that hollow, it is not easy to see how, with so short a course and so slight a fall, especially from the south-west (if, indeed, there was not a fall *to* the south-west, which seems much more likely), they could have produced one of such dimensions, for it is both deep[1] and broad.

[1] It is floored by alluvium, and its real bottom may even be below the level of the rock at the exit.

Nor does underground structure help us in any way. Though it is likely enough that there may be some fault or line of weakness along the hollow, there is certainly none of any importance.[1]

Let us consider the relation of the two valley systems to the greatest of Post-Tertiary events, the Glacial Period. The valleys of the dominant system coincide, as is well known, with the general direction of glaciation, and contain abundance of Glacial Drift. They are either of Glacial age or older, and if we admit the possibility of glacial erosion, may have been produced by the ice, as was suggested by Ramsay, or, at any rate, deepened and enlarged by it.

The Ravine, lying directly across the path of the ice, cannot have been produced by it, and must be either Pre- or Post-Glacial. It must therefore be Pre-Glacial, as we have seen that it must be older than the Trefollwyn Valley. Confirmation of this is found in the presence in its bottom of Boulder-clay, undisturbed as far as I can see, at the south point of the great bend west of Pandy.

The Cefni, then, is a Pre-Glacial river.

If now we suppose that it received two small 'subsequent' tributaries from north-east and south-west, which met near the farmhouse of Trefollwyn, and that their combined hollows were deepened and greatly widened by glacial erosion to form the large valley of that name, we shall be able to understand the severance of the two portions of the Pre-Glacial Cefni, the production of the curious closed oval hollow, and the anomalous configuration and drainage of the present day.

Indeed, it seems probable that in Pre-Glacial Anglesey the drainage to north-west or south-east was much more continuous and systematic than it is now, and that the history of the present anomalous drainage cannot be understood without reference to the events of the Glacial Period.

A curious and very interesting consideration in connection with the ancient river Cefni is that, in the earlier stages of its history, far back in Pre-Glacial time, there must have been a fine waterfall close to where is now Llangefni Station. For, at that point, the river has cut through a lenticular band of very hard quartzite, about 100 feet thick, which is conspicuous from the Station, as of it are composed the white crags below the fir-trees just opposite. Resisting erosion much more strongly than the schist on either side of it, it gives rise, even now, to a rapid. In the early stages of erosion this rock, while freely allowing the river to cut *back* to it from below, must have retarded cutting *down* in its rear for a very long time: and consequently for long ages a fine cataract must have poured over a crag some 80 or 100 feet in height. Like Gray's flower in the famous Elegy, it came into being, and then dwindled gradually away, unwatched by any but the old wild beasts, and perhaps by some men almost as wild.

[1] A fault which partly coincides with the course of the Cefni between the town and the marsh does not pass into the Ravine, but somewhat to the eastward.

REVIEWS.

I.—The Extinct Animals of Egypt. A Descriptive Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt, based on the Collection of the Egyptian Government in the Geological Museum, Cairo, and on the collection in the British Museum (Natural History), London. By Charles William Andrews, D.Sc., F.R.S. Printed by order of the Trustees of the British Museum, 1906. 4to; pp. xxxviii and 324, with a photogravure page frontispiece of the skull of *Arsinoitherium Zitteli*, 99 figures in the text, and 26 quarto plates. (London: sold by Dulau & Co., 37, Soho Square, W., and other Booksellers. Price 35*s*.)

AMONG recent discoveries in palæontology none have excited more interest than the Lower Tertiary Vertebrate faunas of the Fayûm. They add so much to our knowledge of the primitive Mammalia, especially of the Hyracoidea, Proboscidea, Sirenia, and Cetacea, that an exhaustive account of them, so far as discovered, had become essential. The Trustees of the British Museum have therefore availed themselves of the generous co-operation of the Egyptian Government to produce a Descriptive Catalogue of all the more important fossils by which these ancient faunas are at present known. The collection now in the Geological Museum, Cairo, was made by Mr. H. J. L. Beadnell under the direction of Captain H. G. Lyons, F.R.S., Director-General of the Egyptian Surveys, while that in the Geological Department of the British Museum was made partly by Dr. C. W. Andrews, the author of this Descriptive Catalogue, and partly by donation of duplicates from the Egyptian Government. During the past four years Dr. Andrews has had the opportunity of studying both these collections in detail, and has himself enjoyed the rare pleasure of assisting in the extraction of many of the specimens from the matrix in the Fayûm. The result is the present valuable monograph, which testifies alike to the ability of the author and the wise generosity of the Trustees in instigating its publication.

The Fayûm, the lake-province of Egypt, is a district occupying a depression in the desert to the west of the Nile Valley opposite Wasta, a small town about fifty-seven miles south of Cairo. This depression, which is roughly circular in outline, is separated from the river-valley by a belt of desert varying in width from about a mile and a half to some six or seven miles, and crossed at one point by a canal, the Bahr-el-Yusef, which runs through a narrow strip of low ground, and is practically the only source of water-supply for the whole district. The water thus brought in from the Nile is distributed by irrigation canals to the cultivated part of the district, and the surplus eventually finds its way through a number of channels, some of which form picturesque gorges, to the lowest part of the depression, occupied by a large expanse of brackish water, the Birket-el-Qurun. This lake is about twenty-five miles long, with a maximum width of only six miles; it is very shallow, the maximum depth at present being about sixteen or seventeen feet, and its shores in most places are very low and gently sloping. In Pleistocene times the floor of the depression was occupied by a body of water of vastly greater area than the present lake, evidences of its former extent being found in the widely spread lacustrine deposits, chiefly clays, containing in addition to numerous Mollusca, remains of *Elephas africanus*, *Hippopotamus*, *Bubalis*, *Canis*, together with those of Crocodiles, Chelonians, and Fishes. In one or two places also numerous stumps of trees of considerable size occur, indicating that in some parts, at least, in the neighbourhood of the water the country was wooded. Later, within the historic period (2778 B.C.), the lake was converted into an artificially controlled reservoir, Lake Mœris, and was employed to regulate the supply of water in years of exceptionally high and low Nile floods. At this date, though smaller than the earlier Pleistocene lake, the water-covered area was far greater than at the present time, indications of its former extent being found in old shore-lines, still fringed with the stumps of tamarisk bushes, and in the ruins of temples and cities. These remains are now separated from the water by miles of desert. Later still, probably in Ptolemaic times, the lake ceased to be used as a reservoir, and the quantity of water admitted to the Fayûm was limited, so far as possible, to the amount actually required for the irrigation of the district.

A page-size geological map, reproduced from Mr. H. J. L. Beadnell's Report on the Topography and Geology of the Fayûm Province (Survey Dept. Cairo, 1905), is added at p. vi of Dr. Andrews' Introduction, on which report the geological sketch given by him is mainly founded.[1]

With only one or two exceptions, the whole of the vertebrate remains described in the present volume are derived from the Middle and Upper Eocene deposits lying on the northern side of the lake. The list comprises:—

MAMMALIA.

Arsinoitherium, 2 species.
Saghatherium, 4 species.
Megalohyrax, 2 species.
Mœritherium, 4 species.
Palæomastodon, 4 species.
Phiomia serridens.
Barytherium grave.
Ancodon, 3 species.
Rhagatherium ægyptiacum.
Geniohyus, 3 species.
Eosiren libyca.
Hyænodon sp.
Pterodon africanus.
Apterodon macrognathus.
Sinopa ethiopica.
Zeuglodon, 2 species.
Prozeuglodon atrox.

AVES.

Eremopezus eocænus.

REPTILIA.

Crocodilus, 3 species.
Tomistoma, 3 species.
Psephophorus eocænus.
Testudo, 3 species.
Thalassochelys libyca.
Podocnemis, 2 species.
Stereogenys, 2 species.
Gigantophis garstini.
Pterosphenus schweinfurthi.

PISCES.

Fajumia schweinfurthi.
Socnopæa grandis.
Pristis fajumensis.
Propristis schweinfurthi.
Eopristis reinachi.
Aëtobatis sp.
Carcharodon sp.

[1] See also "The Geology of the Fayûm Province of Egypt": GEOL. MAG., 1905, p. 516.

Taking the collections in the British Museum and in the Geological Museum at Cairo as a whole, we find that both in point of numbers and interest the Mammals are by far the most important; next to these come the Reptiles, while the Birds are represented by mere fragments of a single species. The Mammals fall under three sections—(1) those truly endemic to the Ethiopian region; these occur both in the Upper and Middle Eocene beds, and include such genera as *Mœritherium, Palæomastodon, Arsinoitherium, Barytherium, Megalohyrax, Saghatherium,* and perhaps *Geniohyus*; (2) forms of which close allies occur in other regions in approximately contemporary deposits; these, so far as at present known, occur only in the Upper Eocene beds, and include such genera as *Ancodon, Rhagatherium, Hyænodon, Pterodon, Apterodon,* and *Sinopa*; (3) the aquatic Mammals so far not found in the Upper Eocene beds, and comprising *Eosiren, Zeuglodon,* and *Prozeuglodon.* It seems probable that some of these last, like the genera included in section (1), are of endemic origin, having originated from land-mammals inhabiting the region. Of the Subungulates, by far the most striking of the new forms is *Arsinoitherium,* first discovered by Mr. Beadnell in 1900, and since found in considerable numbers, so that nearly all parts of the animal are known, and a complete figure of the skeleton is given on p. 60, $\frac{1}{16}$ nat. size. Figures of the great bicorned skull were given in the Geological Magazine for 1903, Plates XXIII and XXIV.

In general appearance *Arsinoitherium* must have been somewhat like a large and heavily-built Rhinoceros, with two pairs of horns, the larger pair upon the front of the head and the smaller ones behind. Unlike the horns of Rhinoceros, these were solid bony outgrowths of the skull, although most likely they were, in life, sheathed in horn. The muzzle was very narrow, and not suited for grazing, and the animal probably browsed on low bushes and herbage, grasping its food by means of a prehensile tongue or by a mobile extension of the snout as in the Tapir. The height from the ground to the back in the skeleton did not exceed 6, or in life 6½ to 7 feet. Although *Arsinoitherium* is certainly the most extraordinary of the Ungulates found in these beds, the remains of the primitive members of the Proboscidea are perhaps of greater scientific interest, as they help to fill, at least to a large extent, one of the most obvious gaps in our knowledge of the extinct Mammalia.

Previous to their discovery the earliest Proboscideans known were from the Lower Miocene of Europe and North Africa, no other earlier deposits yielding any trace of them. It had been suggested by Tullberg and others that Africa was a centre of mammalian radiation, and among other groups that the Proboscidea probably migrated thence in the early Miocene.

The researches of Dr. Andrews have proved that the earliest traces of land animals from the Eocene of Africa include remains of *primitive* Proboscidea as well as early forms of Hyracoidea, Sirenia, and perhaps some other groups.

The earliest known form of Proboscidean was *Mœritherium* from the Middle Eocene extending to the Upper Eocene. The animal was about the size of a Tapir, and had a nearly complete Eutherian dentition.

This was followed in point of time by *Palæomastodon*, represented by four species, the largest, *P. beadnelli*, being about the size of a half-grown Indian elephant. The next form, *Tetrabelodon angustidens*, preceded the advent of the *Mastodon*, which, in its turn, was replaced by the true elephants of later Tertiary and modern times.

The position of *Barytherium* in relation to the other Ungulates is still uncertain. It suggests relationship to *Uintatherium* and to the Pyrotheriidæ, but more remains are probably needed in order to speak with certainty as to its affinities.

In the Fayûm the Sirenia are represented by one genus only, *Eosiren*, but in the earlier Mokattam Hills, near Cairo, other and more primitive types occur. There seems considerable evidence in favour of de Blainville's view that they are intimately related to the Proboscidea.

Dr. Andrews has also worked out some interesting details in regard to the Zeuglodonts of the Fayûm. These, taken in connection with a species *Protocetus atavus* (described by Professor E. Fraas) from the limestone of Mokattam, form a complete transitional series, as regards their dentition, from the Creodonts to the true Zeuglodonts. In *Prozeuglodon* the canine is distinctly larger than the teeth before and behind it, and the premolars have inner buttresses, supported by a third root.

Numerous figures and descriptions of Egyptian Vertebrates have already appeared in the Geological Magazine; namely, in 1902, pp. 433–439, Pl. XXI; 1903, pp. 225, 337, 529, 531; 1904, pp. 109, 157, 211, 481, 528; 1905, p. 562. It is not therefore necessary to enter more fully into details concerning them here.

The work is illustrated by a fine series of 26 quarto plates (and a frontispiece of the skull of *Arsinoitherium*); and, what is also of very great value, no fewer than 98 very carefully prepared text-figures giving most accurate details of the bones, teeth, and parts of the skeletons, by Miss G. M. Woodward, whose name also appears on fourteen of the plates, the remainder being executed by Mr. A. H. Searle and Mr. J. Green.

In conclusion, we must express our admiration for the way in which the author has completed this very splendid monograph, the outcome of long and careful study of the great series of remains obtained during four Winters spent by himself in the Fayûm, in addition to those obtained by Mr. H. J. L. Beadnell for the Egyptian Geological Survey, which are likewise incorporated in the present work. The Trustees of the British Museum, the Egyptian Government, and the Survey Department may also be congratulated upon the successful issue of this joint memoir, which will undoubtedly greatly advance our knowledge of the evolution of the Tertiary Vertebrates, more especially of the Proboscidea, the Sirenia, and the Zeuglodonts, whose past history was so obscure.

II.—The Great Felines of the French Caves.

Marcellin Boule. Les grands Chats des Cavernes. Annales de Paléontologie, vol. i (1906), pp. 69–95, with 12 text-figures and 4 plates.

As an introduction to this excellent memoir the comparative osteology of the lion and tiger is given, accompanied by very useful outline figures of the characteristic parts. Then follows the description of the large Pleistocene Feline from French caverns, of which the Paris Museum has no less than three skeletons, two of them, the Vence and the Cajarc skeleton, complete, and each made up of the bones of the same individual. The view of some palæontologists, that the large Pleistocene Feline of European caves was the tiger, is discarded; nor does the author consider it to form a separate species; he unites it with *Felis leo*, of which it is considered to be a race (*spelæa*). The skeleton from Vence presents some slight characters of its own; the skull has the 'leonine' characters exaggerated, and the limbs are heavier than usual. Professor Boule calls it *Felis leo*, var. *Edwardsi*, being of opinion that it seems to belong to an earlier stage of the Pleistocene than the other cave lions, and that it might therefore be considered as their ancestral form. We fail to find in the memoir the proofs for the contention of a remoter age for the Vence skeleton.

The memoir concludes with a chapter on the geographical and stratigraphical distribution of the cave lion, accompanied by a map. *Felis arvernensis*, from the Pleistocene of France and Italy, seems to be the ancestral form of the cave lion.

The new *Annales de Paléontologie*, edited by Professor Boule, in the first volume of which the present memoir is published, are a welcome and necessary addition to the existing palæontological periodicals.

III.—Descriptions of New Species of *Testudo* and *Baëna*, with Remarks on some Cretaceous Forms. By Lawrence M. Lambe, F.G.S., F.R.S.C. (Reprinted from the *Ottawa Naturalist*, January 6th, 1906, pp. 187–196, 2 plates.)

I. THE specimens of *Testudo* described in this paper were collected by Mr. Lambe, along with other vertebrate remains, in 1904, in the Oligocene deposits at Bone Coulée, Cypress Hills, Assiniboia. They were found separately, but appear to belong to one species, hitherto undescribed, for which the name *exornata* is proposed.

The three specimens upon which this species is based consist of the proximal end of the left 1st costal, the distal half of the left 5th costal, and the proximal end of the left 6th costal. All the specimens have a grooved surface, the grooves of the left 1st costal being concentric, and indicating an epidermal shield pattern such as is found in some modern species of *Testudo*. The specimens also show that the costal plates were alternately narrow and broad distally, and broad and narrow proximally, a common character of *Testudo.* The peculiarity of the species is the extreme narrowness and thickness of the 5th costal plate.

II. The specimens of *Baëna* were first briefly described by Mr. Lambe in "Contributions to Canadian Palæontology" (vol. iii, 4to, pt. 2, 1902, Geological Survey of Canada)—"On Vertebrata of the Mid-Cretaceous of the North-West Territory." They were there referred to *Baëna Hatcheri,* Hay, from the Laramie of Converse County, Wyoming. Further study of the material has led the author to a different conclusion, and he now regards these specimens as belonging to a new species, to which he assigns the name *pulchra.* They were collected by him in the Belly River (Judith River) Beds of Red Deer River, Alberta, near the mouth of Berry Creek. They consist of the anterior half of the crushed carapace, with the entire plastron of a single individual, and of the anterior half of the plastron of another individual of slightly larger size.

Critical remarks are made upon other species of Chelonia from the Belly River series in Canada, viz., *Trionyx foveatus,* Leidy; *T. vagans,* Cope; *Adocus lineolatus,* Cope; *Basilemys variolosus,* Cope; *Baëna antiqua,* Lambe; and *Neurankylus eximius,* Lambe. Three other species from the same horizon are also referred to; these are *Plastomenus coalescens,* Cope; *P. costatus,* Cope; and *Compsemys ogmius,* Cope. A. H. F.

IV.—Fossil Flying Fishes.

Fossile Flugfische. By O. Abel. Jahrb. k.k. geol. Reichsanst., vol. lvi (1906), pp. 1–88, pls. i–iii, text-figs. 1–13.

DR. ABEL has recently made an exhaustive study of the ganoids with large pectoral fins occurring in the Trias of Austria, Germany, and Italy. He has arrived at the conclusion that their outward shape was very similar to that of the existing 'flying fishes' of the genus *Exocœtus.* He has therefore been led to prepare an elaborate memoir on 'flying fishes' in general, treating them both from the geological and from the biological point of view.

Thoracopterus Niederristi, the 'flying fish' of the Alpine Trias, was discovered long ago, but Dr. Abel has had the opportunity of adding much to our knowledge of its structure. He shows that the fins are arranged exactly as in the modern *Exocœtus,* with the lower lobe of the deeply forked tail distinctly larger than the upper lobe. At the same time he agrees with the determination of the British Museum Catalogue, that the fish is merely an aberrant member of the family Pholidophoridæ.

Thoracopterus is covered with regular rows of rhombic ganoid scales, but Dr. Abel now describes for the first time a contemporaneous fish of nearly the same shape, which is characterised by at least partial absence of scales. This new genus and species, named *Gigantopterus Telleri,* is founded on a well-preserved specimen about seven inches in length from the Upper Trias of Lunz.

The imperfectly-known *Dolichopterus volitans*, from the Upper Muschelkalk of Jena, is then discussed by Dr. Abel, who proposes the generic name *Dollopterus* to replace *Dolichopterus*, which is preoccupied.

A consideration of the so-called 'flying fishes' of the Chalk (*Chirothrix*) leads Dr. Abel to believe that they did not use their fins for skimming through the air. He gives reasons for supposing that they were inhabitants of deep water. He then discusses the whole question of the enlargement of fins, and their adaptation to 'flight' in particular, giving ample references to biological literature. The memoir is, indeed, a model of thoroughness in palæontological work.

V.—Indian Permo-Carboniferous Reptiles, Fishes, and Plants. Geological Survey of India: Palæontologia Indica. New Series, vol. ii, Memoir No. 2: Permo-Carboniferous Plants and Vertebrates from Kashmir. By A. C. Seward, F.R.S., and A. Smith Woodward, LL.D., F.R.S. pp. 1–13, 3 plates. 8vo. Calcutta, 1905.

THE brief contribution to Indian palæontology contained in this memoir is of great interest, for the discovery in 1903 by Dr. Noetling of *Gangamopteris*, associated with the typically Lower Permian fish and Labyrinthodont remains here described, has a most important bearing upon the geological age of the Lower Gondwana beds in the Peninsula of India.

The shales containing the fossils occur at a place called Khunmu, in the Vihi valley, fifteen miles south-east of Srinagar. They are overlain in the section examined by Dr. Noetling by beds containing *Fenestella* and other Polyzoa, and these are succeeded by limestones holding such characteristic Salt Range fossils as *Spirifer Derbyi*, *Productus Indicus*, etc. It should be mentioned that above the plant-bearing shales there is a break in the exposures caused by talus deposits; but Dr. Noetling's opinion was that there was no evidence of a hidden fault that could have brought the Permian limestones into their apparent position above the plant-bearing beds.

The acceptance of this view involved the important conclusion that the so-called *Glossopteris* flora existed in India in Permian times, and that instead of the Lower Gondwanas being of Jurassic age, they represent approximately the Permian of Europe. Mr. Seward, in summing up the evidence regarding the geological position of the Khunmu plants, would put it "at least as low as the Talchir series," and not improbably as corresponding with the Lower Permian or even with the Coal-measures of the Northern Hemisphere.

The plant material available, which was very fragmentary, yielded to Mr. Seward's investigations only a single generic type, *Gangamopteris*, to which he has given the appropriate specific name *Kashmirensis*. A fragment of another frond is referred doubtfully to *Psygmophyllum*.

The fish remains are assigned by Dr. Smith Woodward to two species of *Amblypterus*, viz. *A. Kashmirensis* and *A. symmetricus*.

which are very closely related to the type species *A. latus*, from the Lower Permian of Rhenish Prussia, but have relatively smaller dorsal and anal fins.

The Labyrinthodont fragments belong to the genus *Archegosaurus*, and are referred to a new species, *A. ornatus*. One specimen consists of a portion of a head; the other (belonging to a smaller individual) includes remains of the rachitomous vertebral column, with the characteristic ribs.

The plant and vertebrate remains described in this memoir are made the more easily intelligible by the three excellent plates which illustrate it. A. H. F.

VI.—Permo-Carboniferous Foraminifera of Australia.

A Monograph of the Foraminifera of the Permo-Carboniferous Limestones of New South Wales. By Frederick Chapman, A.L.S., F.R.M.S., National Museum, Melbourne, and Walter Howchin, F.G.S., Adelaide University. 4to; pp. i–xvi and 1–22, with 4 plates. (Sydney: W. A. Gullick, 1905.)

PROFESSOR T. W. EDGEWORTH DAVID, of Sydney, gives an introductory account of the two distinct and widely distant horizons which have yielded the Foraminifera described in this Monograph. The Upper or Wollong foraminiferal horizon belongs to the Branxton stage of the Upper Marine series, at about 2,300 feet above the Greta Coal-measures, and the Lower or Pokolbin horizon belongs to the Lochinvar stage of the Lower Marine series, at about 1,700 feet below the Greta Coal-measures.

A diagram in the text, at page xvi, shows the relative position of these two special horizons, and of the Greta Coal-measures, in the succession of strata in the Hunter River district, New South Wales.

At Pokolbin the Foraminifera occur in an earthy limestone, with scattered particles of volcanic rock and numerous well-preserved Fenestellidæ. This deposit was probably formed on the shores of high volcanic islands, which became gradually submerged, with successive margins of conglomerate, sandstone, and pebbly shales; these passing upwards into foraminiferal calcareous sandstone or earthy limestone. Over the Pokolbin limestone occur about 2,000 feet of sandy shale, with thin Ostracod limestones. Then the Farley Sandstone for about 1,000 feet, with occasional glacial erratics; and then about 200 feet of sandstone, shales, and fire-clays, with two seams of coal (Greta Coal-measures). Marine conditions supervened, represented by pebbly beds, sandstone, and mudstone; the uppermost constitute the Muree Beds with *Strophalosia*. At 200 feet below this and 2,500 feet above the Greta Coal-measures is found the Wollong horizon, with very fine Foraminifera, Corals (*Trachypora*), and some Fenestellidæ.

The above-mentioned deposits constitute part of the great succession of strata formerly regarded as the old Carboniferous system; but, as many animals and plants of kinds that are characteristic of the accepted 'Permian' age are associated in these strata with the characteristic fossil fauna and flora of the 'Carboniferous' period, this composite formation of 'Carboniferous' modified by 'Permian' (in India, America, Africa, and Australia) has been widely referred to by geologists as the 'Permo-Carboniferous.' We are glad to see that in this Monograph the logically correct term 'Carbo-Permian' is used by Messrs. Chapman and Howchin. Professor David goes on to compare the foraminiferal horizons of New South Wales with those known in Tasmania and West Australia.

From the descriptive part of the Monograph (pp. 1–32), we learn that the specimens of rock and detritus collected from these two special zones yielded 14 species of Foraminifera from Pokolbin and 15 from Wollong, and that 6 occurred at both places. These 35 species are referable to the following:—

Porcellanous and Arenaceous	Miliolidæ ...	1	species.	Found at Pokolbin.
	Astorhizidæ ...	2	,,	Found at Pokolbin and Wollong.
	Lituolidæ ...	15	,,	
	Textularidæ ...	4	,,	
Hyaline ...	Lagenidæ ...	11	,,	
	Rotalidæ ...	2	,,	

These 35 species are relegated to 23 genera, all of which have long pedigrees originating in Palæozoic times. Of the species here indicated, their range in time, for the Northern Hemisphere, appears to be as follows:—1 is otherwise known only in the Recent state; 1 in beds of Tertiary age; 3 occur in Cretaceous and 3 in Jurassic rocks; 3 in the Rhætic series; 1 in the Trias; 5 are known in the Permian; 8 in the Carboniferous; and some of these last are even of Silurian age.

Thus these Australian 'Permo-Carboniferous' deposits comprehend not only Upper Palæozoic fossils, but even several characteristics of Mesozoic and Cainozoic times.

We congratulate the Geological Survey of New South Wales on the good results of having obtained the co-operation of Messrs. F. Chapman and W. Howchin in working out the natural history of the two special zones of Foraminifera in the Australian Carboniferous series. The authors of the Monograph are experienced microscopists, and have a wide knowledge of the recent and fossil Rhizopods.

Special notice is made at page 20 of (1) the relative proportions of different kinds; (2) the occurrence of the same Upper Palæozoic forms in the Southern and the Northern series; and (3) the few genera that are apparently confined to strata of the particular series; (4) nine of the Australian species are regarded as new.

A very useful bibliographical list of memoirs having reference to Permian and Carboniferous Foraminifera is given at pp. 21, 22.

Mr. Chapman has carefully drawn 40 figures for the 3 plates, and five sections of the Pokolbin rock for plate iv, in a very trustworthy manner, without any unnecessary artistic niceties.

T. R. J.

VII.—Memoirs of the Geological Survey of England and Wales. Guide to the Geological Model of the Isle of Purbeck. By Aubrey Strahan, M.A., F.R.S. 8vo; pp. 26. (London, 1906: sold by Edw. Stanford, 12–14, Long Acre. Price sixpence.)

EARLY in the present year an interesting and instructive addition was made to the collection of the Museum of Practical Geology in Jermyn Street. This was a geological model, on a horizontal scale of six inches to a mile, of the Isle of Purbeck, prepared by Mr. J. B. Jordan, under the supervision of Mr. Strahan. This model is in three separate pieces, and, in order to give the physical features due prominence, the vertical scale has been made twice as great as the horizontal. Sections are drawn on the edges of the three blocks of the model, and these sections are carried down to 660 feet below sea-level. By this means the interior geological structure as well as the outcrop features are brought to the notice of the observer.

In further illustration of this excellent piece of work a Guide to the Geological Model, compiled by Mr. Strahan, has recently been issued by the Geological Survey. This "Guide" is furnished with two plates, one being a photograph of the model, and the other a small but very clear geological map of the Isle of Purbeck, on the same scale as the photograph, each fitting lengthwise into a full-sized octavo pamphlet. In addition to these illustrations there is a page giving the sections which are drawn on the edges of the three blocks of the model, as shown on the photograph of the model (plate i).

There can be little doubt that the Isle of Purbeck and its natural prolongation along the Lulworth coast present us with one of the most interesting, and at the same time accessible, pieces of geological structure to be found anywhere. Omitting the purely Bagshot country in the northern part of the 'Isle,' where the strata are flat and much obscured by peat, etc., we have in the southern half of the Isle of Purbeck the features of a varied and, in some cases, complex stratigraphy presented to the observer. Indeed, the region from Gadcliff almost to Whitenothe is a mountain chain in miniature dissected by the sea.

Mr. Strahan has not been slow to point out the leading features in the geology of the district—the long and lofty Chalk ridge, the Wealden valley, where the softer beds have yielded more readily to erosion, and then again the resistance offered by the harder Purbeck and Portland limestones. "The scenic features due," he says, "to this sequence of hard and soft beds are reproduced wherever the strata come to the surface, no less in the narrow outcrops near Durdle and Lulworth than in the broader tracts near Swanage." The different results of subaerial and marine erosion are indicated. In the sea-coves may be found the most perfect illustration of the action of the sea upon inclined strata of unequal hardness.

The remarkable folding and faulting of the region is well shown in the Model and further explained in the Guide. Thus we have normal faults, strike-faults, step-faults, etc., and, above all, the great overthrust fault so conspicuous in its effects at Ballard Point. Here the fracture is traceable for two miles inland, where it is cut off by a cross-fault, and beyond this there is no positive evidence of its existence as a fault in connection with the Chalk ridge to the westward. The age of the several folds and the evidence of earlier folds, proving the fact of recurrent folding on permanent lines of weakness, are also discussed.

After glancing at the river system, Mr. Strahan concludes with a stratigraphical summary of the beds from the Kimmeridge Clay to the Lower Bagshots, and this may be regarded as an epitome of the several formations as developed in that district. The section dealing with the Chalk is of especial interest, since it is admitted that no reliable subdivision of the Chalk, of more than local value, is possible except on palæontological grounds. The zonal tables of Dr. Barrois and Dr. Rowe are added. The aggregate thickness of the Secondary formations is estimated at rather more than 4,500 feet in the eastern, and rather less in the western, part of the region.

VIII.—Geological Survey of Western Australia. By A. Gibb Maitland, F.G.S., Government Geologist. Bulletins Nos. 8, 9, and 11 to 20. 8vo. Perth, W.A., 1903–1905.

IT is satisfactory to observe that West Australia, which originated in the old Swan River Settlement, though the last to attain equal rank with its sister dependencies of the Australian Commonwealth, is in no way behind them in the enterprising spirit that ministers so largely to the material progress of a new country. Proof of such progress is to be found in the excellent reports, issued under the authority of the Minister of Mines, here under review. Besides these Bulletins annual "Progress Reports" have been issued since 1897 which contain information relating to the Survey administration, gold and other mining, general geology, and the all-important subject, in mining districts, of water supply. The publications encourage and enjoin the use of scientific methods to aid in the rougher and more practical side of mining work, and accordingly Mr. Gibb Maitland and his able associates have directed their principal energies to the scientific examination of ore deposits, and especially to that of the precious metal.

Mr. Maitland supplies a preliminary report on the geological features and mineral resources of the Pilbara Goldfield (1904), which had not been examined since Mr. H. P. Woodward, the then Government Geologist, reported upon it about ten years previously. This report is accompanied by geological and mining maps explanatory of the text, which runs to 110 pages. It is stated that those parts of the Pilbara Goldfield embraced in the report are, on the whole promising, the 'reefs' giving every indication of permanence.

Facilities for transport are, however, much needed, if the resources of the district are to be properly developed. The stratigraphical sequence of the district examined is for the present largely conjectural; the presence of Tertiary, Cambrian, and Archæan rocks is assumed, but with doubt.

In a later report (Bulletin No. 20, 1905) Mr. Maitland continues his examination of the Pilbara Goldfield in greater detail, describing various mining centres with their auriferous deposits. This report is illustrated with plates, textual figures, and coloured maps and sections.

Bulletin No. 11 (1903) contains Mr. Maitland's notes on the North Coolgardie Goldfield, a detailed account of the mines of this famous region, illustrated with sketch-maps. He also, with the assistance of Mr. C. F. V. Jackson, supplies in Bulletin No. 16 an account of the mineral production of Western Australia up to the end of the year 1903. This report is accompanied by a map of Western Australia, showing the goldfields and other mining districts, and the distribution of useful minerals, which include gold, silver, iron, copper, lead, tin, diamonds, coal, mica, graphite, etc.

The geological features and mineral resources of the Northampton district are dealt with by Mr. Gibb Maitland in Bulletin No. 9 (1903), which contains Appendices by Messrs. H. P. Woodward, J. Provis, and E. S. Simpson. This district was first explored by Mr. Henry Y. Lyell Brown in 1871, who was at that time Government Geologist; his report being followed in 1888 by that of Mr. H. P. Woodward, who also wrote an able report upon the copper and lead mines of the district in 1895. The principal object of attainment was the accurate mapping of certain igneous rocks (basic dykes) which might afford a guide as to the horizontal extension of the metalliferous minerals, and thus assist the operations of private enterprise.

The work of Mr. Charles G. Gibson, Assistant Government Geologist, is recorded in Bulletins 8, 12, 14, and 17. The geology and the auriferous and other mineral deposits of the North Coolgardie, Murchison, and Tilgarn Goldfields were investigated. The "Auriferous Series" of the Murchison Goldfield, which contains the gold-bearing rocks, consists of "persistent zones of schist and allied metamorphic rocks." The most profitable of the gold-bearing rocks are the greenstones, though certain quartz rocks occurring in the granite are also auriferous. Maps, plates, and textual figures accompany and elucidate all these reports.

Finally, we may note Mr. C. F. V. Jackson's reports (Bulletins Nos. 13 and 18) on portions of North Coolgardie and Mount Margaret Goldfields. These contain much detailed information concerning the geological features, mines, and auriferous deposits of the districts surveyed, with ample illustrations of all kinds, as well as maps and sections.

A. H. F.

IX.—Report on Geological Explorations in the West and North-West of South Australia. Prepared under the authority of the Minister of Mines, by H. Y. L. Brown, F.G.S., Government Geologist. Also Contributions to the Palæontology of South Australia, by R. Etheridge, jun., Curator, Australian Museum, Sydney. pp. 1–11 and 13–17, map and plates, folio. (Adelaide, 1905.)

THE records of this exploration, the principal object of which was to define the boundary and limits of the Cretaceous water-bearing area in the west and north-west portions of South Australia, are put into the form of a diary as the explorer and his party proceeded slowly through the somewhat desolate country through which their route lay. Leaving Adelaide in April, 1904, they reached their destination in August of the same year. Their journey conducted them over tablelands, plains, and downs of Mesozoic (Lower and Upper Cretaceous) rocks, through which protruded at intervals outliers of quartzose sandstone, quartzite, and slate, striking N.N.W., and dipping at low angles. The presence of these outliers of Palæozoic rocks is of importance in selecting sites for boring for water, as they constitute the bed-rock of the artesian basin in the district.

Numerous bores have been struck at Stuart's Creek Station, some of which are in proximity to the natural artesian springs.

The most successful bores, not in the proximity of springs, are the J. H. Angas bore, depth 962 feet, yielding 1,400,000 gallons per diem, and the New Year's Gift, depth 237 feet, yielding 300,000 gallons per diem. The depths of the other bores range from 33 to 740 feet.

At another boring, that of Lake Phillipson, bituminous shale, yielding petroleum on distillation, was met with at depths of 312 and 393 feet. This boring gave favourable indications of the existence of artesian water.

The rest of the diary consists of a daily record of the distance traversed and the rocks encountered until on the 5th August "Charlotte Waters" was reached, where the record terminates.

A great drawback to the correct delineation of the shoreline of the Lower Cretaceous artesian area is the accumulation of sand, as sand-hills and sand-plains. Loam and other surface deposits also cover a large extent of the interior of the country, hiding the underlying rocks. The Tertiary and Upper Cretaceous deposits also overlie rocks of older date than the Lower Cretaceous, and owing to the level nature of the surface of the country sections showing the sequence of the rocks seldom occur. The boundaries can therefore only be laid down approximately. Boring can alone determine what rock formations exist between the Recent and Tertiary deposits and the bed-rock.

On the return journey Mr. Lyell Brown made a collection of fossils from the Lower Cretaceous rocks at Dalhousie Springs. These were forwarded to Mr. R. Etheridge, Curator of the Australian Museum, Sydney, whose description of them is embodied in this report. The fossils were found in a hard limestone occurring in boulders, and embedded masses in the soft argillaceous clay and shale which is the prevailing rock formation of the neighbourhood.

The collection is "interesting from the fact that it increases the number of forms from the South Australian rocks in question by five species not hitherto recorded therefrom, and also confirms the identification of two others previously known only from scanty or imperfect material." The genera represented are the following: *Aucella*, *Inoceramus*, *Haploceras*, *Anisoceras*, *Ancyloceras*, *Crioceras*, and Nautilus (*Cymatoceras* ?). The species of *Ancyloceras* (*A. cordycepoides*) is new. A. H. F.

X.—Geological Survey of Canada. Robert Bell, M.D., F.R.S., I.S.O., etc., Acting-Director. Recent Mineral Discoveries on Windy Arm, Tagish Lake, Yukon. By R. G. McConnell, B.A. 8vo. Ottawa, 1905.

THESE discoveries proved so interesting that an examination of the district was deemed advisable. Tagish Lake forms part of a chain of long, narrow lakes, originating within the coast range of mountains and extending northward and eastward for a distance of nearly seventy miles. Windy Arm joins Tagish Lake near its head, and extends south for a distance of twelve miles. The Windy Arm mining district consists chiefly of wide valleys intersecting each other, separated by mountain ridges rising from 4,000 to 5,000 feet above the valleys. The mineral area is situated a few miles north of the great granite area of the coast range.

The rocks out-cropping along the lower part of Windy Arm consist of a wide band of crystalline limestone, followed to the south by hard slates and shales, passing in places into felspathic quartzites. This clastic series is cut off and replaced about five miles above the mouth of the Arm by an eruptive rock of a porphyritic character, exposures of which out-crop along the shores of the Arm for a distance of about five miles. The porphyrite is followed southward by strongly cleaved, dark argillites and fine-grained tufaceous sandstones, alternating with bands of conglomerates and limestone. No data sufficient to determine the age of these rocks were obtained, though they are less altered than the slates and associated rocks north of the porphyrite area. The porphyritic rock separating the two series of clastic rocks constitutes the principal metalliferous formation of the district. It crosses from Windy Arm to Bennett Lake in a band about four miles in width, and also extends some distance east of Windy Arm.

A granite area about three miles in width occurs on Lake Bennett, north of the porphyrites and associated rocks. The granite is similar in character to that of the coast range, and probably belongs to the same period of igneous activity.

The largest and most persistent mineral veins so far discovered occur in the porphyrite area.

The metallic minerals contained in the veins, the gangue of which is mainly quartz, include the following: Native Silver in small spangles, and in a wire-like form; Argentite; Stephanite; Freibergite; Pyrargyrite (ruby silver); Galena (usually highly argentiferous); Chalcopyrite; Native Copper; Malachite and Azurite (due to the leaching out of the copper in the Tetrahedrite and Freibergite); Iron Pyrite; Arsenopyrite; Pyrrhotite; Sphalerite (zinc-blende).

The most valuable product of the veins is the silver; the ferruginous portion of the vein is stated to carry also gold in remunerative quantities.

A detailed description is given of the development of the mining, the general outlook being considered exceedingly promising. The mining conditions are not unfavourable as regards the situation of the veins, cost of supplies, railway communication, and other desiderata. A. H. F.

XI.—Geological Survey of Canada. Robert Bell, I.S.O., M.D., F.R.S., etc., Acting-Director. Annual Report, Vol. XIV, Part J. Report on the Geology of a Portion of Eastern Ontario (to accompany Map-Sheet No. 119). By R. W. Ells, LL.D., F.R.S.C. 8vo; pp. 1–89, map. (Ottawa, 1904.)

THIS report concerns the geology and mineral resources of the area south of the Ottawa River, where it is bounded on the north by a line extending west from the vicinity of Arnprior to a point a few miles north of Clear Lake in the county of Renfrew, and on the south by a line east from Sharbot Lake to a point a few miles south of Smith's Falls. It embraces an area of 3,456 square miles.

The geological formations represented in the area comprised in this map-sheet are the following:—

Post-Tertiary.
Utica shales.
Trenton.
Black River.
Chazy shales and limestones.
Calciferous and Potsdam sandstone.
Mica, chlorite, and hornblende schists and amphibolites, with some conglomerates.

The most interesting part of the report is the discussion of the age of the crystalline rocks, the history of which, dating back for nearly fifty years, is very exhaustively treated, and a lucid account of the views held by the older authorities—Logan, Macfarlane, Hunt, Vennor, Selwyn—is supplied. The later work of Messrs. Adams and Barlow is also adverted to by the author, who himself began in 1891 and the three following years the detailed examination of the area north of the Ottawa, in the typical district where the rocks of the Grenville series of the Canadian geologists were first studied.

The rocks in the area surveyed are roughly divided into four groups, viz. :—

I. Granite-gneiss and syenite, which apparently represent the oldest series upon which the others rest.

II. Gneiss, sometimes highly quartzose and garnetiferous, certain portions passing upward into limestones.

III. Amphibolites with schists, sometimes micaceous, sometimes chloritic, hornblendic or dolomitic, with altered slates and true conglomerates and limestones.

IV. Granites and diorites, some of which are clearly intrusive and newer than the rocks which they penetrate.

A full description of these rocks, geological and topographical, is given under the headings "Underlying granite-gneiss series" and "Newer Limestone, schist and gneiss series."

The succeeding sections of the report refer chiefly to the economic minerals found in the area surveyed. The most important of these are iron, gold, silver, galena, nickel, mica, apatite, graphite, corundum, and felspar, besides other economic products, including building stones, brick clays, shell-marl, lime, and peat.

A short account of the glacial geology with a list of striæ is supplied, and an appendix contains preliminary lists of fossils by Dr. H. M. Ami, with some interesting notes on the fauna.

The coloured map (compiled by Mr. Joseph Keele) which accompanies the report, is drawn to a scale of four miles to the inch and has copious geological notes in the margin. A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 4th, 1906.—R. S. Herries, M.A., Vice-President, in the Chair. The following communications were read :—

1. "On a Case of Unconformity and Thrust in the Coal-measures of Northumberland." By Professor G. A. L. Lebour, M.A., M.Sc., F.G.S., and J. A. Smythe, M.Sc., Ph.D.

The sections described occur on the coast north of the Tyne, near Whitley Sands, between Table Rocks and Briar Dene Burn. The base of the "Table Rocks Sandstone" is found to rest unconformably upon a series of alternating shales and sandstones, among which is a well-marked band of clay-ironstone crowded with *Carbonicola acuta*, one of those 'mussel bands' which are found to be perhaps the most remarkably persistent strata in the North of England Carboniferous rocks. According to the correlation of the Geological Survey, this particular band is the one that is well known as occurring a little way above the Low Main coal-seam. The entire junction, so far as it can be seen at the base of the cliffs and on the foreshore, many parts of which are only swept clear during exceptional weather, has been studied as opportunity offered during a series of years. The unconformity is shown by discordance in dip, by overlap of the Table Rocks Sandstone, and by the existence of a pebble-bed, containing fragments of the mussel band and other parts of the underlying series, in the lower part of this sandstone. But the upper, more massive, beds in the section have been thrust in a northerly direction over the lower and more yielding beds, the plane of gliding corresponding accurately along parts of the section with the plane of erosion. Towards the north of the section the beds of the upper series are weakened by intercalated bands of shale, and then differential action has been set up. The result is that the thrust-plane is no longer a simple one coinciding with the unconformity, but extends some way above it. The effects of the thrust are seen in the ploughing up, folding, and faulting of the lower series, in the penetration of tongues of sandstone from the upper series into the lower, in the curling up and shattering of the pebble-bed, in the puckering and hardening of the shale, and in the blending of fragments of various rocks subjected to its influence. The marks of intense action are practically confined to the surface of the beds of the lower series. The action of the thrust is markedly rhythmical, and its effect is to mask the unconformity; and the great discordance in dip which is at times produced is no criterion of the unconformity. Although the amount of rock removed by intro-Carboniferous denudation from the lower series is unknown, chemical and other evidence is given to show that the lower series has undergone weathering and some leaching out of constituents in the interval between the two series.

2. "The Carboniferous Succession below the Coal-measures in North Shropshire, Denbighshire, and Flintshire." By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

This paper opens with a critical account of previous research among the Carboniferous rocks of North Wales, chiefly the work of the late G. H. Morton, Mr. R. Kidston, and Mr. A. Strahan. There follows a detailed account of the various beds, exposed in numerous quarries worked for road-metal, iron manufacture, lime, cement, chert, or building stone. Fossil lists are given from each exposure of importance. The lower series of the Carboniferous Limestone, as developed in the Bristol area, was never deposited in this district, where the lowest beds contain fossils characteristic of a comparatively late phase of the Carboniferous Limestone Period. Whether this was due to irregular configuration of the ocean floor of that age, or to contemporaneous earth movement of a regional character, cannot as yet be determined. The base of the limestone is characterized by *Daviesiella* (*Productus*) *llangollensis*, and appears to correspond with the junction of the Upper *Seminula* and Lower *Dibunophyllum* Beds of the Bristol area. The next limestones in ascending succession are characterized by the presence of *Dibunophyllum* ϕ and *Cyathophyllum Murchisoni*, fossils which indicate, in the Bristol area, the life-zone which immediately underlies the *Lonsdalia* Beds. These two life-zones have been named by Dr. Vaughan the Lower and Upper *Dibunophyllum* zones respectively. The *Cyathaxonia* Beds and the cherts are equivalent to a zone higher than the Upper *Dibunophyllum* zone of Bristol, and not represented there. The black limestones (containing *Posidonomya Becheri*) with shales, at Teilia, Holywell, and near Bagillt, which occur above the cherts, are the homotaxial equivalents of the Pendleside Series. These beds are followed by the Gwespyr Sandstone, which is correlated with the Millstone Grit. A range-table is given of the chief brachiopods and corals, and the palæontological sequence is compared with that occurring at Bristol and in the North of England. A few notes on the palæontology conclude the paper, and Dr. R. H. Traquair appends a short description of a new species of *Elonichthys*, occurring in the Holywell Shales.

II.—April 25th, 1906.—J. E. Marr, Sc.D., F.R.S., Vice-President, in the Chair. The following communications were read :—

1. "Trilobites from Bolivia, collected by Dr. J. W. Evans in 1901–1902." By Philip Lake, M.A., F.G.S.

Several horizons are represented by these fossils. Two specimens of *Peltura*, probably from the Upper *Lingula* Flags, were collected at Cochaiya, about 3 miles north-east of Pata. New species of *Symphysurus* and *Trinucleus*, probably of Arenig age, were found about a mile from Apolo, Province of Caupolican. An indeterminable species of *Ogygia* was obtained from the right bank of the River Caca, in the same province. *Phacops* cf. *arbuteus*, *Dalmanites Paituna*, and *D. Maecurua* were collected in the track from Apolo to San José de Chupiamonas, also in the province of Caupolican. The nodules from which they were derived are probably of Lower Devonian age. Descriptions are given of the new species and other forms mentioned. It is worthy of remark that, while the earlier forms show affinities with the contemporaneous European fauna, the Devonian species are much more closely allied to those of South Africa and North America.

2. "Graptolites from Bolivia, collected by Dr. J. W. Evans in 1901–1902." By Ethel M. R. Wood, D.Sc. (Communicated by Dr. J. W. Evans, LL.B., F.G.S.)

In black pyritic shales from three localities several specimens of *Didymograptus* were collected ; one referable to *bifidus*, one of the type of *affinis*, and one of the *Nicholsoni* type. *Phyllograptus*, *Glossograptus*, *Cryptograptus*, and *Diplograptus* were also obtained. A pale, silky grey shale shows also rare graptolites, belonging to a species comparable with *Climacograptus confertus.* These forms indicate that both the black and the pale shales belong to horizons in the Upper Arenig rocks (Lower Llanvirn of Hicks).

3. "The Phosphatic Chalks of Winterbourne and Boxford (Berkshire)." By Harold J. Osborne White, F.G.S., and Llewellyn Treacher, F.G.S.

Data collected in the district dealt with in this paper suffice to show that the more or less Phosphatic Chalks above the *Uintacrinus*-band lie in a trough or basin, the formation of which antedates the deposition of the Reading Beds. When the area of observation is extended, it is found that the *Uintacrinus* Chalk of that tract itself lies in a structural depression. In view of the development of phosphatic and of hard, rocky beds, indicative of slow and interrupted sedimentation, in the underlying *cor-anguinum* zone, it seems not unlikely that this basin is an original or inherent feature of the Chalk directly attributable to a local attenuation of that zone; but the authors believe the depression to be due mainly to differential earth movements, of which there are many indications. The exposures are found in the eastern (Winterbourne) and western (Boxford) sides of a spur lying in the angle between the converging valleys of the Lambourn and the Winterbourne. On the eastern side the following succession is recognized:—

1. Reading Beds of the Borough Hill outlier.		
2. Chalk with some flints.		Zone of *Actinocamax quadratus.*
3. Phosphatic Chalk.		
4. Phosphatic Chalk.	*Marsupites*-band.	Zone of *Marsupites.*
5. Very feebly phosphatic Chalk.	*Uintacrinus*-band.	
6. Chalk with tabular flints.		Zone of *Micraster cor-anguinum.*
7. Chalk with flints.		

and on the western side—

1. Reading Beds.		
2. Phosphatic Chalk.		Zone of *A. quadratus.*
3. Phosphatic Chalk.	*Marsupites*-band.	Zone of *Marsupites.*
4. Feebly phosphatic to normal Chalk.	*Uintacrinus-band.*	
5. Normal flinty Chalk.		Zone of *Micraster cor-anguinum.*
6. Phosphatic Chalk.		
7. Normal flinty Chalk.		
8. Phosphatic Chalk.		
9. Normal flinty Chalk.		

The maximum thickness of the Phosphatic Chalk Series is about 130 feet. Detailed accounts of the various exposures are given, as also lists of fossils from the various bands, and an account of the microscopic features of washed residue from the softer chalks of the pit a quarter of a mile north-west of Winterbourne Church. This yields: (1) pieces of *Inoceramus* shell, the majority unphosphatized; (2) foraminifera, frequently phosphatized; (3) angular chips of scales, bones, and teeth of fishes; (4) irregular, angular, or subangular lumps and platy pieces of calcite, probably in the main fragments of oysters; (5) rod-like objects, smooth, cylindrical, or tapered—probably spines of echinoids; (6) coprolites of small fishes, etc.; (7) tests of entomostraca; (8) quartz in subangular and well-rounded grains; (9) black granules, apparently of iron-oxides; (10) rich-brown, polished phosphatic concretions; and (11) dull-green grains, imperfectly rounded. These constituents are enumerated as nearly as possible in order of abundance.

The Winterbourne-Boxford phosphates have a known range in time considerably greater than those of Taplow. Their advent far down in the *cor-anguinum* zone is especially interesting; for in England, as Mr. Jukes-Browne has remarked, that subdivision of the Chalk almost everywhere "presents the appearance of having been quietly and continuously accumulated in water that was seldom disturbed by bottom currents," albeit a tendency to develop hard bands at one horizon, at least, is apparent in the western part of the London Basin. The Phosphatic Chalks of Winterbourne and Taplow evidently mark places on the sea-floor particularly liable to the impingement of strong currents, and may mark places above which the water commonly had a gyratory motion. In any case, their zonal range argues a marked degree of stability in the current-system of the body of water in which they were laid down.

CORRESPONDENCE.

THE TRIMMINGHAM CHALK AS A ZONE.

Sir,—I hope you will allow me at this late hour to reply to Mr. Jukes-Browne's letter in your February number. It raises some very large questions which cannot be adequately dealt with in a letter, but I should like to define my position.

It appears to me that the term 'zone' is applied indiscriminately to at least two different conceptions. One of them is what may be labelled the 'international zone.' This covers the great ill-defined subdivisions which persist over large areas embracing more than one natural province, and by which we correlate the equally ill-defined local territorial names such as 'Norwich Chalk,' 'Maestricht Chalk,' 'Meudon Chalk,' etc. These correlations are interesting, but of little practical value, as the zones themselves are rarely, if ever, accurately defined.

The other conception above referred to is what may be called the 'provincial zone.' Each of these zones contain such a thickness of sediment as from place to place over a natural province (whether made natural by modern geographical or ancient geological conditions) contains *throughout* (*pace* Mr. Jukes-Browne) some well-marked form which is comparatively scarce or altogether absent both above and below. These zones have upper and lower limits which are well defined either palæontologically or stratigraphically, often in both ways. They are therefore capable of practical application by the pit-worker, who most stands in need of help, and through him by allied sciences. The 'zone of *Marsupites*,' to which Mr. Jukes-Browne appeals, is one of the finest possible examples of what I mean. The 'zone of *Marsupites*,' introduced by Barrois, was an international zone. It was adopted from a country in which not much was known about it, and it had not even received a separate name; its upper boundary for England was wholly undefined, its lower boundary was only defined in the Margate area by a physical character which Barrois only thought he recognised again in the Sussex area, and there wrongly according to Dr. Rowe, and the type fossil only occurs in about 40 feet out of some 300 feet attributed to this zone by Barrois. I do, though I gather Mr. Jukes-Browne will disapprove, most strongly urge the limitation of the 'zone of *Marsupites*,' for the south of England at any rate, to the important bed of very uniform thickness and position in the series which contains *Marsupites* "in every foot," and outside which *Marsupites* is practically non-existent. Can there be any doubt as to which of these two zones is the more logical and practically useful?

Now it so happens that the international zones introduced by Barrois up to and including the zone of *M. cor-testudinarium* are sound provincial zones for the south of England, answering (except in the case of the zone of *B. plena*) very well to what Mr. Jukes-Browne considers such an unreasonable test, i.e. the occurrence of the type fossil in every foot of the zone. But that does not make it any the less desirable if we are establishing a new zone to establish the most accurately defined one that we can. Does Mr. Jukes-Browne's zone of *O. lunata* satisfy the reasonable requirements of scientific accuracy? How would he define its upper and lower boundaries? Clearly not by the appearance and disappearance of *O. lunata*, for there are at least 10 feet of chalk exposed at Trimmingham below the lowest occurrence of this species and anything from 25 feet upwards above the highest occurrence, and I cannot see any other possible criterion. The zone of '*Terebratulinæ*' which I propose begins where *Terebratulina gracilis* appears (and I am in hopes of satisfying myself that this is just above the hard yellowish bed, in which case the zone of *B. mucronata* would have at Trimmingham an upper boundary defined both physically and palæontologically), and will end where *T. gracilis* disappears, unless before that point is reached some other fossil worthy of being made a zone fossil comes in. The only objection I can see to my zone of *Terebratulinæ* will be removed when the characteristic fossil of the zone below that of *H. planus* is properly named, and I hope we shall not have to wait much longer for this.

R. M. Brydone.

16, South Audley Street, W.

[Erratum.—In Mr. R. M. Brydone's article in February number, Geol. Mag., 1906, p. 77, line 33 from top of page, for 'blending' read 'banding.'—Edit. Geol. Mag.]

OBITUARY.

PROFESSOR EUGÈNE RENEVIER,

For. Memb. Geol. Soc. Lond.

Born 26th March, 1831. Died 4th May, 1906.

With deep regret we record the death of Professor Eugène Renevier, son of a distinguished lawyer (Charles Renevier). He was born at Lausanne on the 26th March, 1831, and died, through an accidental fall from a lift, on May 4th. Towards the age of 17 he began to follow the lectures at the polytechnical school of Stuttgart, where he became intimate with Oppel. He seems to have remained for about three years at Stuttgart. In 1851 we find him doing work with Professor Pictet at Geneva, where he prepared his "Mémoire géologique sur la Perte du Rhône," published in 1854. In the same year we find him working in Paris, under Professor Hébert, on the Nummulitic deposits of the Alps.

In 1856 he began his teaching at the Lausanne Academy, starting with lectures on zoology; and in 1858 he began the teaching of geology. The present year was the fiftieth anniversary of his academic teaching, and was to have been celebrated by his friends in Lausanne with unusual honour.

In 1893 Professor Renevier presided at the Meeting of the Société Helvétique des Sciences Naturelles, convened at Lausanne. In 1894 he was President of the Sixth International Geological Congress at Zurich. He took a very active part in all the International Congresses; and from the first he was Member of the Commission for the Unification of Nomenclature.

He was the founder and, from the commencement, President of the Swiss Geological Society.

For the above particulars we are much indebted to the courtesy of Professor Maurice Lugeon, Professor of Geology in the University of Lausanne, Switzerland. C. I. F. M.

The following is a list of the principal publications of Professor Renevier (there are about 100 in all):—

Mémoire géologique sur la Perte du Rhône (Nouv. Mém. Soc. Helv. Sc. Nat., vol. xiv, 1854).

Description des fossiles du Nummulitique supérieur de Gap, Diablerets, etc. (en collab. avec Prof. Hébert) (Bull. Soc. stat. Isère, iii, et Bull. Géol. Fr., ser. ii, xi, 1854).

Geological and Palæontological Notes on the Alps of Vaud:—
- (1) Infralias et zône à *Avicula contorta* (Bull. Soc. Vaud. Sc. Nat., viii, 1864).
- (2) Massif de l'Oldenhorn et Col de Pillon (Bull. id., viii, 1865).
- (3) Environs de Cheville (id., 1866).
- (4) (Avec F. J. Pictet) Céphalopodes de Cheville (id., 1866).
- (5) Complément de la Faune de Cheville (id., 1868).
- (6) Gisements fossilifères houillers du Bas Valais (id., 1879).

Tableaux des terrains sédimentaires (Bull. Soc. Vaud. Sc. Nat., xiii, 1874).

Structure géologique du Massif du Simplon (id., xv, 1878).

Rapport au Congrès Géol. International de Bologna sur l'unification des procédés graphiques (C.R. Congr. Bologna, 1881).

Etude géologique sur le nouveau projet de tunnel coudé au travers du Simplon (en collab. avec Heim, Lory, Taramelli) (Bull. Soc. Vaud. Sc. Nat., xix, 1883).
Les Faciès géologiques (Arch. Sc. phys. et nat. Genève, xii, 1884).
Monographie des Hautes Alpes Vaudoises (Mat. Carte géol. Suisse, xvi^e livraison, 1890).
Chronographe géologique (C.R. Congrès géol. Int., VI^e session, Zurich, 1894).

CHARLES EUGENE DE RANCE,

Assoc. M. Inst. C. E., F.G.S.

Born November 22, 1847. Died May 9, 1906.

We regret to record the death of Mr. C. E. De Rance, which took place at Blackpool on the 9th May from an accident on the 28th April, at the age of 58 years.

He was the son of Colonel De Rance of the French National Guard, who was exiled from France at the Revolution in 1848. His mother was also a native of France, her father, Colonel Turquand, having been likewise a refugee in 1848.

C. E. De Rance was educated at King's College School, London, and subsequently trained in the engineering office of R. W. Mylne, F.R.S. He joined the staff of the Geological Survey in 1868, and, as remarked by Professor A. C. Ramsay, then Director for England and Wales, De Rance during his first year "surveyed a large tract with the skill of an old geologist." The field-work carried out by him was mainly in Lancashire, Cheshire, and Flintshire, and in due course he wrote memoirs on the "Geology of the country between Liverpool and Southport" (1869), "Geology of the country around Southport, Lytham, and South Shore" (1872), "Geology of the country around Blackpool, Poulton, and Fleetwood" (1875), and "Superficial Geology of the country adjoining the coasts of S.W. Lancashire" (1877). To some other memoirs he also contributed notes. Practical geology gradually absorbed his chief interest. He acted for many years as Secretary of the British Association Committees on the Circulation of Underground Waters and on Coast Erosion, and in 1882 he published a book on "The Water Supply of England and Wales." As an expert, his advice was sought in many contested cases. In later years his enthusiasm and his ability to carry on scientific work declined, and in 1898 he resigned his appointment on the Geological Survey, but continued to the end in private practice as a consulting mining and water engineer at Blackpool.

Among his earlier papers, more especially noteworthy are those on the Gault of Folkestone and on the Cretaceous strata in the south-west of England, published in the Geological Magazine (1868 and 1874). Other subjects from time to time engaged his attention, such as Glaciation and Cave-deposits. As a man who commenced his career with such marked ability, it is sad to think that he did not live to fulfil the high expectations of his early friends.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. III.

No. VII.—JULY, 1906.

ORIGINAL ARTICLES.

I.—Further Notes on the Stratigraphy and Fauna of the Trimmingham Chalk.

By R. M. Brydone, F.G.S.

(WITH 13 TEXT-FIGURES.)

(*Concluded from the March Number, p.* 131.)

BEFORE proceeding to the description of new species it may perhaps be well to make a few remarks on the classification of the Cretaceous Polyzoa and in particular of the Cheilostomata, the suborder which embraces all the species I propose to describe.

The main features of D'Orbigny's classification of the Cyclostomata have been generally accepted, but his classification of the Cheilostomata has suffered very severely at the hands of subsequent authors both in principle and in detail. It was based very largely on two principles, one the generic importance of habits of growth, and the other the generic importance of variations in the number and position of the dwarfed avicularian appendages which he called 'pores spéciaux.' The latter principle has been entirely discarded by recent authors, and with undoubted justice, as it involves the assumption of the perfect regularity of the most irregular feature of the Cheilostomatous cell. The application of the other principle and the importance attributed to it have been gradually more and more restricted, until we have reached a stage where it is still generally admitted to hold good in the case of the Lunulitidæ and Hippothoidæ, but on the strength of the behaviour of certain recent and Tertiary species has been denied even specific importance in the other Cheilostomatous families. It is time that a protest was entered against this rigid application of conclusions drawn from Tertiary and recent forms to the classification of Cretaceous forms. It is unfortunately the case that D'Orbigny, by an oversight in applying his principle in detail, laid it unnecessarily open to attack. It must be obvious that even if the principle be fully accepted, the separation which D'Orbigny made between the free and encrusting unilamellate species, e.g., *Semieschara* and *Cellepora*, *Semiflustrella* and *Reptoflustrella*, must be unsound. It is quite impossible to say that any of the free unilamellate forms found in the Chalk *grew* free. Seaweeds and other perishable bodies must have been fairly plentiful in the Chalk sea—in the zone of *B. quadrata* we find great numbers of free small *Serpulæ* (*ampullacea* and *granulata*) whose bases show clearly that they grew attached to some long slender body, no doubt a seaweed—and any specimens which had grown attached to such perishable bodies would now be indistinguishable from those which had never been encrusting. These two forms of growth are, in fact, not unfrequently shared by Cretaceous species, e.g., *Homalostega vespertilio* and *Cribrilina Gregoryi*, though the majority of encrusting forms are practically never found free, and some free forms, e.g. *Semieschara Canui* (*post*), are never found encrusting. If D'Orbigny's unilamellate genera, which are separated only by this point of growth, be merged, we have left a number of genera based on habits of growth which constitute for the Cretaceous forms convenient and often natural groups which do not seriously overlap. No doubt they are artificial, but that is not yet a destructive criticism of any classification of the Polyzoa.

But though it may well remain a matter of individual opinion whether habits of growth are of any value in the definition of genera, I do not think that any field student of the Cretaceous Cheilostomata would deny them great value in the definition of species. It is very rare in the English Chalk for any species to occur in more than one habit of growth (treating the free and encrusting unilamellate forms of growth as identical). A better test could hardly be offered than the two very similar Onychocellæ figured respectively by D'Orbigny as *Cellepora Parisiensis* and by Beissel as *Eschara galeata* (the latter species is the one commonly identified as *E. Lamarcki*, but which corresponds only to Beissel's figure of *E. galeata*). *E. galeata* is a bilamellate form and the most abundant Cheilostome at all horizons above the zone of *M. cortestudinarium*. The specimens which have passed through my hands must run well into tens of thousands, yet I have only one encrusting specimen and no mature free unilamellate specimen, notwithstanding that it commonly grows from an unilamellate base. *Cellepora Parisiensis*, on the other hand, is one of the commonest encrusting species, and I must have seen thousands of specimens, yet I have no bilamellate specimen (and only one free unilamellate specimen). Stronger testimony to the fidelity of these species at any rate to a certain habit of growth can hardly be possible, and nearly all species of Cretaceous Cheilostomata show equal or nearly equal fidelity. Here, then, we have a point of considerable importance, in which the rigid application to Cretaceous forms of canons of classification derived from the study of Tertiary and recent forms is very undesirable.

Another such point is to be found in the prevailing tendency to unite Cretaceous, Tertiary, and recent specimens in one species. This involves the general assumption that polyps which produce skeletons which cannot be distinguished *must* be identical in organisation. We can admit the absolute propriety of this assumption in the case of specimens more or less contemporaneous and yet be free to doubt whether it must necessarily hold good in the case of specimens of widely differing age. The Polyzoa are a particularly good group in which to test this alleged persistence of Cretaceous forms into recent seas, for the complexity of their skeletons, at any rate in the Cheilostomata, makes it possible to define an enormous number of species, in fact all but the most primitive, with clearness and certainty in a way unattainable in other groups. Now it is not strongly marked species that are identified both in recent seas and the Chalk, but primitive forms such as *Stomatopora granulata* and *Membranipora reticulum*. I am not inclined to admit that the presence in the Chalk of *Membraniporæ* whose skeleton cannot be distinguished by any absolute character from that of the recent *M. reticulum* is conclusive or even presumptive evidence that polyps identical with those of the recent *M. reticulum* lived in the Chalk sea. It is not necessarily the case that because we habitually assume that a simple polyp did not have a specialised skeleton we are entitled to assume the converse that a specialised polyp did have a specialised skeleton, or in other words that a simple cell like that of *M. reticulum* could not be sufficient for the requirements of two or more differently organised polyps. There is nothing that I can see to warrant this assumption, and until it can be supported by stronger evidence it seems more prudent to continue to recognise the great physical break between the Cretaceous and Tertiary epochs as a justification for refusing to admit the identity of primitive Cretaceous forms with recent species.

From the foregoing it will be gathered that I desire to see it recognised as a principle that in dealing with the Cretaceous Polyzoa we are not bound by the Tertiary and recent forms, and any strict assimilation would be *a priori* injudicious, for it must be remembered that the recent Cheilostomata with hard skeletons, the only ones which can be compared with the Cretaceous Cheilostomata, may fairly be considered to form a group in which the general lines of development have long been settled, a middle-aged group. They are, from the geological standpoint, absolutely contemporaneous, but represent almost every possible variety of surrounding conditions. The Cretaceous Cheilostomata, on the other hand, represent the vigorous youth of the group when all sorts of experiments in development were taking place, not only those which resulted in the formation of stable families and genera which still exist, but also those which produced such unstable and shortlived families as the Melicertitidæ. They represent a long period, but on the whole only one set of conditions. Under these circumstances it is only to be expected that rules which apply to one fauna will not always apply satisfactorily to the other. Differences which in one case were of genuine specific importance might well in the other indicate merely variations of a single species under the influence of distance in space and variety of surroundings, and capable of being proved to be such by a chain of intermediate forms. The importance of taking such considerations into account is exemplified by the history of Hagenow's species *Onychocella* (*Cellepora*) *Koninckiana*. Hagenow gave two figures of this species, and at first sight it would seem impossible that they should belong to the same species. Gregory accordingly gave to the second figure the specific name of *Hagenowi*. This involved the attribution to Hagenow of a careless blunder, but would have been justifiable, as far as the creation of species from published figures only can be justifiable, if Hagenow's specimens had come from the settled conditions of ordinary Chalk. But they came from the unsettled shallow-water conditions of the Maestricht Beds, where unprogressive variation, as well as the progressive variation which we call evolution, would be particularly likely to occur in the Cheilostomata, and I have little doubt that Hagenow united his figures in one species for the reason that I reunite them, namely, that he had seen specimens responding accurately in different parts to both figures. The species is evidently a variation which did not prove advantageous and so did not lead to further developments, and to which as a species from Maestricht we need not attach any importance, but which, if it were to appear in recent seas, would be a bombshell indeed.

The recent genera *Mucronella* and *Cribrilina* do not give satisfactory results when applied to the Cretaceous Polyzoa. In the first place, the accepted definition of *Cribrilina* excludes species with radiating or transverse furrows which are not punctured. There does not, however, seem to be good ground for treating the presence or absence of pores in the furrows (a point often very obscure in fossil forms) as necessarily generic, and I propose for convenience to treat the definition of the genus as extended accordingly. In the second place, the two genera cover an enormous number of Cretaceous species, and a study of these indicates that many of them possess characters which would, if their front walls were not furrowed, place them in entirely different genera and even families. Can such forms be logically retained in a single genus? Certainly *Cribrilina* and *Membraniporella* are not for the Cretaceous forms genera in the same sense that, say, *Mucronella* and *Porina* are, but rather agglomerations of the early stages of development of other families and genera, while the family and generic peculiarities were coming into existence, and after they had come into existence, but while the development of a fully calcified front wall was still incomplete. If the two genera were dismembered a large number of species could be successfully grouped with other families; indeed, I think additions out of the Cribrilinidæ would be made to nearly all the important groups except the Celleporidæ, Porinidæ, and Hippothoidæ, and it is interesting to note that Jullien puts the two latter groups in a separate suborder. Even if the Cribrilinidæ are not dealt with in this way the Cretaceous forms suggest that they are the product of two totally distinct lines of development from the primitive Membraniporidan cell. One of these lines is the commonly recognised one, the arching over and fusion in the middle line of marginal spines. But this will not satisfactorily account for the very large number of species in which the front wall is attached to the side of the side walls and does not rest on their surface.

Here the front wall must have arisen by symmetrical calcification of the membranous covering, starting no doubt from points along its junction with the side walls and proceeding inwards. There would therefore, on this hypothesis, be a morphological distinction of the greatest importance in the Cribrilinidæ (and through them in the majority of the Cheilostomata) between cells with a distinct rim and those without a distinct rim, a distinction which would make it impossible to retain the family Cribrilinidæ. It is distinctly favourable to this hypothesis that Marsson has on other grounds given great prominence to the question of rim or no rim in classifying the Cheilostomata. The Cretaceous forms also suggest a third line of development of the calcified front wall through such forms as *Membranipora Trimminghamensis* (*post*). The cell in these forms is clearly an ordinary Membraniporidan cell tilted forwards, and by the squaring of the lower part of the aperture and pressing downwards of the straight lower lip thus formed, we pass by easy stages represented by the Cretaceous forms of *Pyripora* to a *Micropora* practically indistinguishable from one developed through Cribrilinid forms, but with a front wall morphologically quite distinct in its origin from those developed through Cribrilinid forms.

DESCRIPTION OF SPECIES.

A. *Trimmingham Species.*

MEMBRANIPORA GRIFFITHI,[1] sp. nov. (Fig. 1.)

Colony adherent, normally growing equally in all directions with almost the regularity of a *Lunulites*, and possessing a common crust out of which the cells stand sharply. Cell nearly circular, with a sharp-edged, narrow, smooth wall. The mature cells almost invariably have both an ovicell and an avicularium. Ovicell immediately above the cell, about half the width of the zoœcium,

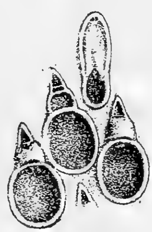


FIG. 1.

and of the usual semi-globose shape. In a large number there is a triangular incision in the rounded end, apparently giving double access to the interior, and the sides of the ovicell are extended along the side wall of the avicularium as far as the crossbar. Avicularium sharply triangular, placed immediately above the ovicell. It is spanned close to its base by a very slender bar, which is often

[1] Dedicated to Mr. C. Griffith, of Winchester, a friend of long standing, who first introduced me to the study of geology.

preserved. Large vicarious specialised cells, possibly vibracularia, occur scantily but regularly. They are long, rather narrow, and constricted towards the lower end. The aperture is situate at the lower end, and is round below and pointed above. The lower two-thirds of it are enclosed by the cell-wall, and the upper one-third by a depressed front wall, which occupies the rest of the area.

MEMBRANIPORA TRIMMINGHAMENSIS, sp. nov. (Fig. 2.)

Colony adherent, growing as a rule in one direction only. Cell elongated and pear-shaped, with an oval aperture occupying with its marginal wall (which has its edges bevelled off) rather more than half the cell, the lower part forming an external area and tapering away. On the marginal wall is a single row of denticles. At the upper end the marginal wall is exceedingly thin, which is easily

FIG. 2.

seen, owing to the free edge of the ovicell being concave. Ovicell globose, narrower than in the preceding species, but similarly placed at the head of the aperture. Avicularium placed above the ovicell, oval with an oval aperture, divided into two lobes (the upper being slightly the larger) by two lateral denticles, which were joined by a slender bar, which is generally destroyed. This species can almost be constructed from the preceding one by rounding and smoothing all sharp angles and corners.

MEMBRANIPORA BRITANNICA, sp. nov. (Fig. 3.)

Colony adherent. Cell subcircular to oval, the marginal wall chiefly a common wall. On the foot of practically every cell is placed either the ovicell or the avicularium of the cell below. The ovicell is of the semi-globose type, but wide, flattened, and steep-sided, so as to appear almost rectangular. Its free edge

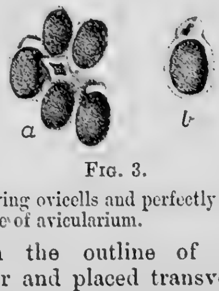


FIG. 3.

a. Group of cells showing ovicells and perfectly preserved avicularium.
b. Cell with usual type of avicularium.

coincides exactly with the outline of the cell-wall beneath. Avicularium mandibular and placed transversely with the point of the mandible indifferently to the right or left. It is generally stumpy (*b*), but in well-preserved specimens the point is long and slender and projects over the adjacent cell (*a*). The point being raised much higher than the rounded end, the aperture is in an inclined plane facing the cell adjacent to the base of the avicularium. It is an almost invariable rule that every cell (except the very early ones) has either an ovicell *or* an avicularium. The species is very characteristic of the Trimmingham Chalk, but is recognisable in the zone of *M. cor-anguinum*, though rare below the zone of *B. mucronata*.

SEMIESCHARA MUNDESLEIENSIS, sp. nov. (Fig. 4.)

Colony always adherent. Cell large and subpyriform, with the external area of the pyriform type occupying usually about one-third of the cell, but only tapering very slightly as a rule. Where the marginal wall divides the internal and external area it is very faint. The aperture is very large and occupies nearly the whole of the space within the marginal wall, and is slightly heart-shaped, its lower margin being indented by a blunt denticle projecting from the internal area. The internal area is usually very insignificant, but is

FIG. 4.

very variable in extent, and may absorb almost the whole external area. It slopes forwards and downwards. The ovicells are not at all prominent, and are little more than swellings of the foot of the succeeding cell, but have a very remarkable thickened broad rim to the aperture. Avicularia rare and very irregular in occurrence. They are narrow elongated membraniporine cells, with a slight area at the foot sloping gently towards the aperture, which is slightly constricted rather above the middle. The size of the aperture makes the species easily recognisable.

SEMIESCHARA CANUI,[1] sp. nov. (Fig. 5.)

Colony always free, but unilamellate. Cells relatively broad, aperture placed in the upper third, small, trifoliate, upper lobe semi-

FIG. 5.

circular, other lobes narrow and exactly alike. No ovicell observed. Avicularium an elongated cell, slightly constricted rather above the

[1] Named in honour of my friend M. F. Canu, the French authority on Polyzoa.

middle at a point on a line with the upper edge of the aperture, which is small and transversely oval, with a strongly denticulated lower lip.

ESCHARA ROWEI, sp. nov. (Fig. 6.)

Colony free, bilamellate, growing in expanding fronds, which are very fragile. Cell long and narrow, aperture occupying quite half the cell, heel-shaped, and elongated, with sides constricted close to the lower lip, and a strongly projecting lower lip. No ovicell. Avicularium an elongated cell with pointed ends, broad in the middle,

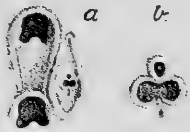


FIG. 6.

tapering more rapidly below than above. Aperture rather below the middle, appearing under a low power as a transverse oblong with rounded corners, and a distinct pore above and a faint pore below (*a*). Under higher powers the structure shown in (*b*) is revealed. This structure is rarely preserved, the specimens generally presenting it in varying degrees of ruin.

CRIBRILINA SHERBORNI, sp. nov. (Fig. 7.)

Colony always adherent. Cell widely oval, apparently based on a primitive form (*a*), with an elongated heel-shaped aperture in a plane at a slight angle to the horizontal, a front wall rising from all sides to a central circular platform in which are cut a series of radiating furrows, two long lateral slits in the front wall commencing between the aperture and the margin and running outwards close to the margin, and a globose ovicell at the top of the cell some distance above the aperture. The first stage of development appears to be that the lower lip of the aperture rises slightly, and the rest of the

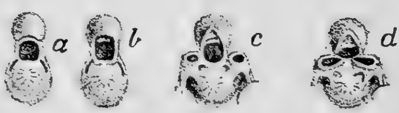


FIG. 7.

margin of the aperture rises considerably to form with the upper edge of the aperture of the ovicell an oval secondary aperture (*b*). Next there are developed over the lateral slits lateral avicularia, set on legs so as to allow free access of water to the slits (*c*). These avicularia are very faintly mandibular, with the point of the mandible on the inner side, but the least attrition makes them circular. At the same time the sides and base of the secondary aperture are further raised, and the sides are produced up the sloping surface of the ovicell to meet at the central crown. In the final stage (*d*) the avicularia develop very decided beaks, connected by a thin, almost horizontal plate into a barrier right across the cell which overhangs and entirely conceals the primary aperture, while even the area between the primary aperture and the ovicell is now so deep set as to be visible only in special lights. It is the rule for every cell to attain this stage, but the fragility of the plate between the avicularia produces many variations in the shape of the secondary aperture when the specimen is handled at all roughly. *Cellepora pinguis*, Hag., appears to be a relation.

CRIBRILINA DIBLEYI, sp. nov. (Fig. 8.)

Colony always adherent. Cell elongated. Aperture heel-shaped, surrounded by a flat raised margin, the lower lip being triangular, with the apex directed down the front wall. The upper lip bears four or five hollow denticles (when there are five the fifth is a small one between the two at the head of the cell). Ovicell large and globose, with faint radial markings, and covers the two (or three) upper denticles. Front wall marked by about 17 lines of fine

FIG. 8.

pores, increasing slightly in size towards the margin. These lines do not (except the topmost pair) meet in the middle, but leave an imperforate bar down the centre. Nearly every cell has one avicularium, many have two. They are either mandibular and slender, with thin marginal walls connected by a slender rod near the base, or broadly oval. The latter are probably decayed or worn specimens.

CRIBRILINA JUKES-BROWNEI, sp. nov. (Fig. 9.)

Colony always adherent, generally growing in narrow ribbons. Cell based on a primitive form like *Repteschareila inæqualis*, D'Orb., but with a decided rim. It has a long globose ovicell, up the front of which two slender ridges run diagonally from each corner of the aperture, meeting in an angle at nearly the highest point of the ovicell. The lower lip of the aperture is produced forwards and upwards into a broad band in three sections. The lowest of these is bluntly triangular, with the apex pointing downwards. At the sides of the cell it rises gently to the second section, which is, however, strongly arched in the middle, and so leaves there an opening between it and the first section. The third section is at a higher level still, more or less flattened and buttressed, apparently not against the side walls but against two lateral tubes (presumably avicularian), which rest on the side walls and open just beside the aperture. In the centre this third section rests on the second section, and its lower edge having a deep sinus an inlier of the second section is exposed. At the sides the third section rises considerably above the second section, and so there is a well-marked opening left. The upper edge of this third section carries two very minute and slender beak-shaped avicularia lying transversely with their beaks directed inwards. These constitute the apparent lower lip of the aperture, and according as they do not quite meet, just meet, or rather more than meet, in the middle line, the apparent lip has

Fig. 9.

a central sinus, is quite straight, or has a central denticle. This apparent lip is on the same vertical plane as the deep-set aperture of the ovicell, and entirely conceals the aperture of the cell, and leaves only a small space between itself and the sloping surface of the ovicell. Below the transverse band is seen the normal front wall with five pairs of radiating furrows, and a single unpaired one in the middle line at the foot. The ovicell and transverse band are practically always present, and the species, which is quite small, is easily recognisable with a pocket magnifier, though the details are hardly discernible under the microscope.

Mucronella Batheri, sp. nov. (Fig. 10.)

Colony always adherent, small and very prominent, partly owing to the compactness of its surface and partly apparently to its being bilamellate. The cells of the lower lamella are wide, but very shallow, and some of them may generally be seen round the edge of the colony. They rarely exhibit more than the marginal wall, but occasionally one may be seen with a front wall consisting apparently of a number of irregular plates with a round pore in the centre. On

Fig. 10.

the foundation afforded by these cells is built a layer of cells of normal depth. Here the primitive cell is a simple lepralian cell with an oval aperture in a sloping plane. But as the cell matures the lower lip of the aperture is produced in the plane of the surface of the colony into a broad square mucro overhanging the greater part of the aperture and leaving only a very narrow space on either side of it and between it and the broad ovicell. The latter is nearly always present, and is set on the base of the succeeding cell, and so deeply sunk that its rather flattened upper surface is practically flush with the general surface of the colony. This gives the colony its uniquely compact appearance. Every cell bears one or two avicularia, consisting of long slender tubes lying on the front wall with the wider and open end a short way below the mucro, and tapering away posteriorly and sinking gradually into the front wall. Cells which carry at the foot the ovicell of a preceding cell have two lateral avicularia; those which do not carry such an ovicell (e.g. the first of an intercalated series) have one median avicularium.

B. *Senonian Species.*

SEMIESCHARA WOODSI, sp. nov. (Fig. 11.)

Colony usually adherent, occasionally free and unilamellate. Cells hexagonal and arranged quincuncially. Aperture approximately oblong and transverse, the upper lip being sometimes rather shorter than the lower, and sometimes slightly convex. This upper lip slopes sharply inwards, and may therefore be overlooked unless the light is thrown from the *foot* of the cell. Ovicell very rare, merely a swelling of the foot of the succeeding cell. Avicularia fairly but

FIG. 11.

variably plentiful. They are separate cells, but not vicarious. They are more or less shuttle-shaped, with a small round aperture in the point of the shuttle. The species appears at least as low as the Marsupite zone, but attains its zenith in the base of the *B. mucronata* zone. It is probably lineally related to *Cellepora Michaudiana*, D'O., but easily distinguished by the shape of the apertures both of cell and avicularium.

SEMIESCHARA PERGENSI, sp. nov. (Fig. 12.)

Colony adherent. Cells hexagonal, of varying dimensions, arranged more or less quincuncially with a very broad and ill-defined common wall. Front wall arched from side to side, and also sinking slightly

FIG. 12.

from the foot (where it is almost on a level with the top of the cell-wall) towards the aperture. The aperture is semicircular and large, with rounded basal angles, and stretches from side wall to side wall, but its apparent breadth is restricted by a very slight infold of the inner edge of the side walls. The lower lip is almost straight, but the very slight curve is often accentuated by the arching of the front wall from side to side. The avicularium is an elongated cell with an oval aperture occupying two-thirds of the area, and touching the cell-walls at its widest, but separated from them above that point by a very slight deep-seated front wall, and below that point by a considerable front wall rising towards the foot of the cell to the plane of the top of the cell-wall. The species is very characteristic of the upper part of the zone of *B. quadrata.*

CRIBRILINA GREGORYI, sp. nov. (Fig. 13.)

Colony either adherent or free and unilamellate. Cells large, with walls on the whole common, though often showing signs of separation. Aperture large and semicircular, surrounded by a broad smooth border, which extends between the upper edge of the aperture and the foot of the next cell for a distance equal to or greater than the height of the aperture. From the upper part of this band two prominent denticles project out over the aperture. The front wall springs from slightly below the surface of the side walls, and is gently arched. It bears about seven rows of punctures, running straight across from side to side, the two punctures next the side walls being much larger than the others. There are usually two avicularia, always one, to each cell, closely associated with the

FIG. 13.

lower corners of the band round the aperture. They are small and mandibular, but except in well-preserved specimens from the zone of *B. quadrata*, where this species reaches its zenith, the mandible is poorly or not at all developed, and the avicularia present themselves as very small circular perforate denticles. No ovicell has yet been observed, though many thousands of specimens have been seen. The species most nearly resembles *Semiescharipora dentata*, D'Orb. (which is, however, near the *Membraniporellæ*), but is easily distinguished from that and all other species by the two imperforate denticles overhanging the aperture. It appears in the zone of *M. cor-testudinarium* (at Seaford), and becomes steadily more prevalent until in the upper part of the zone of *B. quadrata* it is the dominant form; above the base of the zone of *B. mucronata* it soon becomes comparatively rare.

II.—Sedgwick Museum Notes.

New Fossils from the Bokkeveld Beds, South Africa.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATES XVI and XVII.)

A SMALL collection of fossils from the Bokkeveld Beds has recently been sent to me for identification by the South African Museum, and some of them have been generously presented to the Sedgwick Museum. Amongst this material it is interesting to find some genera not previously recorded from the Cape and some new species. The majority of the specimens are in the condition of internal casts, and hence present especial difficulties in their determination, so that in a few cases some uncertainty must remain as to the generic position of the fossils. However, I am able to record for the first time from these beds the occurrence of the well-known lamellibranchiate genus *Buchiola*, and of a shell which may be identified with *Nyassa arguta*, Hall, of the North American Devonian. The genus *Buchiola* occurs in argillaceous nodules from the Zwartberg Pass crowded with individuals of the species which I have named *B. subpalmata* and with a few examples of an undetermined species. No other associated fossils can be recognised in these nodules, but I am informed that an abundant fauna is found in the beds at this locality.

There are only single specimens in the collection of the species which I have determined as *Nuculites* cf. *Smithi*, *Sanguinolites* (?) *acer*, and *Nyassa arguta*, and only two of *Sanguinolites niger*. The fine large brachiopod which appears to be probably referable to the little known Bolivian genus *Scaphiocœlia*, or may belong to a completely new generic type, is represented by eight specimens, all of which are sandstone casts with occasionally portions of the shell attached.

The genus *Ptychospira* is now for the first time identified in the Bokkeveld Beds.

The following is a list of the species in the collection :—

[1] *Tentaculites crotalinus*, Salter.
Buchiola subpalmata, sp. nov.
Buchiola sp. ind.
[1] *Nuculites* cf. *Smithi*, Clarke.
Sanguinolites niger, sp. nov.
S. (?) *acer*, sp. nov.
Nyassa arguta, Hall.
Scaphiocœlia (?) *africana*, sp. nov.
Rensselæria cf. *confluentina*, Fuchs.
[1] *Ptychospira variegata*, sp. nov.

The present author has previously published an account of the principal collection of brachiopods and molluscs from the Bokkeveld Beds in the Annals of the South African Museum, vol. iv, pts. 3 and 6 (1903–1904).

[1] These three species occur associated together on the same rock specimens from an unknown locality.

LAMELLIBRANCHIATA.

BUCHIOLA SUBPALMATA, sp. nov. (Pl. XVI, Figs. 1, 1*a*, 2.)

Diagnosis.—Shell subquadrate or subcircular, nearly equilateral and nearly as high as wide, more or less swollen; hinge-line straight, shorter than shell, cardinal angles obtusely rounded. Beaks subcentral, a little nearer anterior than posterior end, opposed, directed slightly forwards, strongly incurved. Valves more or less inflated, most so in middle, somewhat compressed near cardinal region on both sides of beaks. Surface marked with 11–13 raised, flattened, radiating ribs with sharp edges, elevated abruptly above the narrower intercostal grooves, which are rounded. The middle 5–7 ribs are stronger than the others, of subequal height and size, and curved slightly forwards; at the margin of the shell they are 1½–2 times wider than the separating grooves. The anterior 2–3 ribs are smaller, less elevated, and slightly concave on their surface, and are curved more upwards; the posterior 3–5 are likewise lower and much less conspicuous than the middle ones, and have their surface sometimes rather concave, and they are curved up slightly towards the hinge-line. Fine, inconspicuous, regular, closely set, concentric striæ cross the ribs and grooves, and are slightly arched on the former. (These are not distinctly shown in the figures.)

Dimensions:

Average	length	5·5–6·0 mm.
,,	height	5·25–5·5 ,,
,,	thickness	3·50–4·25 ,,

Locality.—Zwartberg Pass.

Remarks.—The genus *Buchiola* has not been previously recorded from South Africa, and I have not found it mentioned amongst the Devonian fossils from South America, to which the fauna of the Bokkeveld Beds has been shown to bear a close resemblance in composition and species. It is, on the other hand, a characteristic European genus, represented, especially in the Rhenish Devonian, by many species which Beushausen[1] has described, and it occurs also in North America, where Hall applied the generic name *Glyptocardia* to it. The range of the genus extends from the Upper Silurian (Bohemia) to the upper horizons of the Devonian. In the Rhenish provinces it appears to be limited to the Middle and Upper Devonian.

The affinities of our South African form are undoubtedly with *B. palmata* (Goldfuss)[2] in the shape, number, and distribution of the ribs; but as regards the subequilateral form of the shell and its inflated character *B. ruppachensis*, Beush.,[3] resembles it more closely. *B. speciosa* (Hall),[4] from the Genesee Slate, is closely allied to, if not identical with, *B. palmata*, as Beushausen has observed.

[1] Beushausen, Lamell. rhein. Devon: Abh. kön. preuss. geol. Landesanst., N.F., xvii (1895), pp. 322–338, pls. xxxiv, xxxv.

[2] Ibid., p. 333, pl. xxxiv, figs. 3–5.

[3] Ibid., p. 324, pl. xxxiv, figs. 8*a–f*.

[4] Hall: Palæont. N.Y., vol. v, pt. 1 (1883), pl. lxx, figs. 6–8.

The South African form, however, appears sufficiently distinct from all the described species of *Buchiola* to warrant a separate specific designation, and the name *subpalmata* is accordingly proposed as indicating its nearest ally.

BUCHIOLA sp. ind.

There is another species of *Buchiola* occurring in the nodules from the Zwartberg Pass, but I have only been able to discover impressions of portions of the exterior surface or imperfect internal casts. It is characterised by the ribs being very flat and scarcely elevated above the shallow grooves, and by both being of equal width. The ribs are broad and few in number, and bear arched striæ; but the material is too poor for further details. *B. angulifera*, Roemer,[1] appears to resemble it in the character of the ribs.

Locality.—Zwartberg Pass.

NUCULITES cf. SMITHI, Clarke.

One specimen of a shell belonging to the genus *Nuculites* occurs on the same slab of greyish micaceous clay as *Tentaculites crotalinus* and *Ptychospira variegata*, and comes from an unknown locality. It consists of a right valve (with the ends slightly broken) of an elongate species, having the clavicular ridge set unusually far forward in front of the beak, which is placed at about two-fifths the length of the shell from the anterior end. The general shape of the shell, position of the beak and clavicular ridge, more resemble *N. Smithi*, Clarke,[2] from the Devonian of Brazil, than the allied *N. africanus* (Salter)[3] from the Bokkeveld Beds; and it is also comparable with *N. elongatus* (Conrad) of the Hamilton Group of New York.

Dimensions:

Length	*ca.* 20 mm.
Height	*ca.* 12 ,,

Locality.—Unknown.

NYASSA ARGUTA, Hall (?). (Pl. XVI, Figs. 3, 3*a*.)

One somewhat imperfect internal cast of a lamellibranch from the Zwartberg Pass shows the following characters:—Shell elongated, oval, slightly curved, widest in front, narrowing a little posteriorly, and obliquely truncated behind. Valves gibbous, especially in anterior portion, not compressed nor flattened behind. Beaks low, subterminal, very broad, obtuse, rounded; a strong curved umbonal ridge runs to postero-inferior angle of shell; and a broad, well-marked, but shallow depression, widening below, extends obliquely from beak in front of ridge to inferior margin, occupying nearly two-thirds the length of the shell. Hinge-line arched; inferior margin broadly and rather deeply sinuated; anterior end broadly

[1] Beushausen: op. cit., p. 337, pl. xxxv, figs. 18, 19.
[2] Clarke, Palæoz. Faunas of Para: Archiv Mus. Nac. Rio de Janeiro, vol. x (1899) (English edit.), p. 71, pl. viii, fig. 5.
[3] Sharpe: Trans. Geol. Soc., ser. II, vol. vii, p. 211, pl. xxvii, fig. 2 (? 4). Reed: Ann. S. Afr. Mus., vol. iv, pt. 6 (1904), p. 256.

rounded; posterior end narrowed, truncated above, somewhat pointed below. Cardinal margins of valves strongly thickened internally as far forward as anterior adductor scars, with traces of 3–4 small elongated pits in hinge-plate between and in front of beaks. Adductor scars deeply impressed, oval, obliquely placed close below beaks and on anterior lateral margin. Surface of shell marked with a few strong oblique concentric growth-ridges.

Dimensions:

Length	...	...	...	25 mm.
Height	...	...	...	15 ,,
Thickness	...	...	...	14 ,,

Locality.—Zwartberg Pass.

Remarks.—This shell appears to be identical with *Nyassa arguta*, Hall,[1] from the Hamilton Group of North America. It is only in the matter of the teeth (which probably are absent in our specimen owing to its condition of preservation) that any difference is noticeable. Beushausen[2] identifies Goldfuss' *Sanguinolaria dorsata* from the Upper Calceola Beds and the Stringocephalus Limestone with the American species. I am doubtful if Sharpe's *Sanguinolites* (?) *corrugatus*[3] from the Bokkeveld Beds is identical with our specimen, Sharpe's type being merely the impression of one pair of valves.

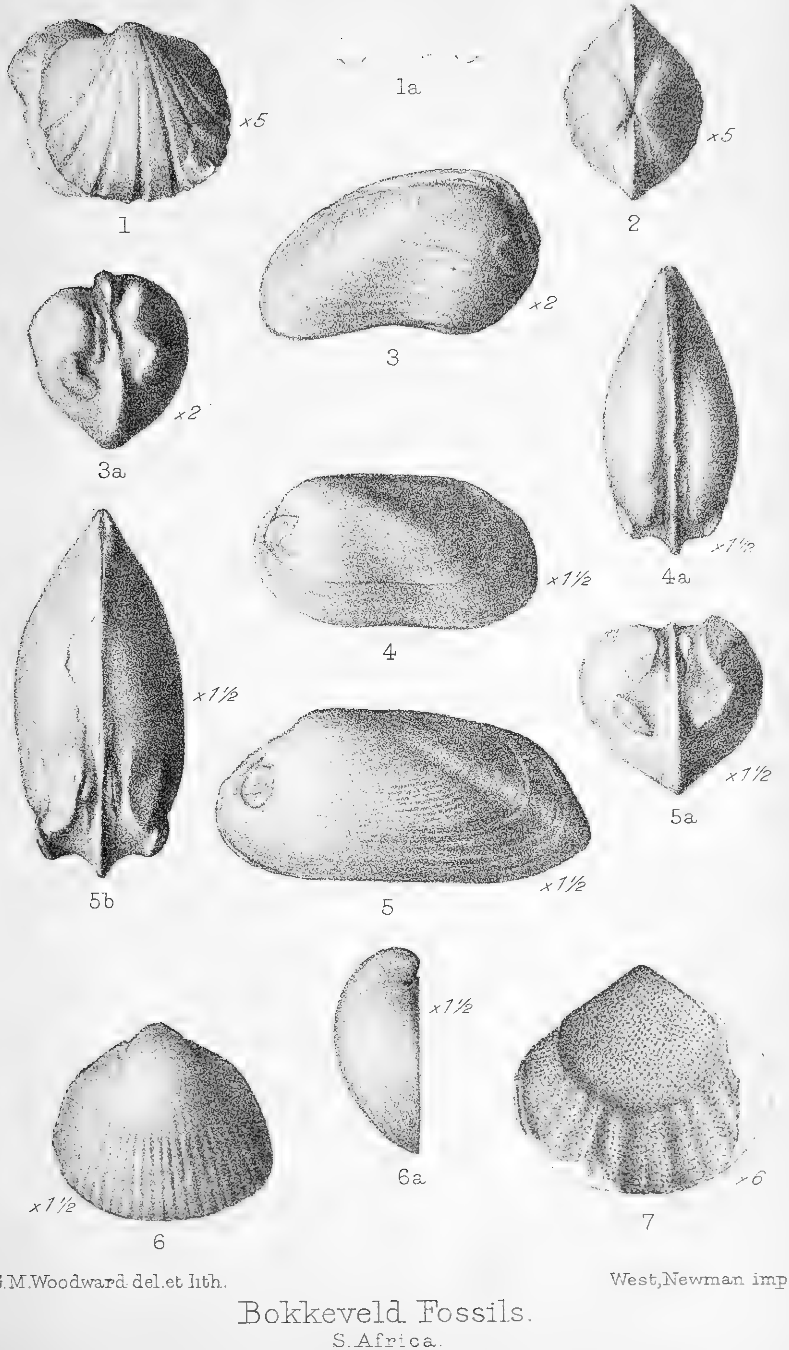
SANGUINOLITES NIGER, sp. nov. (Pl. XVI, Figs. 4, 4*a*.)

Two examples of another lamellibranch from the Zwartberg Pass likewise consist of internal casts, one of which is nearly perfect, but the other has the posterior end broken off. From the former the following description is drawn up:—Shell oblong, upper and lower margins nearly parallel; posterior and anterior ends broadly rounded, the former rather broader and more obtuse. Cardinal margin behind beaks straight and horizontal; inferior margin indented with wide, shallow sinuation in middle, and curving up more gradually in front than behind. Beaks subanterior, broad, obtuse, low, scarcely rising above hinge-line, and directed forwards; broad, undefined umbonal ridge runs down with decreasing strength to posterior third of inferior margin, and has a weak, shallow depression in front of it corresponding to marginal sinus. Valves moderately convex, most so on umbonal ridge, flattened and compressed behind. Anterior adductor scars deep, oval, situated just below beaks, close to anterior margin. Posterior adductors indistinct. Cardinal and anterior margins thickened internally, with elongated, lanceolate, ligamental area behind beaks, and one or two elongated pits between beaks parallel to hinge-line. No teeth present.

Dimensions:

Length	...	...	...	24·5 mm.
Height	...	...	...	14·5 ,,
Thickness	...	...	...	11·5 ,,

[1] Hall: Palæont. N.Y., vol. v, pt. 1 (1883), pl. liii, figs. 9–20.
[2] Beushausen: op. cit., p. 31, pl. iii, figs. 7–9.
[3] Sharpe: op. cit., p. 212, pl. xxvii, fig. 8.



G. M. Woodward del. et lith. West, Newman imp.

Bokkeveld Fossils.

S. Africa.

Locality.—Zwartberg Pass.

Remarks.—The true generic position of this shell appears to be in *Sanguinolites*, following Wheelton Hind's definition.[1] In shape and general characters our species seems to resemble Oehlert's *S. Marsi*,[2] but probably it belongs to a new and undescribed species which may be termed *niger*. I do not think any of the Brazilian or Bolivian forms which Clarke and Ulrich have described and figured come very near it.

SANGUINOLITES (?) ACER, sp. nov. (Pl. XVI, Figs. 5, 5*a*, 5*b*.)

There is another internal cast from Zwartberg Pass which may represent a species of *Sanguinolites*, but its generic position is somewhat doubtful.

Shell elongated oval, twice as long as high; valves strongly convex, most so in anterior two-thirds of shell, posteriorly being somewhat compressed. Anterior end rounded, slightly narrower than posterior end, which is obliquely truncated. Hinge-line gently arched; inferior margin nearly straight, a little concave towards middle. Beaks broad, obtuse, low, situated at about one-fourth the length of the shell from anterior end; obscurely defined, transversely oval lunule in front. Umbonal ridge moderately strong, running from beak to postero-inferior angle, with shallow, undefined, weak depression in front of it reaching sinuation of inferior margin, and a narrow, more defined sulcus behind it running nearly straight back to posterior angle. Anterior adductor scars deep, subtriangular, strongly ridged, situated close to anterior margin and about half-way between beak and anterior inferior angle. Pallial line simple, and at about one-fourth the height of the shell. Posterior adductor scars not visible. Margins of valves between beaks and on anterior end thickened internally and rounded; on umbonal hinge-plate thus formed is a short longitudinal furrow parallel to hinge-line and followed by two or three more or less fused pits. Surface of shell ornamented with rather coarse, raised, concentric ridges swelling out into small irregularly spaced nodules (observed on one fragment of shell adhering to the cast).

Dimensions:

Length	33·5 mm.
Height	16·5 ,,
Thickness	15·0 ,,

Locality.—Zwartberg Pass.

Remarks.—It does not seem possible to determine with certainty the genus of this shell. The ridges and grooves on the surface and the ornamentation suggest *Grammysia*; the internal grooves and pits on the hinge-plate are indistinctly seen, but seem to point to the presence of an internal ligament. The general shape, however, more resembles members of *Sanguinolites*, and for the present it may be left in this genus.

[1] Wheelton Hind: Mon. Brit. Carb. Lamell., vol. i, pt. 5 (1900), p. 361.
[2] Oehlert: Bull. Soc. Géol. France, ser. III, vol. xvi (1888), p. 658, pl. xv, fig. 4.

BRACHIOPODA.

SCAPHIOCŒLIA (?) AFRICANA, sp. nov. (Pl. XVII, Figs. 1, 1*a*, 1*b*, 1*c*; 2, 2*a*, 2*b*; 3, 3*a*.)

Diagnosis.—Shell elongate-oval to subcircular, plano-convex. Pedicle valve inflated, strongly convex, compressed laterally, distinctly keeled and angulated on back; beak large, high, incurved, rising well above strongly curved hinge-line and arching over beak of opposite valve, with sharply angular lateral edges and large concave triangular pseudo-area below it; large triangular delthyrium (? covered by concave plate), with margins slightly infolded; small subapical foramen present in beak. Brachial valve flat or very feebly convex; beak smaller and lower, and less incurved than that of pedicle valve.

Interior of pedicle valve with pair of thick, strong, subparallel or slightly divergent dental plates, slightly concave and closely embracing sides of cardinal callosity of opposite valve (Figs. 1, 1*b*, 1*c*). Muscular impression large, oval, extending about one-third the length of the valve, slightly depressed and margined by weak ridges diverging from bases of dental plates, which are connected by a low, faint, transverse ridge in umbonal cavity; the pair of large elongate diductor scars are distinct in the muscular area, but the adductor scars are not visible.

Interior of brachial valve with large massive umbonal callosity or hinge-plate completely fused with bottom of valve and filling up whole of cavity of beak; anterior face of callosity is vertical, marked with shallow longitudinal groove and deep central pit, and it bears on its free edge a pair of small, short, blunt cylindrical processes (bases of crura) projecting into the pedicle valve (Figs. 1*b*, 1*c*). Muscular impression large, oval, consisting of pair of deeply sunk, oval, posterior adductors indistinctly separated from a pair of rather larger, less sunk, anterior adductors, faintly defined in front; a pair of low, rounded, diverging ridges bound the impression laterally, and a narrow, thin, median ridge, thickest and highest between the posterior adductors, divides it longitudinally.

Surface of shell marked with 30–40 low flattened ribs, closely placed and separated only by narrow grooves. In the internal casts the ribs show more distinctly than on the exterior of the shell itself. A few concentric growth-ridges are present in some specimens. Shell substance thick, massive, impunctate.

Dimensions:

	I.	II.	III.	IV.
Length ...	57 ...	53 ...	*ca.* 52 ...	39 mm.
Width ...	32 ...	32 ...	*ca.* 35 ...	38 ,,
Thickness ...	33 ...	*ca.* 34 ...	*ca.* 32 ...	27 ,,

Specimens I and II are in the South African Museum, Cape Town. Specimens III and IV have been presented by the South African Museum to the Sedgwick Museum, and are in the latter.

Locality.—Gouritz River, north of the Langebergen.

Remarks.—Eight specimens of this interesting fossil have been submitted to me for examination, and all are from the same locality. They are in the condition of internal casts, with the exception of one fragment of a pedicle valve (Pl. XVII, Figs. 3, 3*a*), which has the shell of the beak and of the adjoining portions preserved. It is unfortunate that the available material is not better, but by making casts of the specimens it has been possible to draw up the foregoing description.

The generic position and relations of this fossil are not at once obvious, although the general appearance suggests the genus *Rensselæria*, and certain features recall the imperfectly known genus *Scaphiocœlia* from the Devonian of Bolivia. This genus, of which only one species has been described (*S. boliviensis*, Whitfield[1]), is defined by its author as follows:—" A terebratuloid, brachiopodous shell, having a strongly convex ventral valve and a longitudinally and angularly sulcated dorsal valve, both of which are strongly plicated. Internally the ventral valve has a strong, deep, triangular, byssal opening and muscular seat, and the dorsal has strong crural processes; but the loop or calcified appendages are unknown. Shell structure strongly fibrous, without any puncture under a hand-magnifier." Hall & Clarke[2] quote this description, and remark that the genus may be provisionally regarded as allied to *Centronella* and *Trigeria*. The type-species reaches a size of over 3½ inches in length. Our specimens approach this in dimensions, and possess the large incurved beak, foramen, and apparently open delthyrium indicated in Whitfield's figures. The pedicle valve is likewise the more convex of the valves, but the brachial is merely flattened and not "angularly sulcated." The external ornamentation and structure of the shell appear to be similar, though the surface of our specimens is somewhat abraded.

Internally our shell does not exhibit the perforated hinge-plate of *Trigeria* and its allies; and its massive hinge-plate, not divided down the middle and not supported by septa, removes it from *Rensselæria* and *Beachia*. The muscle-scars are also quite different. The characters and prominence of the muscle-scars in the pedicle valve, and the massive hinge-plate, median septum, and large, well-defined, flabellate, adductor impressions in the brachial valve of *Megalanteris ovalis*, Hall,[3] are recalled by the characters of our species, but we have no evidence that the latter possessed a cardinal process similar to that found in *Megalanteris*. The beak of the pedicle valve is less prominent, and the ornamentation of the surface of the shell different, but these features are of less importance. The stout approximate crura in our shell are not specially distinctive.

On the whole, we seem to have a shell externally resembling in many respects *Scaphiocœlia*, and internally showing many features of resemblance to *Megalanteris*. The ignorance which exists as to

[1] Whitfield: Trans. Amer. Inst. Mining Engineers, vol. xix (1891), p. 106, figs. 1–4.

[2] Hall & Clarke: Palæont. N.Y., vol. viii, Brach. ii (1894), p. 275, figs. 193–196.

[3] Hall: Pal. N.Y., vol. iii (1859), p. 458, pl. 106, figs. 2*a*–*l*. Hall & Clarke, op. cit., p. 277, pl. lxxvii, figs. 12–22.

the internal characters of *Scaphiocœlia* is unfortunate; but on account of its external resemblance and its typical occurrence in beds of which the fauna has been proved to be closely allied to that of the Cape Bokkeveld formation, we may provisionally assign our species to this genus, and designate it by the distinctive specific name of *africana*. I am inclined to think that the poor specimen which I described[1] as *Rensselæria*, sp. *a*, from Assegai Bosch, Roode Berg, Ladismith, should be referred to this species, or at any rate to this genus; and it is not impossible that the other form described as *Rensselæria*, sp. β,[2] may also belong to it; but they are in too poor a state of preservation to establish their position without doubt.

Rensselæria cf. confluentina, Fuchs. (Pl. XVI, Figs. 6, 6*a*.)

There is one tough, grey quartzose sandstone fragment, deeply iron-stained on the surface, from the Gouritz River, north of the Langebergen, which contains two specimens of a subcircular, strongly convex, and radiately ribbed brachiopod. Both specimens apparently represent the pedicle valve, and the better preserved one has a regularly convex, swollen shape, with an incurved, moderately high beak, on each side of which small dental plates are indicated by slits in the cast. The surface of the valve shows no fold or sinus, but is covered by about 40–50 regular, closely placed, simple, radiating, small, rounded ribs. A few concentric growth-ridges are visible towards the margin. The dimensions of this specimen are as follows, the maximum width being anterior to the middle:—Length 18·0 mm., width 19·0 mm., depth (of pedicle valve) 8 mm. Another specimen of approximately the same size from the same locality consists of the internal cast of a complete individual, slightly distorted. The shell is biconvex, the pedicle valve being slightly deeper than the brachial; and the shape agrees with that of the previously described specimen. The oval impression of the diductor muscles in the pedicle valve is strong and deep, and extends about one-third the length of the valve from the beak. In the opposite valve the two pairs of adductors form a subtriangular scar, widening anteriorly; the posterior pair is narrow and deeply sunk, while the anterior pair is wider and less clearly defined. A low median ridge divides the pairs longitudinally. The hinge-plate was deeply cleft, but further details cannot be made out. The ribbing on the surface is the same as in the other specimen.

The true generic position of these brachiopods is somewhat doubtful, but I believe they must be placed in the genus *Rensselæria*. The internal characters, so far as they are known, agree with this genus, and in shape and general features *R. confluentina*, Fuchs,[3] from the Lower Devonian of the Rhenish area, may be compared. This species is described and figured as having a subrotundate outline, with 40–50 ribs on the larger mature individuals, with concentric growth-striæ, and mostly without a median septum in the

[1] Reed: Ann. S. Afr. Mus., vol. iv, pt. 3 (1903), p. 176, pl. xxi, fig. 8.
[2] Ibid., p. 177, pl. xxi, fig. 9.
[3] Fuchs: Jahrb. kön. preuss. geol. Landesanst., xxiv, pt. 1 (1904), p. 50, pl. vii, figs. 7–14; pl. viii, figs. 1–14.

pedicle valve. Probably the poor specimens referred previously by me[1] to *Trigeria* aff. *Gaudryi*, Oehlert, belong to the same form.

If a specific name for this shell is considered desirable, as it is probably distinct from any described by other writers, I would suggest the name *rotunda*, in reference to its shape.

Locality.—Gouritz River, north of the Langebergen.

Ptychospira variegata, sp. nov. (Pl. XVI, Fig. 7.)

In three fragments of the bluish-grey micaceous clay containing *Tentaculites crotalinus* and *Nuculites* cf. *Smithi*, from an "unknown locality," there are the imperfect internal casts and external impressions of a small brachiopod, which, by its shape, plications, and remarkable ornamentation, is closely allied to, though not identical with, *Ptychospira ferita* (Von Buch) of the Middle Devonian of the Eifel. The typical shape of this European species is rather more elongate and less transverse; and it has a few rounded, curved plications, increasing in strength towards the margin, the central one of which in the pedicle valve is straight and grooved down the middle. But in our Cape form all the folds are nearly straight, and there seem to be 3–5 lateral ones on each side of the median one, instead of only 3, though those nearest the hinge-line are very faint and weak. The whole surface of our shell is also covered with small, closely-set pits, arranged mostly in irregular quincunx fashion, but forming radiating rows gently curved upwards near the cardinal angles, and towards the front there is a tendency for 2–3 adjacent pits to fuse and form short broken lines more or less concentric to the margin. A few concentric growth-ridges are also present. The more transverse shape of the shell, the number of folds, their smaller curvature, and the distribution and local fusion of the pits on the surface distinguish this imperfectly known shell from *Pt. ferita*, of which Sandberger[2] has well figured the external ornamentation. The average length of our specimens is about 5 mm., and the transverse width slightly greater.

EXPLANATION OF PLATES XVI and XVII.

Plate XVI.

Fig.
1. *Buchiola subpalmata*, sp. nov. × 5. Zwartberg Pass.
1*a*. Ditto. Outline section of ribs to show shape and elevation.
2. Ditto. View of another complete shell from above.
3. *Nyassa arguta*, Hall (?). × 2. Zwartberg Pass.
3*a*. Ditto. Same specimen. × 2. Anterior view.
4. *Sanguinolites niger*, sp. nov. × 1½. Zwartberg Pass.
4*a*. Ditto. Same specimen viewed from above.
5. *Sanguinolites* (?) *acer*, sp. nov. × 1½. Zwartberg Pass.
5*a*. Ditto. Same specimen. × 1½. Anterior view.
5*b*. Ditto. Same specimen. × 1½. Viewed from above.
6. *Rensselæria* cf. *confluentina*, Fuchs. × 1½. Pedicle valve. Gouritz River.
6*a*. Ditto. Same specimen. × 1½. Side view.
7. *Ptychospira variegata*, sp. nov. × 6. Internal cast of pedicle valve. Locality unknown.

[1] Reed: Ann. S. Afr. Mus., vol. iv, pt. 3 (1903), p. 178, pl. xxi, figs. 11, 12.

[2] Sandberger: Verstein. Rhein. Syst. Nassau, 1855, p. 330, pl. xxxiii, figs. 13*c*, *d*. Hall & Clarke: Palæont. N.Y., vol. viii, Brach. ii (1894), p. 112.

PLATE XVII.

FIG.

1. *Scaphiocœlia* (?) *africana*, sp. nov. Nat. size. Side view of internal cast. Gouritz River.
1*a*. Ditto. Same specimen. Anterior view of shell.
1*b*. Ditto. Same specimen, viewed from dorsal (brachial) side.
1*c*. Ditto. Same specimen. Umbonal region of pedicle valve, inverted to show details of structure.
2. Ditto. Another smaller specimen. Nat. size. Side view of internal cast, showing ribbing of shell. Same locality.
2*a*. Ditto. Same specimen. Nat. size. Anterior view.
2*b*. Ditto. Same specimen. Nat. size. Viewed from dorsal side. (The right-hand upper portion of shell is obscured by matrix.)
3. Ditto. Another specimen. Nat. size. Umbonal region of an imperfect individual, with shell adhering to cast of pedicle valve. Same locality.
3*a*. Ditto. Same specimen. Nat. size. Full-face view, showing sharp incurved beak of pedicle valve.

d. diductor muscles; *a.* adductor muscles; *c.* bases of crura; *d.p.* dental plates; *f.* foramen in beak of pedicle valve; *p.* central pit in hinge-plate; *t.r.* transverse ridge in umbonal cavity of pedicle valve; *m.r.* median ridge in brachial valve.

[N.B.—With the exception of the specimens Pl. XVI, Fig. 1, and Pl. XVII, Fig. 3, which are in the Sedgwick Museum, all the above types are in the South African Museum, Cape Town.]

III.—THE ORIGIN AND MODE OF FORMATION OF THE PERMIAN BRECCIAS OF THE SOUTH DEVON COAST.

By BERNARD HOBSON, M.Sc., F.G.S.,
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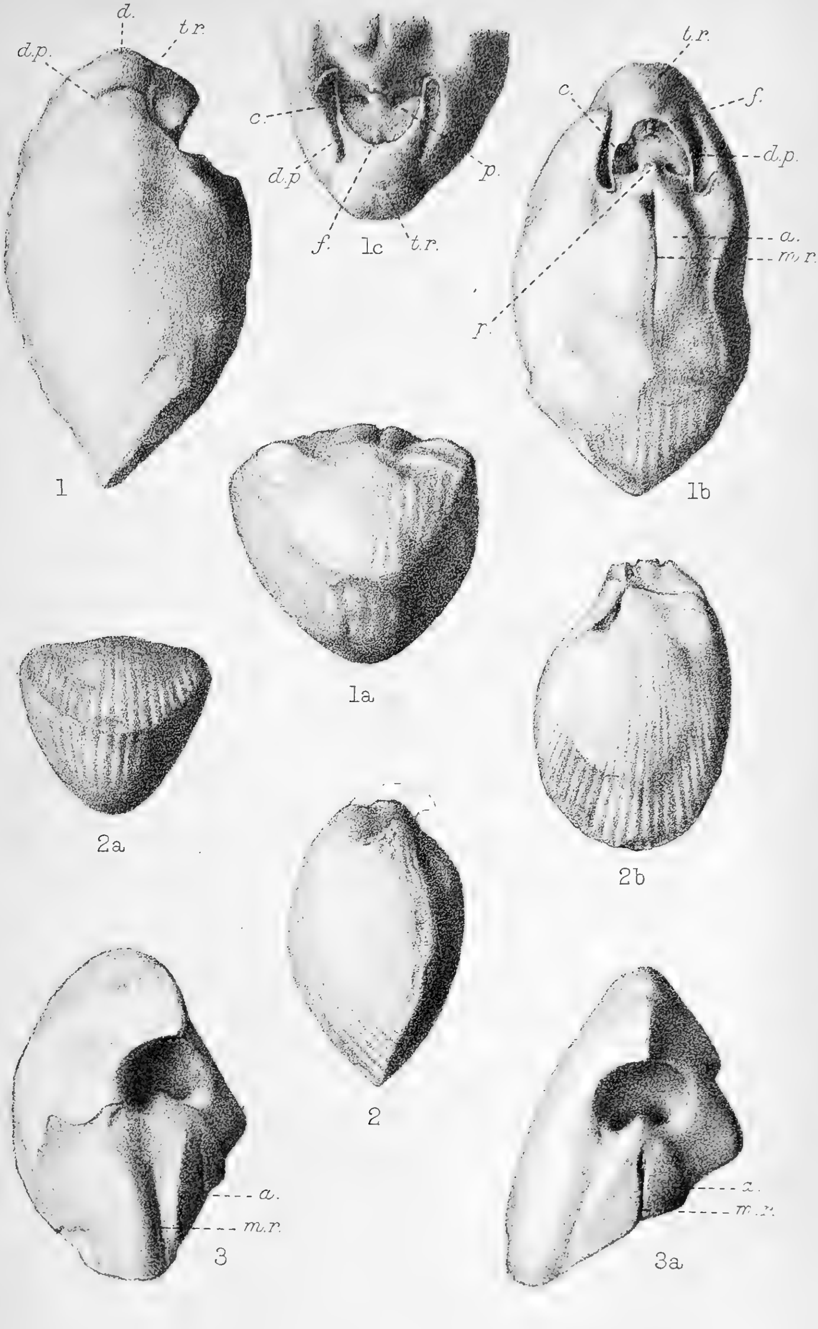
(PLATE XXI.)

AFTER visiting in 1905 the excellent exposure of the Permo-Carboniferous Dwyka Conglomerate, containing glacially striated boulders, overlying glacially striated Barberton beds at the foot of Gotshe Mountain in the Vryheid district of Natal,[1] it occurred to me to examine the Permian breccias of the South Devon coast to see whether I could find any evidence of their being of glacial origin.

The breccias in question have been frequently described, but, so far as I can find, the published information is very vague in some respects, more particularly as to the size of the fragments, blocks, or boulders composing the breccia which, in most cases, are simply described as large or small, than which nothing can be more indefinite.

As large blocks are much more easily transported by ice than by water, I paid special attention to the size of the blocks. The localities visited lie between Roundham Head, Paignton, on the south, and Dawlish on the north, and are shown on the Geological Survey maps (new series), Sheets 339, Teignmouth (1899), and 350 Torquay (1898), and the breccias referred to are those overlying the Watcombe Clay and marked e^2 on the Survey maps.

[1] See G. A. F. Molengraaff, "Geology of the Transvaal," Edinburgh, 1904, p. 66.



G. M. Woodward del. et lith.

West, Newman imp.

Bokkeveld Fossils.

S. Africa.

I.—The Size of the Transported Blocks.

Sir H. de la Beche,[1] describing the Red Sandstone Series, says: "On the side of Little Haldon Hill there are blocks of quartziferous porphyry of more than a ton in weight."

Mr. W. Pengelly[2] says: "Again, the trappean masses are not unfrequently of great size. The largest probably occur near the mouth of the Teign, especially in the cliff between Shaldon and the Ness Point. They are more or less ellipsoidal in form, and sometimes measure fully five feet in greatest diameter."

The late Mr. R. N. Worth[3] says: "We have another valuable hint [of their local character] in the fact that these fragments attain their largest size in the vicinity of Teignmouth, and that thence both to the north and south they rapidly graduate downward to very moderate dimensions, and, in fact, into sand. . . . Especially prominent also are the boulders in the Dawlish valley. Blocks occur ranging to four and five feet in diameter."

In order to facilitate reference I have arranged the descriptions of exposures examined in regular order, beginning at the south and proceeding along the coast northwards.

The chief points to be brought out are:—

(1) The size of the largest blocks observed.

(2) The fact that they often occur amid blocks (not matrix) of much smaller average size.

(3) The point referred to by Mr. R. N. Worth that the fragments (particularly of quartz-porphyry) are largest between Bundle Head and the Ness near Teignmouth, and diminish in size both to the north and south.

(4) That the Devonian limestone fragments, abundant (in most cases) to south are comparatively scarce to north of Teignmouth.

In describing the average size of the fragments in the breccia the matrix, which is present in all cases, is left out of account.

1. *Roundham Head, near Paignton.*[4]

At the shore end of the south side of Roundham Head is a very excellent exposure in the cliff, estimated at 50 feet in height. The upper three-eighths of the cliff face consist of breccia, which overlies a bed of rock-sand about half the total height in thickness and showing very clear current-bedding.[5] It in turn overlies another bed of breccia, and the whole series is thrown down to the west by a fault exposed with diagrammatic clearness.[6] This is perhaps the most convincing exposure I saw, proving deposit by water. At this spot the breccia is not coarse. Most of the fragments are from one to four

[1] "Report on the Geology of Cornwall, Devon, and West Somerset," 1839, p. 204.

[2] "The Red Sandstones, Conglomerates, and Marls of Devonshire," pt. ii: Ann. Rept. and Trans. Plymouth Inst., 1862–3, p. 30.

[3] "The Igneous Constituents of the Triassic Breccias and Conglomerates of South Devon": Quart. Journ. Geol. Soc., 1890, pp. 71, 72.

[4] See Plate XXI, Fig. 1.

[5] Pengelly describes and figures false bedding at Slapton, Start Bay, and Goodrington Sands, Torbay: Trans. Plymouth Inst., 1862–3, p. 31.

[6] See W. A. E. Ussher, Geol. of Torquay: Geol. Survey Mem., 1903, pp. 110, 111.

inches across, but I saw a limestone pebble measuring 1 ft. by 4½ in. The fragments, mostly angular, are chiefly Devonian limestone (which occurs *in situ* within ¾ mile). In addition vein quartz and purplish red sandstone occur.

2. *Preston Cliffs* (*Tor Bay*).

In these cliffs, below the Volunteer Battery, at the northern end of the sea wall, which extends northwards from Red Cliff, six feet of breccia are exposed at the foot of the cliff, overlain by orange-red current-bedded sandstone or rock-sand, and the dip of the beds is gently southwards. (This direction of dip is unusual.) The breccia is fine, the rock fragments being from 1 to 4 inches, exceptionally 6 inches long, and several fragments of the typical red quartz-porphyry, which is a very frequent and characteristic constituent of these breccias, were seen, one of them 4 inches long, besides which purplish sandstone and (not abundant) limestone fragments occur. The small size of the quartz-porphyry and scarcity of limestone fragments are noteworthy.

3. *Petit Tor Crags,*[1] *Babbacombe Bay.*

In the conglomerate of Petit Tor Crags and in the talus of fallen blocks of conglomerate at their foot probably nineteen-twentieths of the subangular fragments consist of grey Devonian limestone, often visibly fossiliferous, besides which there occur reddish quartzite and reddish sandstone and a few pieces of red quartz-porphyry, all in a very hard coarse sandy matrix. The fragments are mostly from 1 to 6 inches in diameter, though limestone boulders up to 1 ft. 3 in. by 1 ft. 1 in. by 8 in. are not uncommon. Thin beds of breccia alternate with layers a foot or two thick of finer material. The abundance of Devonian limestone is not surprising, as it occurs *in situ* in Petit Tor close by.

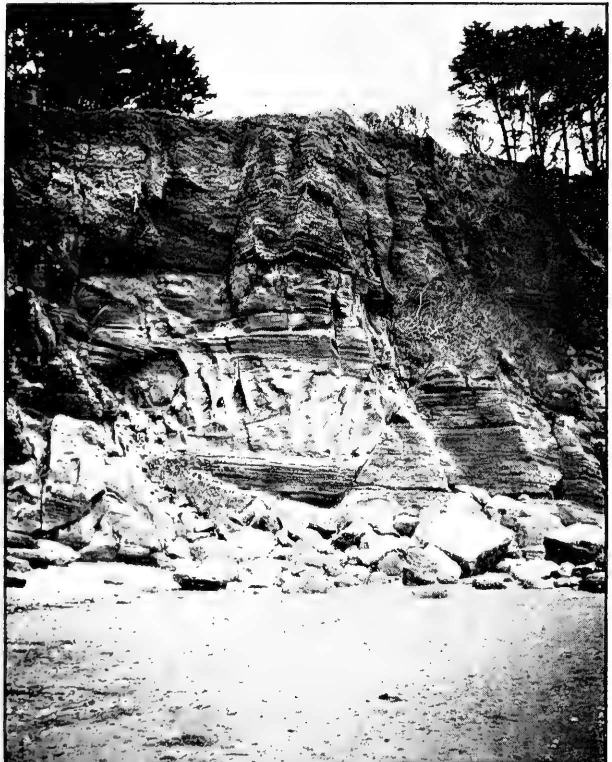
4. *Watcombe Cove.*

At the south side of the cove the breccio-conglomerate is thrown down by a fault against the Watcombe Clay,[2] and dips at 45° northwards. By far the greater proportion of the fragments consist of fossiliferous Devonian limestone, of which an unusually large block measured 1 ft. 10 in. by 10 in. by 6 in. + (partially embedded). Next in abundance (but at a long interval) come fragments of reddish and purplish sandstone, boulders resembling Permian felspathic trap, and a few bits of vein quartz.

A microscopical section of the matrix of the breccia-conglomerate at Watcombe Cove shows large limestone fragments, bits of slate and grit, many angular quartz sand grains, and abundant fragments of volcanic rock. One of the volcanic fragments is crowded with minute spherulites, showing well-defined black cross by polarized

[1] See Plate XXI, Fig. 2, and for section of Petit Tor see W. A. E. Ussher, Geol. of Torquay, Geol. Survey Mem., 1903, p. 109; and "Coast Section from Babbacombe to Watcombe," by W. A. E. Ussher, Proc. Geol. Assoc., vol. xvi (1900), p. 434.

[2] W. A. E. Ussher, "On the Age and Origin of the Watcombe Clay": Rept. and Trans. Devon Assoc. Adv. Sci., ix (1877), p. 298; also section in Proc. Geol. Assoc., xvi, p. 434.



1.—Permian breccias and interbedded current-bedded rock-sand, traversed by a fault, at the shore end of the south side of Roundham Head, Tor Bay.

2.—Fallen blocks of Permian Conglomerate at Petit Tor Crags, Babbacombe Bay.
(Length of hammer head and haft, 1 ft. 10 ins.)

light, and contains porphyritic brown mica. It closely resembles a spherulitic liparite I collected in the Grand Cañon of the Yellowstone. The most interesting volcanic fragments, however, are those which closely resemble the Permian felspathic traps from the Exeter district, which I described in 1892.[1] One of these volcanic fragments shows felspar laths in an opaque matrix consisting partly of iron-ore and partly of red ferruginous matter. It can be paralleled by my section 897 of olivine basalt from Raddon Quarry, west of Thorverton, six miles north of Exeter, although I must confess that none of the fragments in the conglomerate matrix show the red pseudomorphs after olivine so characteristic of most of the Permian felspathic traps. Another type of volcanic fragment very abundant in the matrix shows felspar laths, iron-ore, brown mica, and abundant faintly greenish short prisms, which appear to be apatite. This rock resembles the one I termed mica-augite-andesite (Mr. Teall[2] terms it biotite-trachyte), especially my section 900 from Killerton Park, 5½ miles N. 33° E. of Exeter, except that the Killerton rock contains augite, which I have not found in the Watcombe fragments.

The late Mr. R. N. Worth[3] also records felspathic traps from the Permian breccias of Torbay and Teignmouth. On the other hand, Mr. W. A. E. Ussher[4] says: "The absence of signs of contemporaneous vulcanicity in the New Red Rocks of the area [Geol. Survey Map, new series, sheet 350, Torquay] is accounted for by their evident attenuation through a conformable overlap, as they are traced northward towards Exeter, the volcanic horizon being higher in the series than the strata represented on the map."

Three alternatives occur to me—either Mr. R. N. Worth and I are mistaken in our identification of Permian felspathic traps in the breccias, or Permian felspathic traps may occur *in sitû* beneath and hidden by the breccias, or Mr. Ussher may perhaps be mistaken in considering that they lie at a higher horizon.

5. *Cove ¾ mile south of Bundle Head.*

Here, again, the Devonian limestone fragments in the breccio-conglomerate still form a majority: the largest (subangular) limestone block observed measured 1 ft. 4 in. by 1 ft. 1 in. by 8 in.; an average fragment would be about 3 inches across. Fragments of red and purple sandstone, quartz-porphyry and so-called lydian stone[5] occur. A subangular block of quartz-porphyry measuring 1 ft. by 6 in. by 11 in. + (partially embedded) was observed, and about a dozen smaller quartz-porphyry blocks occurred within three yards of it. The rock fragments here are on the whole smaller than at Petit Tor Crags and Watcombe Cove. Seams of breccia alternate

[1] Quart. Journ. Geol. Soc., p. 496.
[2] Ussher & Teall, Geol. of Exeter: Geol. Survey Mem., 1902, p. 78.
[3] Quart. Journ. Geol. Soc., 1890, p. 76.
[4] Geol. of Torquay: Geol. Survey Mem., 1903, p. 112.
[5] Rev. J. J. Conybeare, "On the Red Rock Marle, or Newer Red Sandstone": Annals of Philosophy, N.S., vol. i (1821), p. 257; Conybeare & Phillips, Geol. England and Wales, pt. i (1822), p. 294; also Ussher, Geol. of Torquay, 1903, p. 111, line 4.

with seams of sandstone and dip slightly southwards. There is much more matrix and a smaller quantity of fragments than in the two preceding exposures.

6. *Bundle Head and the Ness.*[1]

As Bundle Head is half a mile south of the Ness, it should, strictly speaking, be described first, but it is more convenient to describe the two as approached from Teignmouth.

Crossing the Teign at the ferry from Teignmouth to Shaldon, I walked to the Ness (at the mouth of the Teign), passing on the way several large blocks of quartz-porphyry on the beach. The conglomerate at the base of the Ness contains a considerable proportion of Devonian limestone, often visibly fossiliferous, purplish-red sandstone, some red quartz-porphyry, and a few fragments of the so-called lydian stone. Going southward round the foot of the Ness, I found lying loose upon the beach a block of red quartz-porphyry measuring 3 ft. by 2 ft. 6 in. by 2 ft. 8 in., and eighteen paces to south of it another block of the same rock 2 ft. 10 in. by 2 ft. 4 in. by 2 ft. 4 in. Both of these blocks agreed petrographically with the red quartz-porphyry blocks embedded in the conglomerate. This red quartz-porphyry is very characteristic of these Permian conglomerates and breccias, and its petrographical characters will be referred to later. A few yards south of the last-mentioned loose block is a mass of the same red quartz-porphyry 3 ft. 6 in. by 2 ft. by 2 ft. + partially embedded in the conglomerate, and another few yards south a similar block 2 ft. 10 in. by 2 ft. by 1 ft. 5 in. also in the conglomerate. A thousand paces south of the block last mentioned, at a promontory which is, I believe, Bundle Head, and lying among great fallen blocks of the conglomerate, is another loose block of red quartz-porphyry 5 ft. by 3 ft. by 3 ft.; six paces from it is another similar block 3 ft. by 3 ft. 6 in. by 2 ft. 9 in. Only 23 paces further south is a block of Devonian limestone 2 ft. 6 in. by 1 ft. 6 in. by 1 ft., apparently embedded as to its lower surface in the conglomerate, though it may have been squeezed down into it by the action of the sea. Yet most of the blocks in the conglomerate hereabouts are only 3 to 6 inches in diameter. Five paces from the last limestone block another, roughly elliptical in form, 3 ft. 6 in. by 2 ft. 8 in. by 1 ft., lies loose on the beach. Eleven paces from the limestone block last mentioned (and lying on the top of fallen conglomerate masses) are two blocks of red quartz-porphyry lying close together, one measuring 4 ft. 6 in. by 4 ft. by 2 ft., the other 4 ft. by 4 ft. by 3 ft. Eight paces further south is the largest boulder (of any rock) I saw on the South Devon coast, a block of red quartz-porphyry, 5 ft. 4 in. by 5 ft. by 3 ft. 6 in., to which I shall refer again. It lies loose on the beach amid huge fallen masses of conglomerate. Four hundred and fifty paces south of the last (after passing several others) I found lying loose on the

[1] See G. W. Ormerod, "On the Murchisonite Beds of the Estuary of the Ex, and an attempt to classify the Beds of the Trias thereby": Quart. Journ. Geol. Soc., 1875, p. 349, and section from Minnicombe to Lympstone, fig. 3.

north side of a scar of conglomerate a similar boulder 3 ft. 6 in. by 2 ft. 9 in. by 2 ft. 9 in.; 120 paces further south two similar blocks, 2 ft. 4 in. by 3 ft. by 1 ft. 4 in. and 2 ft. by 2 ft. by 1 ft. 6 in. respectively. I have no doubt that all the loose blocks hitherto mentioned are derived from the neighbouring Permian conglomerate, as they agree lithologically with the blocks in the conglomerate. Lying, as most of them do, amongst fallen masses of conglomerate, they do not appear to have been appreciably worn by the action of the existing sea. All the quartz-porphyry blocks at Bundle Head and the Ness are subangular. It is on account of their exceptionally large size, and not as average specimens of the blocks composing the conglomerate, that they are referred to.

7. *Teignmouth.*

On walking along the promenade (sea-wall) at Teignmouth towards Dawlish, one sees the breccio-conglomerate exposed at the back of the promenade just before it reaches the Great Western Railway. The rock fragments in the breccio-conglomerate there are generally 2 to 4 inches across and smaller. Quartz-porphyry is common; a subangular block of it measured 1 ft. 4 in. by 1 ft. 4 in. by 1 ft. + partially embedded. Purplish-red sandstone fragments are abundant, and the so-called lydian stone occurs. No limestone was observed;[1] indeed, the difference between the abundance of limestone fragments at the Ness on the south side of the Teign and its comparative scarcity at and north of Teignmouth is such that perhaps one may suspect that the beds on the north of the river are faulted down compared with those at the Ness.

8. *Along the Great Western Railway between Teignmouth and Dawlish.*

North of Teignmouth, at the 208½ mile-post (from London) on the railway, the breccia has an apparent dip of 16° to 20° northward, and consists of distinctly angular fragments, mostly about 3 inches or less, but running up to 7 inches, and exceptionally, in the case of a quartz-porphyry block, 18 inches in diameter. The fragments consist of grey quartzite, greenish quartz-porphyry weathering reddish, the typical red quartz-porphyry, purplish-red sandstone, black quartzite. No limestone was observed, though, as remarked in reference to Teignmouth, a minute search might discover some.

Where large boulders occur in these South Devon breccias they, so far as observed, lie with their longer axes parallel to the bedding-planes[2]—for instance, at a point 150 paces south of the 208¼ mile-post (G.W.R.) a quartz-porphyry boulder 2 ft. 8 in. by 9 in. by 1 ft. 4 in. + partially embedded, elliptical in form, moderately well rounded, lies in the breccia 20 to 30 ft. above the rails; 5 paces north of it is a subangular block of fine-grained mottled red sandstone 2 ft. 4 in. by 1 ft. 6 in. + partially embedded, and about

[1] Very likely a minute search might discover some.

[2] Pengelly says: "The pebbles lie with their longest axes parallel to the planes of bedding" ("The Red Sandstones, etc., of Devonshire," pt. ii: Ann. Rept. and Trans. Plymouth Inst., 1862–3, p. 31).

15 ft. above it another inaccessible block of rock over 1 ft. in diameter. All these blocks lie parallel to the bedding-planes, which have an apparent dip of 20° northwards. No evidence of a boulder dropped by ice and bending down the laminæ below it, as described by Professor James Geikie [1] as occurring near Uddingston, Lanarkshire, was anywhere seen. At the 208¼ mile post (G.W.R.) several fragments of limestone, one of them 11 inches long, elliptical, fairly well rounded, occur in the breccia; and 4 paces north of the 207¾ mile-post limestone fragments up to 6 inches long occur in the breccia, which is here coarser than it is nearer Teignmouth. At 124 paces north of the 208 mile-post a block of reddish quartz-porphyry 2 ft. by 1 ft. 3 in. occurs; north of the 207¾ mile-post at 12 paces is a boulder of typical red quartz-porphyry 1 ft. 4 in. by 8 in.; at 130 paces a (quartz-porphyry) block 3 ft. by 2 ft. by 1 ft. 6 in. +; at 243 paces a (quartz-porphyry) block 2 ft. 2 in. by 1 ft. All these four blocks are in the breccia. At the north end of Parson's Tunnel (the first north of Teignmouth) fragments of red quartz-porphyry, quartz-porphyry with greenish groundmass, grey quartzite, weathering purplish, and limestone occur in the breccia. At the south end of the second tunnel from Teignmouth (129 paces north of the 207 mile-post) the breccia is not at all coarse; most of the fragments are not more than 2 inches, a few 4 inches, and in rare cases 6 inches across. Just north of Dawlish station at the 206 mile-post the rock consists of alternating beds of red sandstone and breccia, each 4 inches to 3 feet thick. The breccia consists of small angular fragments, mostly 1 inch in diameter or less, but a few 3 to 5 inches across.

II.—The Origin of the Quartz-porphyry Blocks.

The late Mr. R. N. Worth has decribed [2] the red quartz-porphyry so common in the breccia as a "Deep-red porphyritic rock, varying to red brown and purplish brown; compact felsitic base with porphyritic quartz and felspar, some of the latter kaolinized, some Murchisonite; occasionally, but not invariably, some mica. This is the so-called red 'porphyritic trap' more or less characteristic of the conglomerates within our area, from Torbay to the Crediton valley, and the origin of which has been a special topic of discussion. Save in colour, however, these fragments are hardly distinguishable from some Dartmoor elvans." A microscopical section which I have had made from a block, which measures 1 ft. 4 in. by 9½ in. by 5 in. + and still remains embedded in the conglomerate, at the Ness opposite Teignmouth, shows phenocrysts of quartz, felspar, brown mica, and apatite. The felspar consists chiefly of much altered large porphyritic crystals without any visible twinning lamellæ, and of much scarcer, smaller, and fresher porphyritic crystals of lath-shaped form, also not visibly twinned. The mica phenocrysts are sometimes inclosed in the larger felspars. The ground-mass appears by reflected light reddish, by transmitted light brownish, owing to ferruginous matter.

[1] "The Great Ice Age," 3rd ed. (1894), p. 274.
[2] Quart. Journ. Geol. Soc., 1890, p. 75, item 29.

By polarized light it is not isotropic, but cryptocrystalline, and in some parts microcrystalline, in which case it consists of quartz and felspar. I have written to Mr. R. Hansford Worth to inquire whether he knows of any definite locality where this rock occurs *in sitû*. He has kindly sent me a specimen of the felsite from the Slope of Legis Tor (N.N.E. of Plymouth), long. 4° 0′ 23″, lat. 50° 23′ 20½″, described by him.[1] It bears some resemblance to the red quartz-porphyry of the Permian breccia, but it differs in containing "frequent spheroids and aggregates of minutely crystalline schorl," in its ground-mass being more granular (distinctly crystalline) and salmon-coloured instead of compact and chocolate red, and in having, according to Mr. Worth, a specific gravity of 2·57, whereas I found for a specimen from the (sectioned) block *in sitû* in the conglomerate at the Ness 2·49. Mr. R. H. Worth writes to me: "But from Legis Tor there comes another variant. The same red ground-mass. Porphyritic quartz well developed, and cream-coloured felspars numerous and prominent. Kaolinize these felspars and you have one of the Teignmouth rocks at once." Though I doubt whether an exact match would be thus obtained, I think it likely that when Dartmoor is more thoroughly known such will be found. The nearest part of the granite mass of Dartmoor is nine miles from the Ness. In 1892 I mentioned[2] that "A mass of genuine quartz-porphyry measuring about 4 feet by 1 foot is exposed on the west side of the road opposite to the entrance gate of Dunchideock House [3½ miles south-west of Exeter], but it appears to belong to the New Red Breccia." I have no note as to whether this was the typical red quartz-porphyry, but it is only 4½ miles from the Dartmoor granite.

III.—The Possibility of Transport by Water of the largest Blocks observed.

If we assume, for the moment, that the blocks in the breccia and conglomerate have been transported by water, it is of interest to calculate the velocity of the current required to move the largest block of quartz-porphyry observed near Bundle Head. The dimensions of 5 ft. 4 in. by 5 ft. by 3 ft. 6 in. give 93⅓ cubic feet. Taking its specific gravity at 2·49 (that of the red quartz-porphyry block *in sitû* in the conglomerate) and the weight of a cubic foot of water at 62·4 lbs., we obtain 6 tons 9 cwt. 1 qr. 26 lbs., or, if we deduct 10 per cent. on account of irregular form, 5 tons 16 cwt. 2 qrs. 4 lbs. for its probable weight. Prof. A. Penck[3] gives a formula from which the velocity of current at which a cube of rock with a given length of side l will just remain motionless on a horizontal surface can be calculated; it is $v = 3{\cdot}86 \sqrt{l}$. If we take the contents of the block to be 93 cubic feet it would correspond to a cube of 4·531 ft. or 1·381 metre side. The required velocity is 22·33 kilometres,

[1] "The Petrography of Dartmoor and its borders": Trans. Devon. Assoc. Adv. Sci., vol. xxxiv (1902), p. 519.
[2] Quart. Journ. Geol. Soc., 1892, p. 506.
[3] "Morphologie der Erdoberfläche" (1894), vol. i, p. 280, line 18.

or 13·84 miles per hour. Penck assumes a specific gravity of 2·2, and that of the quartz-porphyry may be taken as 13½ per cent. higher; but having made no deduction for its irregular form in calculating its contents, the result will be approximately correct, so that a current of 14 miles an hour would move it from a horizontal surface. According to Prof. F. Ratzel[1] torrents may attain a velocity of 6 metres per second (21·6 kilometres per hour). Sir A. Geikie[2] says even the current "of a torrent does not exceed 18 or 20 miles in the hour." It is therefore quite possible that the block was transported by water.

IV.—The Mode of Formation of the Breccias.

Mr. W. Pengelly[3] seems to have regarded the breccias as due to marine action. He says, "The aggregation, however, does not appear to be such as would have resulted from the action of a stream or current; it rather indicates the agency of waves on an open beach." He also assumes that the beds were deposited horizontally, and not inclined as in a delta face. for he gives[4] a table of 34 observed dips from which he calculates the mean amount of dip at 15½° and the mean direction between Saltern Cove and Flat Point (Straight Point) as N. 44½ E. true. From these data he calculates[5] that the thickness between Goodrington Sands and Straight Point is four miles, to which he adds 1½ miles for the thickness between Straight Point and Charton Bay, giving 5½ miles for the New Red Rocks as a whole, while Mr. Ussher[6] calculates the total thickness of the New Red Rocks of Somerset and Devon at 3,280 feet, though he says 2,500 feet appears a more likely estimate.

Mr. Pengelly seems to have had some misgivings as to the beds having been deposited horizontally, for he quotes[7] Sir Charles Lyell's well-known description of inclined deltaic deposits at Monte Calvo, near Nice,[8] but adds, "Possibly something of this kind may have occurred in the formation of the Devonshire Trias; nevertheless, I am not aware of a single fact on which to base such an hypothesis."

Mr. Jukes-Browne[9] quotes the same account from Lyell, and says that "the coarse sandstones of Teignmouth and Dawlish, with their angular fragments of local rocks, seem to be torrential deposits of this kind."

In the account of the "Excursion to Newton Abbot, Chudleigh, Dartmoor, and Torquay"[10] there occurs the following passage with

[1] "Die Erde und das Leben" (1902), vol. ii, p. 86.

[2] "Textbook of Geology," 3rd ed. (1893), p. 376; 4th ed. (1903), p. 487.

[3] "The Red Sandstones, Conglomerates, and Marls of Devonshire," part ii: Ann. Rept. and Trans. Plymouth Inst., 1862–3, p. 31.

[4] Loc. cit., p. 29.

[5] Same paper, part iii (1864–5), p. 40.

[6] "On the Triassic Rocks of Somerset and Devon": Quart. Journ. Geol. Soc., 1876, p. 392.

[7] Loc. cit., p. 45.

[8] "Elements of Geology," 6th ed. (1865), p. 18.

[9] "The Building of the British Isles," 2nd ed. (1892), p. 168.

[10] Proc. Geol. Assoc., vol. xvi (1900), p. 434.

regard to the Oddicombe Cliffs: "Mr. Hunt, turning to the cliffs, remarked that the conglomerates were too angular and irregular for marine action, and on too vast a scale for river action. He knew of no agency to which they could be attributed. Mr. Teall at once pointed out that similar accumulations were known in the Himalayas, where the disintegration of strata exceeded the available transport; the conglomerates were torrential."[1] To come to my own observations—At every locality on the coast visited there was clear evidence that these breccias and conglomerates have been deposited by water. The section at Roundham Head, Paignton, first described, is perhaps the most convincing exposure, but at every locality the bedding in the breccias and conglomerates is clearly seen.

The fact that the large boulders in the breccia lie with their longer axes parallel to the bedding-planes has been mentioned in describing the section between Teignmouth and Dawlish. Well-rounded pebbles like those of a marine shingle beach or of many rivers are exceedingly uncommon. Most of the fragments are either angular or subangular, and this, together with their general local character, is against their having been transported far. Their angular character may be due to the action of frost. On none of the boulders or fragments did I observe any striæ which I could regard as being of glacial origin. In favour of their being deposited by torrents and in originally inclined beds of deltaic character, is the huge size of some of the blocks occurring amongst much finer material, for it is difficult to imagine two such contradictory conditions occurring in combination as a current of torrential velocity flowing far over a comparatively horizontal surface of deposit, and at the same time transporting huge blocks. On the other hand, it is a very remarkable fact that just where the largest blocks occur at the Ness and Bundle Head there is a gentle syncline with horizontal beds in the centre and a gentle dip to N.N.E. and S.S.W. on the respective sides (shown on Geol. Survey map).[2] Here, if anywhere, one would have expected a deltaic angle of dip. This is a point in favour of possible transport by ice. Unless this be considered an exception, no definite evidence in favour of glacial action in transporting the fragments in the breccias was found. This fact, however, would not exclude the possibility that the breccias might be of fluvio-glacial origin. Not only have they been deposited by, but probably in, water. This is indicated by the frequent current-bedding, and by the presence at West Town (Ide) and Pocombe, near Exeter, etc., of sandstone veins[3] in the contemporaneous lavas. It would be rash to conclude that evidence of glacial conditions may not yet be found by local geologists who can examine the contact of the breccia with the underlying Devonian and Carboniferous rocks, and might possibly

[1] See also Rev. Dr. A. Irving, Quart. Journ. Geol. Soc., 1888, p. 157.

[2] Pengelly (Trans. Plymouth Inst., 1862–3, p. 29) gives the dip at Ness Point as 5° to N. 129 E. mg. = E. 15½° S. true.

[3] Ussher, "Geology of Exeter": Geol. Survey Mem., 1902, p. 59. B. Hobson, "Basalts and Andesites of Devonshire, etc.": Quart. Journ. Geol. Soc., 1892, p. 500.

find striæ. Finally, it may be well to add that no attempt has been made to give an exhaustive list of the rocks represented by fragments in the breccias at any locality, and that while all the exposures described are in the breccia and conglomerate e^2, those to the north are usually on a higher horizon than those to the south, owing to the prevailing north-easterly dip.

IV.—On the Carboniferous Basement Beds at Ingleton.

By Cosmo Johns, M.I.Mech.E., F.G.S.

During the Spring meeting of the Yorkshire Geological Society at Pateley Bridge it was suggested that, as a first step towards the zonal classification of the Lower Carboniferous rocks of Yorkshire, it would be desirable to determine the horizon of the basement beds at Ingleton as compared with the Avon sequence. As the Yorkshire Naturalists Union had arranged a meeting at Ingleton for May 12–14th, the geological route was arranged so as to include as many exposures of the basement beds as possible. The result of the observations made then and during subsequent visits is the subject of this communication.

The district investigated is so well known and has been described or noticed by so many workers that a list of references would be out of place in a short note like this. It does not appear that any previous attempt has been made to determine the exact horizon of these particular beds. They are cut off towards the south by the North Craven Fault, but are well exposed at Norber, on both sides of Ingleton Dale, and also in Thornton Dale below Thornton Force. The beds are best seen in Ingleton Dale, and can be easily traced by the line of springs which follow approximately the 800 foot contour-line on both sides of the valley. The structural features are simple; the basement beds follow the uneven lines of the pre-Carboniferous land surface. These older rocks are folded and denuded, so that they now stand almost vertical with a strike averaging north-west and south-east. A series of later folds along an east and west axis probably causes a repetition of the beds, and all that can be said at this stage is that we have here probably a complex of rocks older than is generally considered.

Above the basement beds come the Great Scar Limestone, then the Yoredale Series, while a capping of Millstone Grit appears on the highest hills. These beds lie almost horizontal, are practically undisturbed by faults, and, except for an almost imperceptible dip to the north-east, remain just as they were deposited. The basement beds themselves consist of a conglomerate of varying coarseness, replaced here and there by pure limestone. The conglomerate generally appears in the hollows of the pre-Carboniferous floor, while the crest of the eminences are often covered with limestone bands free from included pebbles. Quartz pebbles of all sizes are abundant, and layers of conglomerate are often separated by limestone bands. At the foot of Norber, where 25 feet of basement beds appear, the lower series of fine conglomerate with well-rolled pebbles of the older grits is interstratified with dark limestone bands, and is succeeded by a very coarse conglomerate with large angular boulders of grit, proving that the old land surface was still undergoing denudation somewhere. No Carboniferous Limestone inclusions were found, though carefully looked for. This would indicate that the older land surface was being progressively submerged.

Fossils were only collected from the actual basement beds, and from those exposures where their relationship to the older rocks could be made out. Corals and Brachiopods were specially searched for in view of the remarkable success that has attended Dr. Vaughan's adoption of them in his zonal classification[1] of the Lower Carboniferous rocks of the Bristol area. The successful application of the same methods in the Pendine, South Wales,[2] Mendips,[3] East Derbyshire,[4] and Rush, co. Dublin,[5] made it all the more desirable to commence the investigation of the Yorkshire area north of the Craven faults.

Corals were found in nearly every exposure, but the Brachiopods were very badly preserved. Nothing but indeterminable fragments were found at Norber or the eastern side of Ingleton Dale. Larger fragments and a few fairly well preserved specimens were obtained from the western side, chiefly from exposures opposite the 'Granite' Quarry. Fragments of *Bellerophon* sp. were obtained on both sides of the Dale. Large *Euomphali* were observed in sections near the waterworks.

It had been stated that a limestone band[6] with *Lithostrotion basaltiforme* appears in the conglomerate at Fox Holes. This would seem to be an error. This species was not observed in any of the exposures visited, but as it was seen in the stone walls a search was made at Norber, and it was found plentifully *in situ* about 125 feet above the basement.

From Dr. Vaughan's correlation note below it will be seen that the horizon of the Ingleton basement beds is equivalent to the top of the *Syringothyris* zone and the base of the *Seminula* zone, or C_2 and S_1 of the Bristol sequence. It corresponds to the break in the faunal succession[7] dividing the lower (Clevedonian) from the upper (Kidwellian) there. It also approximates to the time of volcanic activity at Weston.[8] The striking conglomerate and very probable unconformity[9] at Pendine in South Wales is of the same age; while the Rush[10] conglomerate of co. Dublin is also synchronous. Thus

[1] Quart. Journ. Geol. Soc., 1905, p. 181 et seqq.
[2] Summary of Progress, 1904, p. 43.
[3] Quart. Journ. Geol. Soc., 1906, p. 324 et seqq.
[4] Wedd: Quart. Journ. Geol. Soc., 1906, p. 379.
[5] Quart. Journ. Geol. Soc., 1906, p. 275 et seqq.
[6] Trans. Leeds Geol. Assoc., part v, p. 26.
[7] Quart. Journ. Geol. Soc., 1905, p. 263.
[8] Ibid., p. 250.
[9] Summary of Progress, 1904, p. 44.
[10] Quart. Journ. Geol. Soc., 1906, p. 288.

the final collapse of the pre-Carboniferous land surface at Ingleton, north of the Craven faults, was contemporaneous with widespread disturbances extending from Ireland into Wales, and was indicated in the Bristol area by the outpouring of the Weston lava.

The widespread disturbances already referred to would naturally follow or accompany the final breakdown of the ancient land surface in the north, which had remained unsubmerged during the whole of the Old Red Sandstone and Clevedonian periods. That earth-movements of such magnitude over such a wide area should occur at the horizon which marks the faunal break at Bristol, and be indicated by practically the same faunal assemblage at places like Rush and Ingleton, affords perhaps the best proof of the correctness of the zonal classification employed.

An investigation of the faunal succession of Ingleborough and the relation of the various zones to the lithological divisions seen in the neighbouring dales is in progress.

The writer desires to thank Dr. Vaughan for determining the fossils, and for the note on the faunal correlation below. He would also like to express his indebtedness to Mr. W. Robinson, of Sedbergh, for his valuable assistance during the several visits made to the district.

Note by Arthur Vaughan, B.A., D.Sc., F.G.S.

Fauna of the basement beds at Ingleton (Preliminary Notice).[1]

Corals.

Syringopora cf. *distans*: abundant.
S. cf. *reticulata*: common.
Michelinia (cf. *M. megastoma*): fragmentary.
Caninia (cf. *C. cylindrica*, mut. S_1): common.
Campophyllum (?).
Cyathophyllum ϕ: abundant.
Lithostrotion cf. *Martini*: common only on east side of Ingleton Dale.
L. sp. (compare form common at Giltar, near Tenby).
Clisiophyllid (cf. *Carcinophyllum mendipense*): common.

Brachiopods.

Productus (cf. *P.* θ and *P. corrugatus*, mut. C): abundant but fragmentary.
Papilionaceous *Chonetes*: common.
Schizophoria resupinata: one fragment.
Bisulcate *Spirifer*: fragmentary.
Spiriferid (? *Spiriferina*): fragmentary.
Athyris cf. *expansa*: common.
Seminuloid Athyrids: fragmentary.

[1] Before a final opinion can be expressed as to the exact position which these beds occupy in the Avonian sequence, it will be necessary to have several of the corals sliced, and to study the Brachiopod fragments more minutely. I do not, however, anticipate that the result of such further work will in any way affect the main conclusion which is here stated.

Gasteropods.

Bellerophon: common. (The fragments agree with the form which is abundant in the upper part of C in the fact that, whereas the young stage exhibits a sulcate periphery, the adult is strongly keeled.)

CORRELATION.

Were such a faunal assemblage as that cited above met with in the South-Western Province, the level at which it occurred would unhesitatingly be referred to the top of the *Syringothyris* zone and the bottom of the *Seminula* zone (C_2–S_1), that is, to the middle of the Avonian sequence. This correlation does not rest solely upon the close similarity of the Corals and Brachiopods to forms which characterize the C_2–S_1 level in the South-Western Province, for the conclusion is confirmed by *the absence of any Brachiopod or Coral which is known to be confined to higher levels.* Assuming, then, that the above correlation is correct, the conglomerate at the base of Ingleborough was deposited at the same time as the conglomerates of Pendine[1] (north of Tenby) and of Rush[2] (co. Dublin).

Hence we owe to Mr. Cosmo Johns a new and an important page in the history of the widespread Mid-Avonian movement.

REVIEWS.

I.—THE FACE OF THE EARTH. By EDWARD SUESS, Professor of Geology in the University of Vienna. Translated by HERTHA B. C. SOLLAS, Ph.D., of Newnham College; under the direction of Professor W. J. SOLLAS, LL.D., F.R.S., etc. Vol. ii. 8vo; pp. vi, 556, with 3 plates, and 42 other illustrations. (Oxford: at the Clarendon Press, 1906. Price 25*s*. net.)

IT is a privilege for which many of us cannot be too thankful, to be able to read in clear and well-chosen language the story unfolded by Suess of the physical history of the Earth. We drew attention in the GEOLOGICAL MAGAZINE for May, 1905, to the translation, by Dr. Hertha Sollas, of the first volume of "Das Antlitz der Erde"; we have now the satisfaction of notifying the publication of the second volume. The previous work, divided into two parts, dealt with the Movements in the Outer Crust of the Earth, and with Mountain Ranges. The present work (part 3) deals with the Sea. The subject is introduced to us in pleasant, not to say poetic language: "We have descended from the mountains and stand on the sea-shore. The eye roams unchecked over the vast expanse of waters. A great wave approaches and seems about to reach us; suddenly its crest curls over, it plunges downwards, and with a dull roar sweeps a little further on without wetting our feet. Then the water streams

[1] Summary of Progress, 1904, p. 44.
[2] Quart. Journ. Geol. Soc., vol. lxii (1906), p. 285.

back, and a long green ridge of seaweed remains to mark the limit of its advance. Soon a second wave follows, then the third, and from time to time one somewhat higher than the rest, which whirls the seaweed further up the beach, and drives us back towards the foot of the cliff."

We are then drawn to examine traces of an older strand, standing high above the existing level of the sea, and to study the history and origin of the displacements of the strand-line. In order to avoid "the adventurous sea of theories for the solid ground of fact" the author uses for the older term "elevation of the land" the *negative displacement of the strand-line*, and for "subsidence of the land" the *positive displacement of the strand-line.*

We are then led to consider the outlines of the Atlantic and Pacific Oceans, and of various lakes and islands. We are, in fact, conducted all over the world, from Greenland to Borneo, to Cochin China and Australia. The characters of the strata forming the lands, and the folds and disturbances to which they have been subjected, are treated in remarkable detail, considering the vastness of the area. The tilted strata of some lands, the horizontal beds of others; the distribution of the formations, the overlaps; the changes in fauna that were due to retreat of the sea or to incoming of fresh-water conditions, are among the many topics discussed. Oscillations of relative level of land and water are considered in reference to detrital and calcareous material, and to the sequence of deposits that make up the geological formations.

In this way the accumulations formed in Palæozoic, Mesozoic, and Tertiary seas are described. The later evidences of physical changes afforded by the Temple of Serapis and by the Baltic and North Seas are discussed at some length.

While the margins of the great oceans are seen to be of different ages, the basins are recognized as sunken areas, and "the wedge-like outlines of Africa, India, and Greenland, all pointing towards the south, find their explanation in the conjunction of fields of subsidence which reach their greatest development in the same direction."

It is difficult to give more than a bare outline of the subjects discussed in this volume, but stratigrapher and palæontologist, geographer and petrologist, will all find matters of abundant interest. The pity is, as we before stated, that no index is given. The ever-increasing literature precludes time being given by all geologists to the perusal of a work like the present. There are particular points or sections that specialists may desire to consult; to them an index would have been most useful. The persistent reader would have been thankful also, as new terms are introduced, and it is not always easy to remember the explanation.

Despite this drawback we must return thanks to the translator and her gifted father for the pains bestowed on the work, and to quote again, from the concluding part of the volume: "Our voyage of inquiry through libraries and literature is now at an end, and we return to the sublime spectacle which served us as our starting-point, the beach and the long inflowing roll of the ocean waves. Still, the mighty chorus resounds; still, and at the same level, the rising tide pauses before it recedes, and the ebb before it returns. And at this same level the ebb and flood have paused, without sensible change, as far back as man can penetrate into the past of his own race."

II.—Albert Gaudry. Fossiles de Patagonie. Les Attitudes de quelques Animaux. Annales de Paléontologie, publiées sous la direction de Marcellin Boule. I: pp. 1–42, 53 text-figures. 1905.

This second part of Professor Gaudry's "Fossiles de Patagonie" is, like the first,[1] chiefly synthetical, and, accordingly, the majority of the numerous figures are more or less restorations. The reader who, after enjoying the author's brilliant synthesis, wishes to fully appreciate his work, is referred to the originals in the Paris Museum: "il sera d'ailleurs facile de vérifier mes interprétations sur les pièces du Muséum." Doubtless it is an easy matter for those who are on the spot; unfortunately, in no other European museum is there an equally rich collection of Tertiary mammals from Patagonia. That is not Professor Gaudry's fault, but it is certainly the merit of Monsieur André Tournouër, to whose untiring energy and generosity the Paris Museum owes the collection in question.

The author divides the Patagonian Ungulates into Rectigrada and Flexigrada, and the latter again into Digitigrada and Plantigrada. *Pyrotherium* and *Astrapotherium* resemble the Proboscidia and Amblypoda by their almost straight and massive limbs; the principal function of the bones of the foot, tightly crowded together, being apparently to afford a solid basis to these articulated pillars. These are the Rectigrada (Rütimeyer's term 'Säulenfüsser,' for the Proboscidia, implied the same meaning).

Ungulates with more flexible limbs, as the result of the display of more activity, either made use of their limbs for locomotion alone, both fore- and hind-limbs touching the ground by means of their third phalanges only (*Theosodon, Diadiaphorus, Proterotherium*), or the fore-limbs were modified for fossorial or prehensile functions (*Nesodon, Colpodon, Homalodontherium*, etc.). When they were thus employed, the weight of the body had to be supported solely by the hind-limbs resting on the whole planta. The former are the Flexigrada digitigrada, the latter the Flexigrada plantigrada.

Anterior limbs.—The anterior limbs of *Pyrotherium* are exceedingly short as compared with their hind-limbs, so that the head must have been inclined towards the ground. *Astrapotherium*, with longer fore-limbs and not provided with a proboscis, was enabled to turn its fore-limbs obliquely outwards, and thus to reach the ground with its mouth after the manner of the giraffe. The anterior limbs of the North American *Dinoceras* present striking resemblances with those of *Astrapotherium*.

[1] Albert Gaudry, "Fossiles de Patagonie. Dentition de quelques Mammifères" (Mém. de la Soc. géol. de France, Paléontologie, t. xii, mém. No. 317, 1904).

The digitigrade *Proterotherium* was more monodactyle even than the horse; the differences with the 'Solipeda' are, however, considerable.

Nesodon, among the Plantigrada, has fore-limbs presenting more analogies with the Carnivora and certain Rodents (e.g. the squirrels) than with the herbivorous Ungulates. The fore-limbs of *Homalodontherium* at first sight recall those of an enormous Carnivore, but like those of *Nesodon* were endowed with less mobility.

Posterior limbs.—The posterior limbs of *Pyrotherium* are, like the anterior, those of a Rectigrade; having to fulfil the same functions as the posterior limbs of the Proboscidia and the Amblypoda, these organs have converged in the three distinct groups. *Astrapotherium* also was apparently a Rectigrade; the body being less massive than in the typical Rectigrada, the posterior limbs were endowed with a certain degree of mobility.

Like the Rectigrada, the Digitigrada touched the ground with their ungual phalanges only; the conformation of their astragalus, however, shows that their posterior limbs possessed a great amount of flexibility. Besides, their limbs were slenderer and more elegant.

In the Plantigrada, on the contrary, the rotation of the tibia on the astragalus was rather limited; their fore-limbs being adapted to prehensile or fossorial functions, they required a certain amount of immobility in their posterior limbs.

III.—Det centrale Norges fjeldbygning. By K. O. Björlykke. 8 and 595 pages and map. With a supplement: Notes on Graptolites from Bratland in Gausdal, Norway. By Charles Lapworth. 16 pages and plate. Norges Geologiske Undersögelse, No. 39. Kristiania, 1905.[1]

THE first part of this memoir of the Geological Survey of Norway deals with the district around the Mjösen Lake. The formation known as Sparagmite is in great force. It lies unconformably on the Archæan, and consists of—

1. At the top, light-coloured felspathic sandstone and conglomerate.
2. A limestone, the Biri-kalk.
3. A conglomerate, the Biri-conglomerate.
4. A dark-coloured sparagmite (felspathic sandstone).

Above the Sparagmite Formation there is a quartz-sandstone and grey-greenish shales, shown by the author to be allied to the blue quartzite of Valdres, and above this come the schists, etc., of the Silurian. The author gives a full account of the Sparagmite Formation, and in his second part traces it into Osterdal, the valley through which the Christiania-Trondhjem railway runs.

The third part of the memoir deals with Gudbrandsdal. The author describes some small patches of rock which underlie the dark

[1] "On the Geology of Central Norge," by K. O. Björlykke. A summary of a larger (the above) work, 2 and 27 pages and map, Kristiania, 1905.

sparagmite, and which he believes to be the oldest part of that formation.

Passing to the tributary valley of the River Jöra, the author deals with a rock, which, though resembling sparagmite, rests upon and not under, the Silurian, and he names it the Younger Sparagmite. He believes it to be of Devonian age. It is closely associated with the post-Silurian eruptive rocks of the Jotunheim Mountains.

The fourth part of the work deals with Valdres, Hemsedal, and Laerdal, and the author traces the Younger Sparagmite to the Sogne Fjord, and south-west into the district around Vossevangen. The rocks included in the Younger Sparagmite Formation are a part of those grouped together by Kjerulf[1] under the general title Höifjelds kvartsen.

Brögger speaks of the group as the Younger Gneiss Formation, and has described it in his valuable memoir on the Hardanger vidda.[2] He points out that in places it bears a great resemblance to the Archæan Gneiss, but, like Kjerulf, he treats the succession as normal, and the Younger Gneiss as of later date than the Silurian schists upon which it rests.

In the present work Mr. Björlykke describes how various authors, himself included, have been led to suggest that some part, at least, of this younger gneiss may be overthrust masses of the Archæan. Professor A. E. Törnebohm has gone much further, and has brought forward a series of overthrusts on a gigantic scale in explanation of the structure of the Scandinavian mountains.

Mr. Björlykke's recent work in the field leads him to think that the theory of overthrusting has been carried much too far, and he doubts whether the evidence goes further than to show quite local pushing of strata over one another. He accordingly reverts to the opinion of Kjerulf and Brögger, that the succession is on the whole normal, and the Younger Gneiss group newer than the Silurian schists. He divides that group into two parts. The first is the Younger Sparagmite Formation, of which we have already spoken, and in the other he places the more gneiss-like rocks, suggesting that they are more or less metamorphosed igneous rocks connected with the great mass of post-Silurian eruptives which are largely developed around the head of the Sogne Fjord and in the Jotunheim Mountains.

The author explains that Norway is affected by two systems of folding. The first, which he terms the "Mountain-chain" system, runs N.N.E. and S.S.W., whilst the other, which he terms the "Strike-system," runs W.N.W. and E.S.E.

The memoir is accompanied by a sketch-map geologically coloured, and numerous maps and photographs are inserted in the text.

In the Supplement, Professor Lapworth describes and figures a series of Graptolites collected by Mr. Björlykke in Gudbrandsdal.

HORACE W. MONCKTON.

[1] Th. Kjerulf, "Udsigt over det sydlige Norges geologi," Christiania, 1879, p. 164.
[2] "Lagfolgen paa Hardanger vidda Norges Geologiske undersögelse," No. 11, 1893.

IV.—United States Geological Survey (Bulletin No. 266, Series C, Systematic Geology and Palæontology). Charles D. Walcott, Director. Palæontology of the Malone Jurassic Formation of Texas. By Francis Whittemore Cragin. With Stratigraphical Notes on Malone Mountain and the surrounding Region near Sierra Blanca, Texas. By T. W. Stanton. pp. 1–109, plates i–xxix. 8vo. Washington, 1905.

IN the introductory portion of this paper Mr. Cragin describes the geology of the region, with remarks on the fossils and related faunas. This is followed by a stratigraphical sketch by T. W. Stanton, accompanied by a map, showing the Sierra Blanca and other mountain chains with their contour-lines. The rest is taken up with a description of the species of fossils.

After describing the topographical features of the region, an account of its geology is given, in which it is stated that all the fossils were obtained from Malone Mountain and the neighbouring hills — the Malone hills. These hills extend, trending at first eastward and then southward as a practically continuous Jurassic outcrop through the Neocene, for a distance of a mile and a half.

The Malone formation was found to be extremely rich in fossils, as the long lists clearly testify. They include a new species of *Astrocœnia* (*A. Maloniana*), two echinoids, *Holectypus* and *Pygurus*, many molluscs, a serpula, and the fin spine of a selachian of an indeterminate genus.

The affinities of its fauna clearly refer the Malone formation to the Jurassic. The sections Undulatæ and Costatæ, to which several of the Malone Trigonias belong, are exclusively Jurassic. With one exception, represented by a single somewhat imperfect mould, none of them agrees perfectly with generic groups hitherto known from Cretaceous rocks exclusively. This evidence of the age of the rocks is further strengthened by that afforded by the Ammonites, the genus of most frequent occurrence being *Perisphinctes*, the species of which show the closest affinities with those of the Tithonian of Europe.

It is observed that a considerable number of the fossils of the Malone formation are identical with some of those of the Alamitos beds, described by Castillo and Aguilera in San Luis Potosi, Mexico, and there can be little doubt that the Malone and Alamitos beds represent approximately the same horizon.

Twenty excellent plates and a serviceable index complete this interesting monograph on Jurassic fossils. A. H. F.

V.—Contributions to the History of American Geology. By George P. Merrill, Head Curator of Geology, U.S. National Museum. From the Report of the United States National Museum for 1904, pp. 189–734, with 37 plates and 141 text-figures. 8vo. Washington, 1906.

THIS record of the birth and growth of geology in the United States and Canada, written by one of the most able and indefatigable workers, is of exceptional interest. It is indeed a wonderful record. That a geological map of the United States of America (the area referred to at that time being east of the Mississippi) should have been published in 1809, is in itself a remarkable fact, and one of which Americans may justly be proud. That map, showing the areas of Primitive, Transition, Secondary, and Alluvial Rocks, and also tracts of Rock Salt, was the product of William Maclure. It was the earliest attempt at a geological map of America, and was published six years prior to William Smith's map of England and Wales: of course, a far more elaborate work. Geological descriptions, mostly of a mineralogical nature, had been published in America as early as 1785. The author terms the first period of American geology the Maclurean era (1785–1819), the second, the Eatonian era (1820–29), being marked by the labours of Amos Eaton; and onwards the periods are divided according to the State Surveys, the first decade of which dates from 1830 to 1839, and here again the United States was in advance of Britain. From beginning to end the work is full of information on the history and progress of geology; and it is profusely illustrated with portraits of the workers, from those of Benjamin Silliman and William Maclure to E. Billings and C. D. Walcott. Special efforts were made to obtain portraits representing the individual at the period of his career under discussion. In an appendix there are tables showing the gradual development of the geological column, as given in the principal textbooks; and there are also brief biographical sketches of the leading workers in American geology.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I. — May 9th, 1906. — Aubrey Strahan, M.A., F.R.S., Vice-President, in the Chair.

The Chairman read, on behalf of the Council, a letter of condolence addressed by the Foreign Secretary to the Swiss Geological Society on the loss of Professor Eugène Renevier, For. Memb. G.S., whose death was the result of an accident, which took place only a few days before the proposed celebration of his professorial jubilee at Lausanne University.

The Chairman announced that the Council had resolved to award the proceeds of the Daniel Pidgeon Fund for 1906 to Miss Helen Drew, Newnham College, Cambridge, who proposes to examine the relationship of the Caradoc and Llandovery rocks in South Wales, between the Llandeilo and Fishguard districts.

The following communications were read:—

1. "The Eruption of Vesuvius in April, 1906." By Professor Giuseppe de Lorenzo, For. Corr. G.S.

After the great eruption of 1872 Vesuvius lapsed into repose, marked by merely solfataric phenomena, for three years. Strombolian activity followed, varied by lateral outpourings of lava in 1885, 1889, 1891, 1895, etc., and by outbursts from the principal crater in 1900 and 1904. Fissuring of the cone and slight outpourings of lava began in May, 1905, and continued until April 4th, 1906, when the first great outburst from the principal crater occurred, accompanied by the formation of deeper and larger fissures in the southern wall of the cone, from which a great mass of fluid and scoriaceous lava was erupted. After a pause the maximum outburst took place during the night of April 7th and 8th, and blew 3,000 feet into the air scoriæ and lapilli of lava, as well as fragments derived from the wreckage of the cone. The south-westerly wind carried this ash to Ottajano and San Giuseppe, which were buried under 3 feet of it, and even swept it on to the Adriatic and Montenegro. At this time the lava which reached Torre Annunziata was erupted. The decrescent phase began on April 8th, but the collapse of the cone of the principal crater was accompanied by the ejection of steam and dust to a height of from 22,000 to 26,000 feet. On April 9th and 10th the wind was north-easterly, and the dust was carried over Torre del Greco and as far as Spain; but on April 11th the cloud was again impelled northward. The ash in the earlier eruptions was dark in colour, and made of materials derived directly from the usual type of leucotephritic magma; but later it became greyer, and mixed with weathered clastic material from the cone. The great cone had an almost horizontal rim on April 13th, very little higher than Monte Somma, and with a crater which possibly exceeds 1,000 feet in diameter; this cone was almost snow-white from the deposit of sublimates. Many deaths were due to asphyxia, but the collapse of roofs weighted with dust was a source of much danger, as was the case at Pompeii in A.D. 79. The lava-streams surrounded trees, many of which still stood in the hot lava with their leaves and blossoms apparently uninjured. The sea-level during the 7th and 8th of April was lowered 6 inches near Pozzuoli and as much as 12 inches near Portici, and had not returned to its previous level on April 18th. The maximum activity coincided almost exactly with the full moon, and at the time the volcanoes of the Phlegræan Fields and of the Islands remained in their normal condition. The author believes that this eruption of Vesuvius is greater than any of those recorded in history, with two exceptions—those of A.D. 79 and of 1631.

2. "The Ordovician Rocks of Western Caermarthenshire." By David Cledlyn Evans, F.G.S.

The ground dealt with is practically identical with that examined by the late Thomas Roberts, whose notes were published in 1893. It extends from the River Cywyn on the east to the Tave on the west, and from the base of the Old Red Sandstone on the south to the top of the *Dicranograptus* Shales on the north. The area is, in the main, a denuded anticlinal fold with an east-and-west axis, complicated by minor folds, faulting, thrusting, and crushing. The succession on the northern limb of the anticline is as follows:—

BALA-CARADOC.	
LLANDEILO.	*Dicranograptus* Beds. *Asaphus tyrannus* Beds.
LLANVIRN.	*Didymograptus Murchisoni* Beds. *Didymograptus bifidus* Beds.
ARENIG.	*Tetragraptus* Beds.

The succession on the southern limb is similar, but passes up into higher beds, as shown below:—

LOWER LLANDOVERY.	
BALA-CARADOC.	Slade Beds. Redhill Beds. Sholeshook Beds. Robeston Wathen Limestone.
LLANDEILO, LLANVIRN, and ARENIG as above.	

The crushing and fracturing of the rocks have brought together into a small area facies of rocks differing lithologically and in faunas, the difference being well shown in corresponding beds on opposite sides of the anticline. The majority of faults are strike-faults, many of them being thrusts; these are sometimes so close together that the structure cannot be fully displayed on the 1 inch scale. Cleavage affects the rocks on the northern limb, but is almost absent on the south; it was induced at a later date than the faulting. The chief igneous rocks are intrusions of diabase; and there are ashes in the Llanvirn and Llandeilo Beds and an ashy shale in the Arenig.

A description of the entire succession of rocks is given, accompanied by lists of fossils, and each division of importance is followed through its whole extent as shown in the area. In correlating the rocks, it is shown that the Middle and Upper Arenig rocks compare with those of St. Davids; the Llanvirn rocks are very similar, lithologically, to the beds of Llanvirn and Abereiddy, and the faunas are practically identical; the Llandeilo rocks are in the main like those of Pembrokeshire, but the *Leptograptus* division of the *Dicranograptus* Beds closely resembles the Rorrington Flags of Shropshire; the Bala-Caradoc rocks fall into the divisions already established by Marr & Roberts in an adjoining area; and the rocks assigned to the Lower Llandovery are barren of organic remains, as they are elsewhere.

II.—May 23rd, 1906.—R. S. Herries, M.A., Vice-President, in the Chair. The following communications were read:—

1. "On the importance of *Halimeda* as a Reef-forming Organism; with a description of the *Halimeda* Limestones of the New Hebrides." By Frederick Chapman, A.L.S., F.R.M.S., and Douglas Mawson, B.E., B.Sc. (Communicated by Prof. T. W. Edgeworth David, B.A., F.R.S., F.G.S.)

Calcareous algæ, nullipores, *Lithothamnion*, etc., have been frequently referred to as forming important contributions to the rock of coral reefs. The material obtained in the great boring, the lagoon borings, and lagoon dredging at Funafuti has yielded a considerable quantity of *Halimeda*; and Dr. Guppy has described a *Halimeda* Limestone in the Solomon Islands. Evidence such as this shows that the important deposits of calcareous plant-remains forming at the present day can scarcely be paralleled by any deposit formed in past geological times, except, possibly, the limestones of the Alpine Trias, which owe their origin to the thallophytes *Diplopora* and *Gyroporella*. Among other *Halimeda* Limestones mentioned by the authors are those of Christmas Island, Fiji and Tonga, and the New Hebrides. The examples from the last-named group are described in detail. They differ considerably one from the other in the condition of preservation of their chief organic contents. Chemical and microscopic analyses of the several examples are given. *Halimeda* seems to be more liable to decay than *Lithothamnion*, corals, or foraminifera, and yet it appears to retain its structure to a considerable depth in reefs. Much of the fine powdery limestone associated with coral reefs, and more especially with upraised coral islands, may be primarily due to lagoon and other deposits formed by the agency of *Halimeda*.

2. "Notes on the genera *Omospira*, *Lophospira*, and *Turritoma*; with descriptions of New Species." By Miss Jane Donald. (Communicated by Professor E. J. Garwood, M.A., Sec. G.S.)

In a previous paper the author referred to the researches of Ulrich and Koken among the earlier Gasteropoda, and to the groups into which they had divided them. Much knowledge is still required with regard to their origin and relationships before really satisfactory divisions can be made. The new species described in the paper belong to three genera, characterised by the possession of a band on all the whorls formed by the gradual filling up during growth of a sinus, and not a slit, in the outer lip. The genera *Lophospira*, Whitfield, and *Turritoma*, Ulrich, are not really true Murchisonidæ, but are allowed for the present to remain in that family. Ulrich places *Omospira* in the family Raphistomidæ, but it is not a characteristic member, for the whorls are more convex and the spire higher than is the case with the other genera belonging to the family. Ulrich's description is quoted and discussed, and one new species is described from beds of Upper Bala age. Of the genus *Lophospira*, Ulrich's four sections, and sub-sections of certain of these, are discussed. Five new species are referred to the *perangulata* section, one new species and one variety to the *bicincta* section, and one species to the *robusta* section. One new species is described of *Turritoma*. The specimens dealt with are mainly from the collections of Mrs. Gray, the Sedgwick Museum, the Bristol Museum, and the Geological Survey of Scotland.

The Rev. H. H. Winwood, in exhibiting a series of water-colour drawings of Mexican scenery, said that these beautiful sketches were executed by Miss A. C. Breton, during a recent visit to Mexico; and, as the International Geological Congress was about to meet in that country, she thought that some of the Fellows might like to see them. They represented that line of active and extinct volcanos which stretches from the Gulf of Mexico on the east to the Pacific Ocean on the west, including Orizaba, Popocatepetl, Jurullo, and Colima. A short extract from the publications of the Mexican Geological Survey, translated by Miss Breton, was read respecting the formation of Popocatepetl ('smoking mountain'), showing how the successive periods of volcanic energy may be marked (*a*) by a period of lava-flow, (*b*) by one of breccia, and finally (*c*) by one of ashes. The angles of slope of the volcanos were drawn to scale.

Professor H. J. Johnston-Lavis exhibited upward of forty lantern-slide views to illustrate the late eruption of Vesuvius and its effects. Nearly all these were taken by the exhibitor, who explained the different phenomena portrayed. He considered this eruption to resemble mostly that of 1822, although the present crater was larger, attaining 1500 feet both north-by-south and east-by-west; it was probably 500 to 600 feet deep at least. The remarkable character about this eruption was the large amount of fragmentary material ejected, especially in a north-easterly direction, crushing in the roofs of the buildings in the towns of Ottajano, San Giuseppe, and Terzigno. At the first-named locality the depth attained was about 0·75 metre, made up as follows:—

m.	
0·04	Grey dust.
0·49	Reddish lapilli, chiefly 'supplementary ejecta.'
0·20	Black vesicular scoria, chiefly the 'essential ejecta.'

The material which fell at the Observatory and Naples had much the same arrangement, but was of course less, and practically only sand and dust. Near the base of the cone the ejecta attain to blocks several tons in weight; and it may be estimated that, at the north-eastern toe of the great cone, in some places the débris must be 60 feet thick. It is to be seen as much as 30 feet in thickness in the new ravines that have been formed

After careful study, the speaker had come to the conclusion that the remarkably uniform and deep scoring of the cone by very regular 'barrancos' was due to the sliding and avalanche-like effect of the rapidly accumulating fragmentary material on the steep slopes, and not due to water action.

The mountain seems to have opened at four, if not five, different places on the south-western, southern, and south-eastern sides, giving rise to at least three important streams of lava. Another rift, to the north-north-east of the cone, emitted lava that forms an apron on that side of the mountain, and must of course have been formed early in the eruption, that is, before the 7th to 8th of April.

The ejected blocks are chiefly old lavas and scoria, partly re-cooked and metamorphosed, with their cavities filled by tachylytic juice from the fluid magma of the neighbouring chimney. The cavities are also often lined by sublimations of augite, hornblende, leucite, microsomite, hæmatite, halite, and a well-crystallized yellow deliquescent mineral, which proves to be a new chloride of manganese and potash, for which a new mineral name is proposed. A few fragments of limestone, and the various mineral aggregates derived by metamorphism from it, are met with, but they are chiefly re-ejected old ejected blocks. A light-green spongy tachylite is also frequent.

The 'essential ejecta,' either as scoria or lava, do not show any marked difference from the usual products of Vesuvius in such eruptions during the last three centuries.

Although much damage has been done, great areas of rugged lava surfaces that would have required centuries to render cultivable, are now available for the growth of woods, vines, and herbaceous plants.

III.—June 13th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair. The following communications were read:—

1. "Recumbent Folds produced as a Result of Flow." By Professor William Johnson Sollas, Sc.D., LL.D., F.R.S., F.G.S.

Professor Lugeon, in his treatise on the pre-Alps of Chablais, has described a series of recumbent folds so greatly exceeding in horizontal extension their vertical thickness, that they are commonly spoken of as sheets rather than folds; they lie with remarkable flatness one on the other, and, as a rule, those higher in the series extend farther to the front than those below, a feature referred to as 'déferlement.' The roots of several of the lower of these folds are visible in the high Alps adjacent, but the roots of the higher folds, which form the pre-Alps, must be sought in the zone of Mont Blanc and the Briançonnais. Thus some of the uppermost folds may have surmounted the obstacle presented by Mont Blanc, on their way to the front in the pre-Alps. Many of the features presented by recumbent folds are more suggestive of flowing than bending. Experiments have been made with pitch-glaciers (poissiers) in which an obstruction had been placed. In this way folds were produced, one of which was not unlike the Morcles fold behind the Diablerets, another was like the Pilatus, and yet another like the Sentis, and the fourth compared with the overslide of the Bavarian front; all four exhibit déferlement. In this experiment the lower limb of each fold is adjacent to the similar limb of its neighbours; but in another experiment, in which two obstacles were used, the results were nearer to those seen in the mountains where the lower limb of a superior fold reposes on the upper limb of the fold immediately beneath it. Movement of this character may possibly explain the want of continuity of certain beds at the conclusion of the movement.

2. "The Crag of Iceland—an Intercalation in the Basalt Formation." By Dr. Helgi Pjetursson. (Communicated by Professor W. W. Watts, M.A., M.Sc., F.R.S., Sec. G.S.)

The existence of fossiliferous deposits on the west coast of Tjörnes, Northern Iceland, has been known for nearly 160 years. Mörch enumerates 61 species of mollusca, and concludes that the temperature must at that period have been much milder than at present. Gwyn Jeffreys and Searles Wood, from the shells, considered that the deposit could not be younger than Middle Red Crag, but Mr. Starkie Gardner was inclined to assign a greater age to it. Dr. Thoroddsen thinks that these Crags are younger than the 'Old Basalts' of Tjörnes. The author finds, however, that, at a height of 500 feet above the sea, they are overlain by the 'Eastern Basalts,' and are indurated and altered by them. Thus there is a fossiliferous intercalation, over 500 feet thick, occupying part of the great gap between the Tertiary and the Pleistocene rocks, the latter containing indurated ground-moraines. The basal layer of the Pleistocene Series is fossiliferous, and has yielded 22 species of mollusca, 20 of which represent a highly Arctic fauna (with *Yoldia arctica*), such as is at the present day found living along the coasts of Spitzbergen. Certain of the larger basalt dykes are cut off at the base of the Crag. The absence of the Crag deposits from other localities is explained by the erosion of the coastline.

CORRESPONDENCE.

THE ZONE OF *OSTREA LUNATA*.

Sir,—I have no objection to the distinction which Mr. Brydone wishes to make between 'international' and 'provincial' zones, but I must maintain my opposition to his conception of a provincial zone.

I believe that I express the generally accepted view of such a zone in briefly defining it as a band of strata characterised by a special group of species. That is the definition of a zone given by me in vol. i, p. 34, of the Memoir on the Cretaceous Rocks of Britain, and the zone of *Ostrea lunata* as proposed in vol. iii of that memoir is based upon that definition, the name being an index of the fauna and not of the zonal limits.

Now Mr. Brydone wants to restrict a provincial zone to a band in which some type-fossil can always be found in every foot of its thickness! Moreover, he has the boldness to say that all the zones introduced by Barrois in the South of England below that of *Marsupites cor-anguinum* answer to the test he imposes. I am greatly surprised that he should commit himself to such a statement, for it is not true even of the Chalk of Dover, while he ought to know that in Dorset *Holaster subglobosus* is so rare in the upper part of the Lower Chalk that I have not heard of one being found. Again, in some parts of Wiltshire *Terebratulina lata* is quite a rare fossil in the *Terebratulina* zone. These are cases in which the Chalk is almost unfossiliferous, and how can his idea of a zone be applied to them?

He asks me how I would define the upper and lower boundaries of the zone of *O. lunata*. I reply, in precisely the same manner as the other zones adopted in my memoir are defined, not necessarily by the index-species, but by means of the fauna as a whole. It may be that its base is best defined by the incoming of *T. gracilis*, and its top (if it has one in England) may be marked by the dying out of other species and by the incoming of a different fauna.

If Mr. Brydone wants to introduce a new system of zonal classification for the Chalk, by all means let him try, but it is not reasonable to find fault with me for choosing *O. lunata* as an index of the Trimmingham zone merely because it does not satisfy his own peculiar idea of what a zone and a zonal index should be.

A. J. JUKES-BROWNE.

ANTHRACOMYA IN THE RADSTOCK COAL-MEASURES.

SIR,—Whilst collecting at the Lower Writhlington Coal-pit, working the Radstock Series of Coal-measures, I had the good fortune to find several specimens of Pelecypods. As no shell except *Carbonicola aquilina* has been so far recorded from these beds, I thought that it would be as well to record them. Dr. Wheelton Hind has kindly identified them as *Anthracomya phillipsi*, Will., and *A. lanceolata*, W. Hind. *A. phillipsi* is typically an Upper Coal-measure species, having been first found in the Ardwick Series of Manchester. The exact locality and horizon of *A. lanceolata*, previously represented only by the type-specimen, are unknown, but the horizon, Dr. W. Hind informs me, is probably high.

D. M. S. WATSON.

MANCHESTER UNIVERSITY.

THE GEOLOGY OF THE PLYNLIMMON DISTRICT.

SIR,—For the past three years I have devoted my leisure time to the detailed examination and mapping of part of the district described by Mr. Walter Keeping many years ago.[1] The district examined extends southwards from the Plynlimmon range towards the valley of the Ystwyth and westwards towards Aberystwyth.

As the conclusions I have come to diverge considerably from those previously published, I venture to think that a short summary will be of some interest to readers of the GEOLOGICAL MAGAZINE. The chief results are the following:—

The Plynlimmon range is a dome formed wholly or partly of Bala rocks. The Lower Llandovery rocks, which are divisible into several zones, wrap round them, and are followed towards the south by the Upper Llandovery and Lower Tarannon rocks in more or less orderly succession. The highest fossiliferous rocks met with belong to the zone of *Monograptus exiguus*. They are followed by thick grits which are probably on the horizon of the Talerddig Grits of the Tarannon country. Hitherto rocks of this age have not been recorded from this area. I hope shortly to publish my results in detail.

O. T. JONES.

28, JERMYN STREET, LONDON, S.W.

[1] Quart. Journ. Geol. Soc., vol. xxxvii, p. 141.

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HORACE B. WOODWARD, F.R.S., &c.

AUGUST, 1906.

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THE
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ORIGINAL ARTICLES.

I.—Cirripedes from the Trimmingham Chalk and other localities in Norfolk.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(WITH FORTY-ONE TEXT-FIGURES.)

SOME years since Mr. Reginald M. Brydone, F.G.S., placed in my hands a number of fossil Cirripedes from the Chalk of Trimmingham, Norfolk,[1] with the request that I would describe them. Others have lately been sent to me by Mr. Clement Reid, F.R.S., from his private collection and from the Geological Survey Museum; also a set of Chalk Lepadidæ from Dr. Arthur Rowe, F.G.S., of Margate, collected by him in the vicinity of Norwich. I now take up the study of these too long neglected specimens.

1. Brachylepas cretacea, H. Woodw., 1901.

Pyrgoma cretacea, H. Woodw., 1868: Geol. Mag., Vol. V, p. 258, Pl. XIV, Figs. 1, 2.

Pollicipes cancellatus, Marsson, 1880: Cirrip. d. Weiss. Schreib. Kreide d. Rügen, p. 24, Taf. ii, fig. 7*a*.

Brachylepas cretacea, H. Woodw., 1901: Geol. Mag., Dec. IV, Vol. VIII, p. 145, Pl. VIII, Figs. 3–5.

In a contribution to "British Fossil Crustacea," made in 1868,[2] I figured and described a portion of a Cirripede from the Chalk of Norwich under the name of *Pyrgoma cretacea*.

No further notice of this species occurred until 1901, when Dr. Arthur Rowe kindly placed in my hands a specimen obtained by him from the Norwich Chalk, which threw a most important light on this interesting fossil, proving it to be quite distinct from the genus *Pyrgoma*, and worthy to form a new genus, having characters which might serve as a connecting link between the more ancient Pedunculata and the more modern Operculata.[3] A reference to this paper will show that *Brachylepas* had a series of three or four verticillate whorls of small scale-like imbricated plates, forming the base of the capitulum supporting the rostrum and carina

[1] For an account of this interesting deposit see "The Stratigraphy and Fauna of the Trimmingham Chalk," by R. M. Brydone, 1900, 8vo, pp. 16, with diagrams; Dulau & Co., price 1*s*. (separately published). Also "Further Notes on the Trimmingham Chalk, Norfolk," by R. M. Brydone, F.G.S., Geol. Mag., 1906, January, pp. 13–22, Plates II and III; February, pp. 72–78, Plates IV and V; March, pp. 124–131, Plates VIII and IX; and July, pp. 289–300.

[2] Geol. Mag., 1868, pp. 258, 259, Pl. XIV, Figs. 1, 2.

[3] Geol. Mag., Dec. IV, Vol. VIII (1901), pp. 145–152, Pl. VIII, Figs. 3, 4.

(the latera, scuta, and terga being displaced, but diagrammatically restored in the woodcut (Fig. 3, given on p. 149). Later on Dr. Rowe contributed another example from the Chalk of Whitway Pit, South Dorset, from the *Bel. mucronata* zone (see Geol. Mag., 1901, p. 528). He also subsequently sent me, among other specimens, eight carinæ and rostra of *Brachylepas cretacea*, together with detached scales, etc., from the Chalk of Edward's Pit, Mousehold, Norwich. I am now able to record *Brachylepas cretacea* as having been found by Mr. Brydone in the Chalk Bluffs of Trimmingham. In his collection sent to me is a single, very well preserved carina, which Mr. Brydone transmitted some years before with other Trimmingham fossils to Dr. Wilhelm Deecke (Professor of Geology and Palæontology in the Royal University of Greifswald, Prussian Germany), who at once identified it as *Pollicipes cancellatus*, Marsson [1] (1880). A careful comparison of Mr. Brydone's specimen with Dr. Marsson's figure on the one hand and with the long series of specimens obtained by Dr. Rowe from the Chalk of Catton, near Norwich, leaves no doubt in my mind that *P. cancellatus*, Marsson, is identical with *Brachylepas* (*Pyrgoma*) *cretacea*, H. Woodw., 1868, so that *P. cancellatus* must be treated as a synonym of *Br. cretacea*. Mr. Brydone writes me: "I never found any more such perfectly preserved valves of *Br. cretacea* at Trimmingham, nor any associated valves, but I must have at least a dozen or more indifferently well preserved examples in my collection, so that 'relatively common' is a fair statement in regard to this species at Trimmingham."

Distribution of *Brachylepas cretacea*: This species has been found in the Upper Chalk (zone of *Bel. mucronata*), Whitway Pit, South Dorset; in the Isle of Wight; at Weybourne and Trimmingham, Norfolk; at Catton, near Norwich; and in the Chalk of Rügen.

[Before describing a new form of *Brachylepas* I desire to express my regret in having in my former paper (Geol. Mag., 1901, pp. 145–152), quite unintentionally, overlooked a most important piece of evidence relating to this remarkable Cirripede, published in 1857, by my old friend Monsieur J. A. H. Bosquet, of Maestricht (who died in 1880). In his "Notice sur quelques Cirripèdes dans le Terrain Crétacé du Duché de Limbourg" (4to, Harlem, 1857, pp. 36, plates i–iii) the author figures and describes some 17 species; 1 of *Chthamalus*, 2 of *Verruca*, 6 of *Scalpellum*, 8 of *Pollicipes*, for which latter he retains Oken's generic name *Mitella*, discarded by Darwin.[2]

[1] See "Die Cirripedien und Ostracoden der Weissen Schreib-kreide der Insel Rügen," von Dr. Th. Marsson, in Greifswald. Mittheil. aus dem Naturwiss. Vereine von Neu-Vorpommern und Rügen in Greifswald. Redigirt von Dr. Th. Marsson, 1880, p. 24, Taf. ii, fig. 7*a*.

[2] Referring to the genus *Pollicipes*, Leach, 1817, adopted by Darwin in his "Monograph on the Fossil Cirripedia" (Pal. Soc., 1851, p. 47), that author observes: "This is one of the rare cases in which, after much deliberation and with the advice of several distinguished naturalists, I have departed from the rules of the British Association; for it will be seen that *Mitella* of Oken and *Ramphidiona* of Schumacher are both prior to *Pollicipes* of Leach; yet as the latter name is universally adopted throughout Europe and North America, and has been extensively

One of these, named by M. Bosquet *Mitella lithotryoides*, of which he describes and figures from the Chalk of Maestricht the five separated plates — viz., the carina, rostrum, sub-rostrum, scutum, and latus; the tergum is not represented (see op. cit., pp. 23–27, pl. iii, figs. 5–10)—shows, like Dr. Arthur Rowe's specimen from the

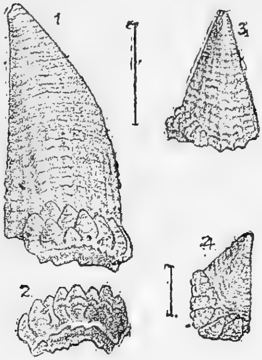


FIG. 1. *Brachylepas (Mitella) lithotryoides*, Bosq., sp. External view of left side of carina, with two or more rows of lateral scales still adherent to its base. Enlarged about twice nat. size. From the Chalk of Maestricht.
FIG. 2. Group of adherent latera viewed from the inside.
FIG. 3. The same valve as in Fig. 1 viewed dorsally. About nat. size.
FIG. 4. Sub-rostrum, showing adherent verticillate latera. About twice nat. size.

(Figs. 1–4 copied from M. Bosquet's memoir on "Cirripèdes dans Crétacé du Duché de Limbourg," 4to, 1857, Harlem, pp. 23–27, pl. iii, figs. 6*a*, *b*, *d*, and 9*a*, *c*.)

Norwich Chalk, portions of three rows of small verticillate, imbricated scale-like plates still adhering to the bases of the carina and sub-rostrum, and although not absolutely specifically identical with Dr. Rowe's *Brachylepas cretacea*, I have no hesitation in referring the Maestricht specimens of *M. lithotryoides* to the genus *Brachylepas*.[1]

used in geological works, it has appeared to me to be as useless as hopeless to attempt any change. It may be observed that the genus *Pollicipes* was originally proposed by Sir John Hill ('History of Animals,' vol. iii, p. 170) in 1752, but as this was before the discovery of the binomial system, by the rules it is absolutely excluded as of any authority. In my opinion, under all these circumstances, it would be mere pedantry to go back to Oken's 'Lehrbuch der Naturgesch.' for the name *Mitella*,—a work little known, and displaying entire ignorance regarding the Cirripedia."

[1] I do not find any very close analogy between M. Bosquet's *Mitella lithotryoides* and the living genus *Lithotrya*, which is a burrowing Cirripede, lodged in cavities bored in calcareous rocks, shells, or corals, having the lower part of the peduncle *quite naked*, the upper margin being covered by two rows of square non-imbricate scales, followed by several rows of minute separate stellate plates, each row becoming less and less in size until they disappear almost altogether. In *M. lithotryoides* the scales are numerous, close set, and imbricated. The valves of the capitulum have a very close agreement with *Brachylepas cretacea*, H. Woodw., and, as I hope to show, also with *B. (Pollicipes) fallax*. I propose therefore, if permissible, to discard the specific name *lithotryoides*, and would suggest that of *B. Bosquetii*, in compliment to the author, as less misleading and more appropriate to the species.

As nearly all the Lepadidæ occurring in a fossil state are met with as detached valves, it will be found convenient to give here a figure of *Scalpellum* (after Darwin) in which the valves forming the capitulum are all named, and their relative position to one another when united is admirably shown (Fig. A).

The other figure given is that of the recent *Pollicipes mitella.* Darwin says of *Pollicipes,*[1] "this is the most ancient genus of the Lepadidæ and seems also to be the base of the genealogical tree; for *Pollicipes* leads, with hardly a break, by some of its species into *Scalpellum villosum,* and *Scalpellum* leads by *Oxynaspis* into *Lepas* and the allied genera; *Pollicipes mitella* is *nearer allied to the Sessile Cirripedes* than is any other pedunculated Cirripede, except perhaps *Lithotrya,* which is also closely connected with *Pollicipes.*"

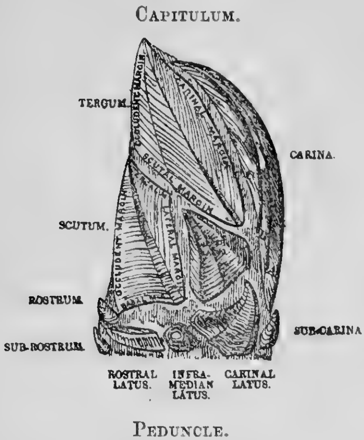


FIG. A.—*Scalpellum fossula*, from the Norwich Chalk (after Darwin).

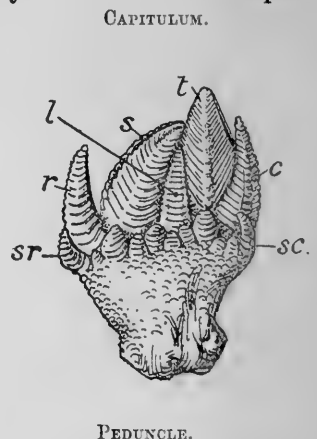


FIG. B.—*Pollicipes mitella*, Linn.,[2] a living Philippine species (after Darwin).

Turrilepas and *Brachylepas* were of course unknown until a much later date. *Pollicipes mitella* certainly enables one to understand the structure of *Brachylepas* better than any other Cirripede with which I am acquainted.]

2. BRACHYLEPAS (POLLICIPES) FALLAX, Darwin, sp., 1851. (Figs. 5–24.)

Pollicipes fallax, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), pp. 75, 76, tab. iv, figs. 8*a*, *b*, 4to.

Mitella fallax, Bosquet, 1857: "Cirripèdes dans le Terrain Crétacé du Duché de Limbourg," 4to, Harlem, pp. 17–23, pl. ii, figs. 1–12; pl. iii, figs. 1, 2.

This species is well represented from the Chalk Bluffs of Trimmingham, Norfolk, and was first described by Charles Darwin in 1851 (*supra*). Darwin only figured a scutum (8*a*) and a tergum (8*b*), twice natural size. These were from the Upper Chalk of Norwich (Fitch Coll.), still preserved and identified by Mr. F. Leney

[1] Darwin, Fossil Lepadidæ: Pal. Soc. Mon., 1851, p. 48.

[2] The letters attached to the valves in *Pollicipes mitella* (Fig. B) correspond to the names on the valves in *Scalpellum* (Fig. A) placed beside it.

in the Norwich Castle Museum. See "Catalogue of Types," by F. Leney, Geol. Mag., 1902, Crustacea, p. 226 [2153]. Darwin records the occurrence of this species from the Chalk of Maestricht, Balsberg, and Kopinge, Scania, and from the Oberer Kreidemergel (U. Chalk), Gehrden, in Hanover.

Five specimens, probably from Plauen, near Dresden (Ober-Quader), have also come into my hands, which, although of larger size, suggest very close relationship to, if not identity with, *P. fallax* of Darwin.

Mr. Brydone writes: — "The whole of the specimens of *Brachylepas fallax* obtained by me at Trimmingham were extracted from the chalk, filling a depression in the base of a large pyramidal flint, in the surface of which there are still imbedded 3 carinæ, 2 right and 2 left scuta, and a rostrum, all belonging to *B. fallax*. There are also two valves belonging to some other species imbedded

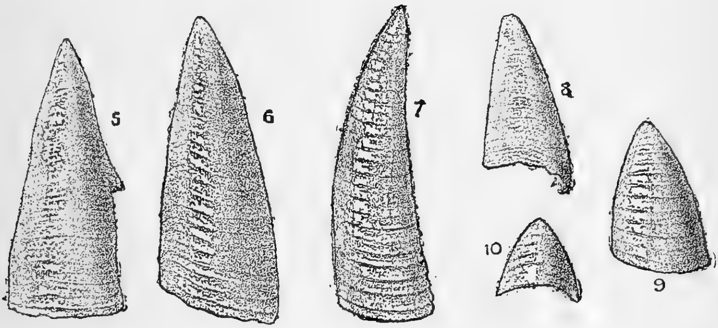


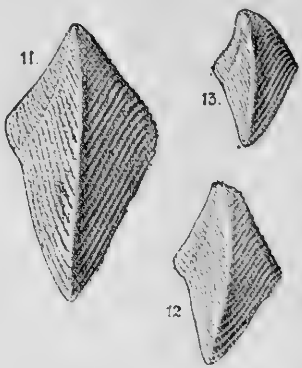
Fig. 5. *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. External dorsal aspect of carina. All × 2 nat. size. From the Chalk of Trimmingham, Norfolk.
Fig. 6. Another specimen (same view).
Fig. 7. Right side view of Fig. 6.
Fig. 8. Rostrum, side view (of smaller individual).
Fig. 9. Rostrum of same species.
Fig. 10. Sub-rostrum of same.

in the *side* of the flint, but otherwise no valves of any other Cirripede were found in, or in connection with, this flint. The grounds, therefore, upon which these valves are associated in one species are of a strength almost unique in the case of chalk forms. Apart from this special series of associated valves it should also be mentioned that *B. fallax* is by far the most abundant species of Cirripede in the Trimmingham Chalk, but the majority of the specimens I have met with are more or less damaged."

In M. Bosquet's memoir, we find in addition to the scutum and tergum (figured both by Bosquet and Darwin) those of the carina, rostrum, sub-carina, sub-rostrum, the upper latus, and seven of the lesser latera carefully figured and described. As these same valves occur in the Trimmingham Chalk, with scuta and terga identical with those figured by Darwin and Bosquet, and referred by them to *P.* (*Mitella*) *fallax*, I give here the description of the additional valves which I propose to treat as belonging to the same form of Cirripede. (See Figs. 5–10.)

Carina (Figs. 5–7).—Nearly straight, semi-conical, feebly swollen in the lower part of its length; the basal border slightly excavated; the interior deeply concave, one sees that a considerable part of the summit projected freely, as does the apex of the carina and that of the rostrum also in the living *Pollicipes mitella* (see *ante*, p. 340, Fig. B, *c*, *r*; and Darwin's "Lepadidæ," Ray Society, 1851, pl. vii, fig. 3). Lines of growth, more strongly marked near the lower border, encircle the carinal valve from the base to the summit.

Sub-carina.—This valve differs but little in form from the sub-rostrum, but M. Bosquet believes it to be the sub-carina on account of its dimensions, and because he thinks its form corresponds with that of the carina; it is much more slender than the latter, and its summit is slightly inflected, and for about one-third of its length it probably projected freely.



Figs. 11–13.—Three terga of *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. × 2 nat. size. From the Chalk of Trimmingham.

Rostrum (Figs. 8, 9).—Smaller than the carina, semicircular at the base, and more triangular in form, the apex more or less inflected, and its basal portion nearly flat, with the feeblest indication of a median longitudinal keel, the transverse lines of growth are clearly marked; deeply concave within and projecting freely at its upper part.

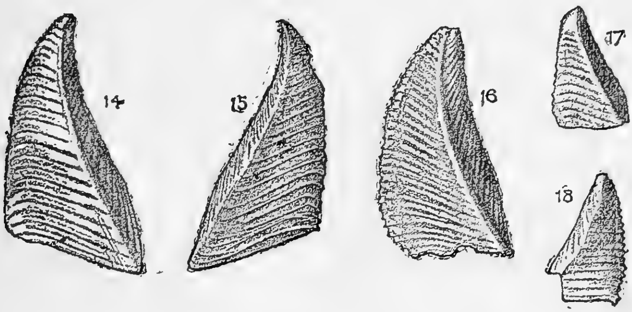
Sub-rostrum (Fig. 10).—This is much shorter and proportionally broader than the rostrum; it is slightly carinated, and the surface shows some very feeble longitudinal grooves, the basal border is very slightly excavated, and the upper part projected freely.

Description of scutum and tergum.[1]—"The valves are moderately thick; they are conspicuously marked with rather wide prominent ridges, forming the basal edges of each zone of growth; they seem in both scuta and terga most strongly developed near the occludent margins. (See Figs. 11–13.)

[1] After Darwin's monograph, p. 75.

"*Tergum* (Figs. 11–13).—Rather broad, convex; apex pointed and much curled towards the scuta; upper carinal margin unusually arched, slightly longer[1] than the lower carinal margin; there is a deep depression parallel to the occludent margin, which is itself rounded, protuberant, and considerably shorter than the scutal margin. A curved ridge projecting up above the general surface of the valve, with sloping sides, runs from the apex to the basal angle, which latter is broad and rounded;[2] the ridge runs down nearly in the middle of the valve." (Darwin, op. cit., p. 76.)

"*Scutum* (Figs. 14–18).—Almost triangular, moderately convex; occludent margin considerably arched in the upper part and bowed towards the terga; basal margin not straight, with a short portion close to the rostral angle, forming a rectangle with the occludent margin; the remaining portion, if produced, would form a rather



FIGS. 14–18.—Five scuta of *Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. × 2 nat. size. From the Chalk of Trimmingham.

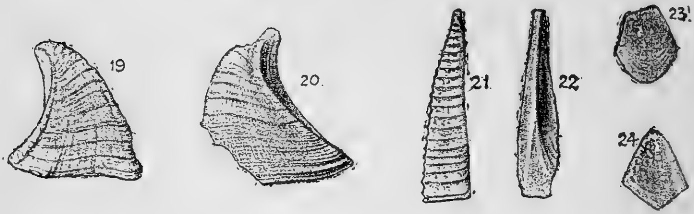
larger angle with it; hence the baso-lateral portion of the whole valve is somewhat protuberant. The tergo-lateral margin is in the upper part slightly hollowed out, and in the lower part almost straight. A very slightly curved ridge runs from the apex to the baso-lateral angle, which is broad, rounded, and not prominent; the ridge has sloping, not wall-like sides. Internally the structure of the upper part closely resembles that of *P. rigidus*. The occludent edge is thickened, broad, and flat, and is marked by lines of growth, and widens towards the apex; there is a rather deep furrow close to the tergal margin, but there is no trace of a central ridge; the deep pit for the adductor muscle lies quite close under the furrow and flat occludent edge. The furrow on the tergal side is rather narrower, and a central portion of the inner occludent margin

[1] This does not hold good in a number of specimens. Thus, the upper carinal margin in four specimens measures 8, 9, 10, and 11 mm.; whilst the lower margin in the same specimens measures 8, 11, 11, and 10 mm.; so that the relative length of the margin and also the degree of curvature varies considerably.

[2] The basal angle in a number of terga of this species, instead of being broad and rounded, is narrow and rather pointed. I am, however, inclined to consider these only trivial variations and of no real specific importance.

(marked with lines of growth) here forms a slightly prominent ridge." The inner basal angle of the specimens now before me is rather more produced to an acute angle than in Darwin's figure.

Latera.—The upper pair of latera (Figs. 21, 22) are much longer than those of the series forming the lower whorls;[1] they are flat, very narrow, tapering, and acutely triangular in form, the summits being worn smooth; the rest of the exterior surface is ornamented by about twenty raised transverse ridges or periodic lines of growth, giving them a somewhat similar appearance to the ornamentation on the surface of the scutum and tergum. These lines of growth pass over the edges of the lateral borders, and are continued on the inner surface of the valve, where they curve upwards, meeting in a raised median longitudinal ridge, which is frequently prolonged to the apex of the latera. Width of larger latera 3 mm., length 13 mm.



FIGS. 19–24.—*Brachylepas* (*Pollicipes*) *fallax*, Darwin, sp. From the Chalk of Trimmingham, Norfolk.

FIGS. 19, 20. Carinal latera, or sub-carinæ. × 2 nat. size.
FIG. 21. Latera, external view. × 2 nat. size.
FIG. 22. Latera, internal view. × 2 nat. size.
FIGS. 23, 24. Sub-latera. × 3 nat. size.

Basal latera.—Two basal latera found associated with the above measure 3 mm. in length by 2 mm. in breadth; they are marked by arching striæ. (See Figs. 23, 24.)

Dimensions of separate valves of *B. fallax* from Trimmingham :—

Scuta.—There are eight examples of scuta. I give measurements of six :—

Colln.	Length in mm.	Breadth in mm.
1. R. M. Brydone	... 18 (apex to angle of lowest curve) ...	11 (greatest).
2. R. M. B. ...	... 17 (pair valve)	(injured on lat. marg.).
3. R. M. B. ...	... 10 (small specimen)	6
4. R. M. B. ...	... 8 (small specimen)	5
5. R. M. B. ...	... 8 (small specimen)	5½
6. Geol. Surv. Mus.	... 8 (specimen imperfect)	5

[1] In his description of *Mitella fallax* from the Maestricht Chalk, Mons. Bosquet says these latera are three times as long as the largest of the lower whorls and many times larger than those of the lowest and smallest series, op. cit., p. 20. On his pl. ii, figs. 7*a*, *b* (op. cit.), Bosquet figures a *latus* precisely similar to Mr. Brydone's specimen from Trimmingham, Figs. 21, 22, *supra*.

Terga.—There are ten examples of terga from Trimmingham :—

	Colln.	Length in mm.	Breadth in mm.
1.	R. M. Brydone ...	15½	10 (a perfect valve).
2*a*.	C. Reid	13 (apex lost) ...	8 (breadth perfect).
2*b*.	C. Reid	12 (base lost) ...	10 ,,
3.	R. M. B.	19 (perfect)... ...	11½ ,,
4.	R. M. B.	14 (base lost) ...	11½ ,,
5.	R. M. B.	10 (perfect)... ...	6 ,,
6.	R. M. B.	10 (perfect)... ...	6 ,,
7.	Geol. Surv. Mus. ...	13 (perfect)... ...	8½ ,,

Carina.—I assume that the larger of the conical series of valves found by Mr. Brydone associated in the hollow of a chalk flint from Trimmingham are referable to *carinæ*. They agree most closely with M. Bosquet's figures of the carina of *Mitella fallax* from the Chalk of Maestricht. The following are the dimensions of four *carinæ* and eight *rostra* :—

Carinæ.

	Colln.	Length.	Breadth at base.	
1.	R. M. Brydone	20 mm.	Estimated on a straight line,	8 mm.
2.	R. M. B. ...	20 mm.	,, ,, ,,	9 mm.
3.	R. M. B. ...	13 mm.	,, ,, ,,	9 mm.
4.	R. M. B. ...	13 mm.	,, ,, ,,	8 mm. (rugose curved form).

Rostra.

	Colln.	Length.	Breadth.	
1.	R. M. Brydone ...	13 mm. (imperfect) ...	7 mm.	
2.	R. M. B.	14 ,, ...	7 ,,	
3.	R. M. B.	10 ,, ...	7 ,,	
4.	R. M. B.	10 ,, ...	6 ,,	(injured at base).
5.	R. M. B.	8 ,, ...	6 ,,	
6.	R. M. B.	5 ,, ...	6 ,,	
7.	R. M. B.	5 ,, ...	4 ,,	(sub-rostra ?).
8.	R. M. B.	3 ,, ...	4 ,,	,,

Three other valves must be noticed; these are carinal latera (Figs. 19, 20). The most perfect example was found by Mr. Brydone attached to a carina of *Brachylepas* (*Pollicipes*) *fallax*, which seems good evidence of its having once formed part of the same capitulum.

Dr. Marsson,[1] in his memoir on the "Cirripedien d. Rügenschen Kreide," p. 12, taf. i, figs. 3*c*, *c'*, figures and describes a precisely similar form of plate under *Scalpellum fossula* ; but I believe that our Trimmingham examples really belong to *Brachylepas fallax* (cf. Figs. 19, 20 with Marsson's taf. i, fig. 3). Dr. Marsson says: "These carinal latera are obliquely triangular, and have an arcuate carinal side, the apex (or umbo) of which has an uncinate curvature directed towards the opposite (concave) side, which presents a parietes-like margin curved at almost a right angle. This margin terminates directly underneath the umbo in a rectangular crest; the surface is marked by longitudinal parallel rib-like striæ, passing over the crest and forming underneath it, alongside the carinal

[1] "Mittheilungen aus dem Naturwissenschaftlichen Vereine von Neu-Vorpommern und Rügen in Greifswald," von Dr. Th. Marsson, xii-xviii, Berlin, 1880.

margin, a rather broad, somewhat hollow zone. The surface is marked by four or five ribs of unequal distance apart; the carinal margin is the narrowest, and is slightly curved inwards; the broadest areas have a longitudinal depression between them. (In the Trimmingham specimens these longitudinal lines are very faint indeed, the horizontal lines being the strongest.) The basal margin is the broadest, the lines of growth run parallel to it and across the longitudinal striæ; these latter give to the carinal latera a somewhat similar ornamentation to that of the scutum and tergum."

Passing over *Brachylepas cretacea*, previously described (see *ante*, p. 337), it will be seen from the foregoing account that *Brachylepas* (*Pollicipes*) *fallax* is the most important of the Cirripedes from Trimmingham, and the one about which the largest amount of evidence has been obtained as to its various valves. This species also occurs in Maestricht and Rügen, probably also in Denmark, in Hanover, and in Saxony.

Those which follow are mostly represented by single detached valves, and, although deserving notice, are of less interest to the biologist.

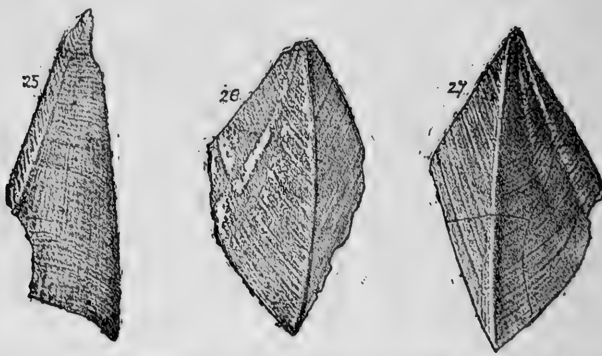


FIG. 25. *Pollicipes Angelini*, Darwin. Scutum. × 2 nat. size. Chalk, Norwich. (Dr. A. Rowe's Coll.)
FIG. 26. Ditto. Right tergum. Chalk, Trimmingham. × 2 nat. size. (Mr. Brydone's Coll.)
FIG. 27. Ditto. Left tergum. × 2 nat. size. Ditto. Ditto.

3. POLLICIPES ANGELINI, Darwin, 1851.

Pollicipes Angelini, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 56, tab. iii, fig. 7.

This form is represented in Darwin's monograph by a scutum and tergum from the Upper Chalk of Norwich (Mus. Fitch); it occurs also in the Chalk of Scania. I have referred to this species six separate *terga*, three only fairly preserved, the others very imperfect, and one *scutum*, the former all from Trimmingham; the latter is from Thorpe, Norwich, *ex* Dr. Arthur Rowe's collection.

Tergum.—The largest complete tergum (which has been broken and mended) (Fig. 27) measures 22 mm. in length by 13 mm. in breadth at its widest angle. In general outline it is rhomboidal, the apex is acute, the base more or less obtuse; a slightly raised keel runs from the apex to the base, and divides the valve into two not quite equal halves, the occludent half being the larger; the lines of growth run parallel to the lower borders of the valve, and bend upwards on either side of the raised keel or ridge; a wide square-edged depression runs parallel to the occludent margin, which is itself rounded and protuberant. (All the terga of *P. Angelini* I have seen are from the Chalk of Trimmingham.)

Scutum.—The scutum (Fig. 25) is 21 mm. in length; its breadth is only estimated, being imperfect along its free margin; it was probably 9 mm. in breadth. Thorpe Pit, Norwich. (Coll. Dr. Rowe.)

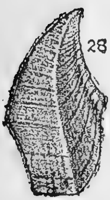
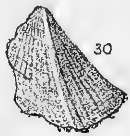
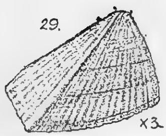
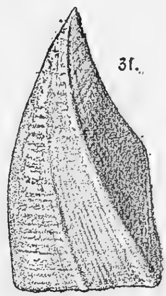
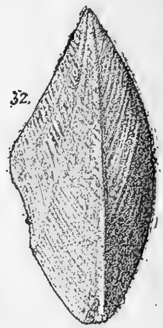






FIG. 28. ? *Pollicipes Hausmanni*, Darwin. Scutum. × 2 nat. size. Chalk, Thorpe, near Norwich. (Dr. A. Rowe's Coll.)
FIG. 29. *Pollicipes concinna*, sp. nov., H. Woodw. Carinal latus. × 3 nat. size. Chalk, Trimmingham. (R. M. Brydone's Coll.)
FIG. 30. Ditto. × 2 nat. size.
FIG. 31. ? *Pollicipes striatus*, Darw., var. *paucistriatus*, H. Woodw. Scutum. × 2 nat. size. Chalk, Trimmingham. (R. M. Brydone's Coll.)
FIG. 32. Ditto. Tergum. × 2 nat. size. Ditto.

4. ? POLLICIPES HAUSMANNI, Darwin, 1851. (Fig. 28.)

Pollicipes Hausmanni, Koch & Dunker: Norddeutsch. Oolithgebild., p. 52, tab. vi, fig. 6.
Pollicipes Hausmanni, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 53, t. iii, fig. 3.

Darwin has figured a carina, scutum, and tergum of this species from Hilsthon des Elligser Brinkes (Lower Greensand, Germany). I doubtfully refer a scutum, from Dr. Rowe's collection, to this species, obtained by him from the Chalk of Thorpe, near Norwich. Length of valve 12 mm., breadth (probably) 7 mm., basal angle broken. This is an elegant valve, with an acute and incurved apex; the base of the valve was probably straight, the inner margin curving rapidly upwards towards the tergal border; the surface ornamented by well-marked periodic lines of growth, stronger than the rest, which are parallel to the base and bend upwards on the inner occludent margin, and are slightly undulated near the tergal border.

5. (?) Pollicipes concinna, H. Woodward, sp. nov.
(Figs. 29, 30.)

There are two valves from the Trimmingham Chalk in Mr. Brydone's collection which I have been unable to collate satisfactorily with any of the species already described from the Chalk.

(*a*) In outline the smaller one (Fig. 29) agrees with the lower latus of *P. unguis* of Darwin, from the Gault, but its ornamentation is not based so much on the lines of growth as upon delicate, fine, radiating costæ diverging from its apex. The valve has two areas, separated by a well-defined ridge; the larger is 7 mm. broad at its base, the smaller, which forms with it an obtuse angle, being only $3\frac{1}{2}$ mm. broad; the height of the valve is 8 mm.; five well-marked zones of growth cross the rib-like ornamentation at irregular intervals. This is a lower latus (or a carinal latus),[1] and in default of a species to which it can be referred it may be known as (?) *Pollicipes concinna.*

(*b*) This (Fig. 30) is a larger valve than (*a*) noticed above, and possibly may belong to a distinct species. At first sight its outline seems to be not unlike a scutum, but in relative proportion it has a broader base and is shorter in height than this valve usually attains. It probably is, like (*a*), one of the lower latera, but being imperfect upon its broader facet is not so easily determined. The ornamentation is composed of radiant lines, but they are fewer in number and coarser than in the above-described form (*a*). Height, 8 mm.; width of smaller perfect side at base, 5 mm.; broader facet at base (estimated to be 6 to 7 mm.?); margin broken. The angle of this valve (*b*) is more curved than is that of (*a*); longitudinal striæ, on narrow face, about six in number, thicker at the basal margin, on broader face at least ten in number. This may have belonged to a form similar to (*a*), but its coarser striation would suggest its being possibly referred to some other species. In the absence of further information I must, however, leave it here until better material turns up.

6. (?) Pollicipes striatus, Darwin, 1851, var. paucistriatus, H. W.
(Figs. 31, 32.)

Pollicipes striatus, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), p. 70, tab. iv, fig. 5.

This form, of which a well-preserved scutum and tergum have been obtained by Mr. Brydone from Trimmingham (Figs. 31 and 32), was previously known from the Upper Chalk of Norwich (Museum Fitch), and figured by Darwin (op. cit., pp. 70–72, tab. iv, fig. 5).

I should state that these Trimmingham specimens were sent some time ago by Mr. Brydone to Professor Deecke, of Greifswald University, Prussia, who marked them as "*Scalpellum fossula,*

[1] It compares very well with the carinal latus in the living *Scalpellum striolatum* of Sars taken between Norway and Faeroe Island (see A. Gruvel, Mon. Cirripedes, 1905, p. 64, fig. 7).

Darwin." On examination it will be seen, however, that Darwin's *S. fossula* is at once distinguished from these valves (which I identify as near to *P. striatus*) by the fact that in *S. fossula* there is a minute but well-defined longitudinal hollow groove on the summit of the ridge or keel of both the scutum and tergum; the ridge on the valves in *P. striatus* is not grooved along its summit, but is a solid well-defined ridge (as seen in Darwin's figures, op. cit., tab. iv, figs. 5*b*, *c*). Both scutum and tergum are stout, thick valves. The general form and proportions in both specimens agree best with Darwin's figures of *P. striatus* from the Norwich Chalk. In one point these valves differ from *P. striatus*, and that is in being less strongly ornamented by longitudinal striæ; but in the colour-bands and in the contour-curvature and lines of growth both valves agree very well with *P. striatus*. They are at most only a less striated variety which might be named *P. pauci-striatus*.

Tergum.—In the tergum (Fig. 32) there is seen a well-defined raised margin along the carinal border and a broad longitudinal undulation running down the valve to its baso-lateral border, which is flexuous; the more or less symmetrically rhomboidal form of the tergum is also modified by the strongly arcuate curvature of the valve, the apex leaning towards the carinal border; the free margin of the valve is also narrower than the latero-carinal side. (In *S. fossula*, as figured by Marsson, the crest of this valve is nearly straight, and the apex inclines slightly in the opposite direction to the Trimmingham fossil.) Length of tergum, 21 mm.; extreme breadth, 10 mm.; length of base of occludent carinal border, 13 mm.; on the upper carinal border, 12 mm. The longitudinal ridge is very arched, and the free border is not only narrower but more steeply inclined than the occludent side; the banded ornament produced by fine lines of growth is accentuated by colour-bands.

There is a second imperfect tergum which also comes from the same spot at Trimmingham, and shows rather stronger longitudinal striæ on the carinal side of the central ridge than the more perfect valve. It is less flat than the tergum of *P. Angelini*, among which I had in the first instance placed it, and it may possibly belong to *P. striatus*.

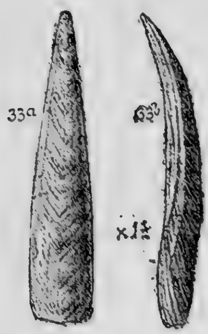
Scutum (Fig. 31).—Rather thick, subtriangular, tumid, and curved, apex acute, basal margin straight, 10 mm. broad, forming a right angle with the lateral margin which is 9 mm. long; tergal margin also 9 mm. long, both margins rather concave; a strongly marked rounded ridge separates the valve longitudinally from the apex to the latero-basal angle into two unequal parts, while a second less prominent line 5 mm. apart divides the occludent side of the scutum into two equal parts, the inner half being marked by seven longitudinal lines, the outer half having only horizontal lines of growth; the lateral side is also marked by a series of less prominent longitudinal lines. All these longitudinal striæ describe a strong curve, the convexity being towards the occludent margin. Colour-bands mark both the scutum and tergum, running parallel to the basal margin and to the lines of growth. This valve agrees very well in general form with Darwin's figure of the scutum of *P. striatus* (op. cit., tab. iv, fig. 5*c*), except that the longitudinal striæ are less strongly pronounced.

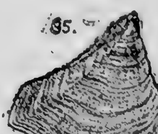
It is probable that *P. striatus* may belong to the genus *Scalpellum*, but I hesitate to remove it without fuller knowledge of the other valves belonging to this species.

7. Pollicipes glaber, Roemer.

Pollicipes glaber, Roemer: Norddeutsch. Kreidegebirg, tab. xvi, fig. 11.
Xiphidium maximum, J. Sowerby: Dixon's Geol. Sussex, tab. xxviii, figs. 6–8.
Pollicipes glaber, Darwin, 1851: Mon. Foss. Lepadidæ, Pal. Soc. Mon., p. 61, tab. iii, figs. 10*a*–*l*.

I must not omit to mention some six small, smooth, but rather imperfect valves of a Cirripede from Trimmingham, marked by Mr. Brydone as having been found by him 'connected.' I am able readily to identify them with Darwin's figures of *Pollicipes glaber* (tab. iii, figs. 10*a*–*l*, op. cit.) from the Chalk of Stoke Ferry, Norfolk. This species also occurs in the Upper Chalk of Northfleet and Gravesend, Kent, and the Chalk Detritus of Charing, Kent, and from numerous localities on the Continent.





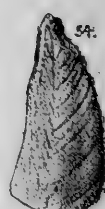


Fig. 33*a*. *Scalpellum maximum*, Darwin. Carina (back view). Chalk, Norwich. (Dr. A. Rowe's Coll.)
Fig. 33*b*. Profile of ditto. × 1½ nat. size. (Dr. A. Rowe's Coll.)
Fig. 34. Ditto. Tergum. (Fragment only.) × 2 nat. size. Ditto.
Fig. 35. Ditto. Carinal latus. × 2 nat. size. Ditto.

Mr. Brydone's Trimmingham specimens comprise a scutum, a tergum, a rostrum, an upper and a lower latus. I do not think it is needful to refigure them here, but they are important as having been found in association in the same piece of chalk.

8. Scalpellum maximum, Darwin, 1851. (Figs. 33*a*, *b*, 34, 35.)

Pollicipes maximus, J. Sowerby: Min. Conch., table 606, figs. 4, 6 (*not* figs. 3, 5).
Pollicipes maximus, Steenstrup: Kroyer Tidsskrift, bd. ii, pl. v, figs. 17, 18.
Pollicipes medius, Steenstrup: Kroyer Tidsskrift, bd. ii, pl. v, figs. 13, 13*, 33.
Pollicipes sulcatus, J. Sowerby: Min. Conch., pl. 606, fig. 2 (*not* figs. 1, 7).
Scalpellum maximum, Darwin, Mon. Foss. Lepadidæ: Pal. Soc., vol. v (1851), pp. 26–34 (and varieties), tab. ii, figs. 1–10.

My father, in his "MS. Illustrations" (tab. xi, figs. 5*a*, *b*), prepared to accompany a published "Synoptical Table of British Organic Remains," by Samuel Woodward (4to and 8vo, 1830, p. 9; London, Longmans & Co.), gives drawings of the tergum and carina of this species (under the genus *Pollicipes*) from the Norwich Chalk.

I have received from Dr. Rowe a very well preserved carina (although wanting a portion of its base) obtained by him from Edward's Chalk Pit, Mousehold, Norwich, measuring in its present state 30 mm. in length by 7 mm. in breadth at its widest part, its profile being 4 mm. deep. It has numerous ⌄⌄-shaped lines of growth passing over the keel, the point directed downwards, ten of which are more prominent than the rest. There are also several longitudinal striæ extending from the apex to the base (Figs. 33*a*, 33*b*). Two longitudinal folds mark the narrow lateral portions of the carina, which is sharply recurved at its apex.

Dr. A. Rowe has also kindly sent me a carinal latus of *Scalpellum maximum*, which agrees with the figure of that valve given by Darwin (op. cit., tab. ii, figs. 4*a*–*c*). It is from Attoe's Pit, New Catton, Norwich (*B. mucronatus* zone). Darwin states that his figure was taken from a specimen from Kopinge in Scania. Dr. Th. Marsson (in his "Cirripedien d. Rügenschen Kreide," taf. i, fig. 2) figures and describes a precisely similar valve, which he says is a carinal latus of *Sc. maximum*. Another small specimen is recorded by Darwin from Charing in Kent (op. cit., p. 32). "Valve thin, of an irregular shape (Fig. 35), sub-triangular, flat, except at the umbo, which projects outwards, owing to a ledge formed beneath and round it; carinal margin very slightly convex, with a linear furrow parallel to it, between which and the edge the lines of growth are abruptly upturned; lower margin considerably convex, upper margin slightly concave, with a slight depression parallel to it, between which and the edge the lines of growth are rectangularly reflected towards the umbo." Height of valve 12 mm., greatest breadth 12 mm.

Mr. Brydone considers it very doubtful as to whether this form occurs in the Trimmingham Chalk, but in looking over some fragments of valves in Mr. Brydone's Trimmingham collection, associated with terga of *P. Angelini* and a scutum and tergum of *P. striatus*, var. *paucistria*, I found a broken scutum of *Scalpellum maximum*. It was a very large and very thick valve, and displays on its inner surface the depression for the adductor muscle. The outer surface has the usual lines of growth and fine longitudinal striæ seen in the other valves belonging to this species. Length of fragment 18 mm., greatest breadth 10 mm. From the proportionate size and thickness of this fragment I am led to conclude that it must have really belonged to *S. maximum*.

Tergum (Fig. 34).—This is only a fragment (from Dr. A. Rowe's collection), but from its form and lines of growth I have no difficulty in recognising it as the apex of a tergum of *S. maximum*. Cf. Darwin's figures of this valve (tab. ii, figs. 7*a*, *b*). It is a narrow crescent-shaped valve (not unlike a boomerang), broad and pointed at its base, much curved and thickened at its free apex by the infolding and union near its summit of the two lateral walls. A fine furrow runs down the exterior surface of the narrow valve, where the usual prominent ridge of the tergum is seen, nearly parallel to the carinal margin.

9. Scalpellum fossula, Darwin, 1851. (Fig. 36.)

Scalpellum fossula, Darwin, Foss. Lepadidæ, 1851: Mon. Pal. Soc., 4to, pp. 24, 25, tab. i, fig. 4.
Pollicipes maximus, J. Sowerby: Min. Conch., table 606 (a tergum), fig. 3.

Tergum (Fig. 36).—A single left tergum in Dr. Rowe's collection is from the Chalk of Thorpe, Norwich. It is thin, narrow, almost smooth, but instead of a ridge running from the apex to the lowest

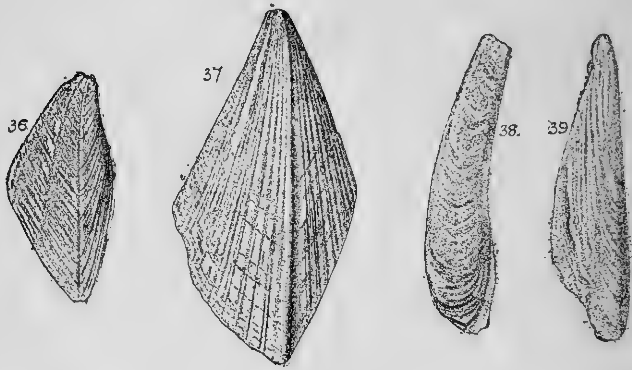


Fig. 36. *Scalpellum fossula*, Darwin. Left tergum. × 2 nat. size. Chalk, Thorpe, Norwich. (Dr. A. Rowe's Coll.)
Fig. 37. *Scalpellum attenuatum*, sp. nov., H. Woodw. × 2 nat. size. Chalk, Harford Bridges Pit, Norwich. (Dr. Rowe's Coll.)
Fig. 38. ? *Brachylepas*. Latera. × 2 nat. size. Chalk, Trimmingham. (Mr. R. M. Brydone's Coll.)
Fig. 39. Ditto. Same valve as Fig. 38, side view, showing great thickness of valve.

point of the obliquely diamond-shaped valve, the line is marked by a delicate furrow, as shown in Darwin's figure (tab. i, fig. 4*b*, op. cit.). This furrow divides the valve unequally into a very narrow area along the carinal border, and a much wider one, bounded by the scutal margin below and the occludent margin above, the centre of which is again subdivided by a single longitudinal line. Length of valve, 16 mm.; greatest breadth, 8 mm.; scutal margin, 11 mm.; occludent margin, 10 mm.

Recorded by Darwin from the Upper Chalk of Norwich and from Northfleet, Kent.

10. Scalpellum attenuatum, H. Woodw., sp. nov. (Fig. 37.)

Among the collection of specimens sent to me by Dr. Arthur Rowe from the Norwich Chalk is a single tergum from Harford Bridges Pit, which is unlike any of those already noticed. In general form this valve resembles the tergum of *S. arcuatum* from the Gault of Folkestone; it may also be compared with that of *S. solidulum* from Scania; in all three *terga* the ornamentation consists of a series of longitudinal raised lines diverging from the apex of the valve at unequal distances apart, some being relatively finer than the others. In *S. arcuatum* the main ridge, passing down the centre of the valve from the apex to the basal extremity, is grooved, whereas in the specimen before us the valve has a well-defined rounded ridge. The radial longitudinal lines on the carinal side of the ridge are extremely fine, and broader and stronger on the outer half of the valve than on the inner side of the main ridge. The occludent margin has a strongly raised border, followed by a wide groove extending from the apex to the scutal margin. The lines of growth are most strongly marked on the occludent margin, but they can be faintly seen over the whole valve. On the inner side of the valve the apex (more particularly on the carinal margin) becomes greatly thickened.

Extreme length of valve, 24 mm.; extreme breadth, 13 mm.; length of occludent margin, 16 mm.; of the carinal margin, 13 mm.; and of the carino-lateral margin, 15 mm. The scutal margin is convex; the carino-lateral margin forms an obtuse angle, the sides of which are straight; the occludent margin is very slightly concave.

The two valves already noticed from Mr. Brydone's collection of Trimmingham Cirripedes, under the tentative name of *P. concinna*, are the only two other valves in the collection having a similar ornamentation of finely radiating longitudinal lines, but we have no other grounds for associating these detached valves together, Dr. Rowe's (as already stated) being from an entirely different locality and horizon (?) in the Chalk.

11. Brachylepas (?), sp. (Figs. 38, 39.)

Latera (Figs. 38 and 39).—We give two views of a remarkable form of detached latus, but it is uncertain to what species of Cirripede it belonged. This is a narrow, elongated, irregular valve, and but for the fact that it is extremely solid it might readily be overlooked and thrown aside as merely part of a very narrow-valved *Ostrea*. There are in all five specimens from the Trimmingham Chalk, having the same ornamentation as shown in the figured example. Two of these are from Mr. Clement Reid's collection, and three from that of Mr. Brydone. There are three other fragments not quite so robust and having a distinctly V-shaped ornament similar to that on the carina of *Scalpellum maximum*, and possibly they were latera of that species. Length of figured specimen, 22 mm.; greatest breadth, 5 mm.; greatest thickness, 6 mm.

Similarly-formed latera occur in *Brachylepas fallax* (Figs. 21, 22, p. 344); also in the recent *Pollicipes mitella* (see Fig. B, *ante*, p. 340, *l*) and many others.

II.—Notes on some Microzoa and Mollusca from East Crete.

By Rev. R. Ashington Bullen, B.A., F.G.S.

(Plates XVIII and XIX.)

THE fossil or sub-fossil remains to which I propose to devote this short paper were procured from a cave-deposit in East Crete by Miss Dorothea M. A. Bate, whose valuable work among the Pleistocene Mammalia in Crete is so well known.

Early in 1905 she kindly sent me some helicoid shells from a cave-deposit in East Crete, together with an interesting collection of land and fresh-water mollusca from various parts of the island, all which I have recorded elsewhere.[1] There were also some marine mollusca found at Kutri, West Crete, in a cave about 25 feet O.D. Mr. E. A. Smith, F.Z.S., identified one as *Calliostoma Laugieri* (Payraudeau), and there were others in the same cave-deposit, which, recognizing as marine, Miss Bate did not collect. These occurred in the same cave, in a crevice of which was also a quantity of sea-sand.

The new material, very small in amount but very great in interest, Miss Bate procured from a large mammalian bone of Pleistocene date, found by her in a cave at Kharoumes, East Crete, 12 to 15 feet O.D.; and, as the minute organisms found therein are all of a marine facies, their evidence, added to the other facts from Kutri, points to oscillations of the land-surfaces, leading to the submergence and re-emergence of those land-surfaces, other evidences of which were commented on by Raulin and Spratt more than 40 years ago, in 1861 and 1865 respectively. The late eminent geologist, Professor Prestwich, carefully summed up their evidence as follows[2]:—"From M. Victor Raulin's work on Crete I gather that there is evidence of the elevation of the island within the historical period to the extent of 15 to 25 feet, and, further, that at a height of about 65 feet a raised beach of Quaternary age is met with at many points of the coast. Admiral Spratt has shown that within recent times there has been a subsidence of the east coast of Crete, whilst the west side has been elevated to the extent of 26 feet.[3] Anchor blocks have been found 11 feet above the sea-level, and the port of Kissamo has been raised 18 feet out of the sea within Christian times. The two piers of the port of Phalasarna,[4] a city of late Hellenic date, and described by Strabo, are now 22 feet above their original level.[5] Spratt also found *Pectunculi* of recent species 40 feet above the shore, and indications of another raised beach, or old sea-level, at 100 feet."

[1] Proceedings of the Malacological Society, vol. vi, p. 307.

[2] Prestwich, "Evidences of the Submergence of Western Europe and the Mediterranean Coasts": Phil. Trans., vol. 184 (1893), p. 969.

[3] Spratt: "Travels and Researches in Crete," vol. ii, p. 241 (the district between Selino and Lissos).

[4] Now Kutri.

[5] Bate: Geol. Mag., Dec. V, Vol. II (1905), p. 199 sqq.

The evidence brought home by Miss Bate tends, in my opinion, to reinforce and corroborate the observations summed up by Prestwich in the above passage.

In a recent volume of the Geological Magazine Miss Bate has described this district in her account of her "Search for Pleistocene Mammalia in Crete."[1] The only cave-deposits found in this part of the island were situated in the rugged limestone cliffs bordering the southern end of the Bay of Kharoumes, not many miles south of Palaikastro. At the foot of these cliffs, and only a few feet to a few yards above the sea, were discovered one small bone-cave, and, on either side, portions of the stalagmitic flooring of two others; all being situated closely together and extending for a distance of a hundred and fifty yards.

In Spratt's map of Eastern Crete[2] the Bay of Kharoumes appears as Caruba, and in the French military map[3] as Carouba for both village and bay, which latter spelling Spratt also uses for the name of the village. As Miss Bate invariably calls the place and bay by the name Kharoumes, this is undoubtedly the later current Cretan form. But to the south of Carouba is a village marked in the French map Asokiramo, which is unnoticed in Spratt's map, and is evidently nearer the original of the name Kharoumes. So acute an observer as Spratt would not be likely to make a mistake in the spelling of a name, especially as he says the karouba[4] is the chief produce, and a village to the north of Zakro Bay is named from it. So here in the text we get yet another spelling of the name! Probably Spratt was not responsible for the spelling of the map, as other persons' names are appended to it, but it is all very puzzling and does not make for clearness or exactitude. And may one venture to say that even in England nothing is more common than the variation in a place-name, and that many of the names differ now from their pronunciation and spelling at the time of the engraving of the Survey maps, though there is sufficient similarity in the variants for purposes of identification.

The Kharoumes Bay district, according to Spratt's Geological map, presents a somewhat central mass of slates and schists, surrounded by a limestone district, flanked on the north, west, and south-east by marine Tertiary deposits. It was in the limestone part of this district only that terrestrial mollusca so far have been found in the stalagmitic breccia.

With regard to the marine microzoa from the same place, critically examined for me by Mr. R. Holland, his report is as follows:—"This material, although very small in amount, has proved extremely interesting on account of the very striking series of varieties of

[1] Spratt: op. cit., vol. ii, pp. 230–2. See also ibid., vol. ii, pp. 135–6. (Evidence of successive uplifts indicated by wave-abrasion and the occurrence of boring molluscs in the cliffs; many shells still *in sitû.*)

[2] Op. cit., vol. i, *ad fin.*

[3] Ile de Crête: dessiné et heliogravé au Service Géographique de l'Armée.

[4] The carob-tree, or St. John (the Baptist's) Bread, is found wild in all countries skirting the Mediterranean. At Malta it is almost the only tree. In Spain we get its Moorish name, algarroba.

Peneroplis pertusus (Förskal). This foraminifer is remarkable for its great morphological range, and, although most authors have given specific names to many of the varying forms, it is now generally held that all these are simply varieties of one protean species (see vol. ix of the 'Challenger' Reports). The occurrence in this small amount of material of so wide a range of forms strongly supports this view. With the exception of *Peneroplis pertusus, Planorbulina mediterranensis,* and *Miliolina reticulata,* the specimens are generally poorly developed." The reason of this we shall see immediately.

The total number of specimens is 148. Some of these are obscured in places by the reddish cement by which they were kept in adhesion to each other and to the bone on which they were found. The worn appearance of a large proportion of them testifies to their great age. On examination with a $\frac{4}{10}$ objective the foraminiferal tests, where broken, are seen generally to be filled with a shining crystalline calcitic material stained red, a colour evidently derived from the cave-earth; some of them, especially *Orbitolites complanata,* are covered with a calcitic crust, which hides the foramina, and there is in the hollows between the striæ of others a chalky-looking paste, white in colour, seemingly derived from the attrition or solution of other foraminiferal tests. The polyzoa also have become crystalline in substance from the infiltration of a calcitic solution. All these characters explain why Mr. Holland, from the microscopist's point of view, reports the specimens as poorly developed, for these characters differentiate them from recent specimens of the same species and betoken their fossil or sub-fossil character.

LIST OF SPECIES FOUND.

Mollusca.

Terrestrial.

Helix pellita,[1 2] Fér. Cave-breccia, Kharoumes.

Marine.

Calliostoma Laugieri[2] (Payraudeau). Pleistocene mammalian bone, cave, Kutri.

Cardium sp.

Rissoa crenulata, Montagu. Pleistocene mammalian bone, cave, Kharoumes.

Crustacea.

Valves of *Entomostraca.* Ditto.

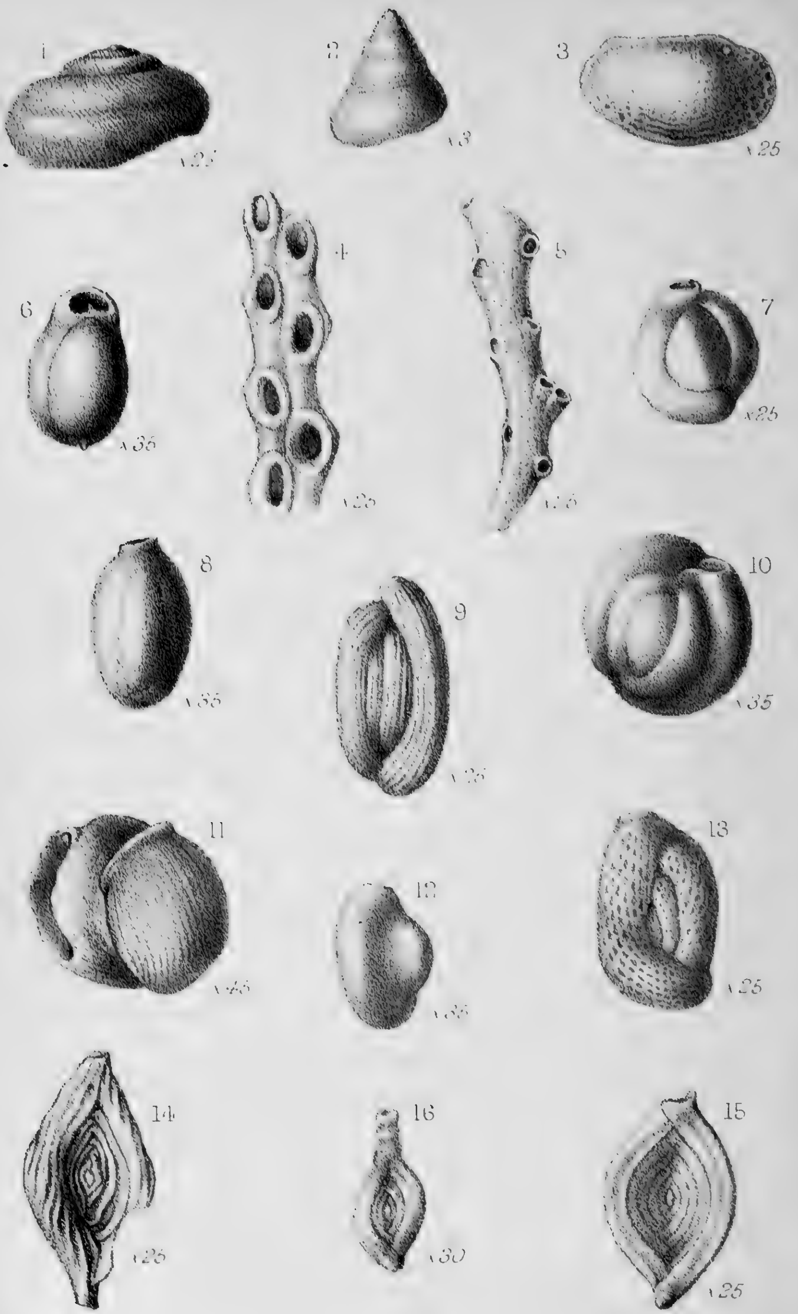
Polyzoa.

Crisia eburnea (Linné). Ditto.

Bugulopsis sp.

[1] Recorded by Pilsbry as a recent shell at Morca, Syra, and Rhodes. Its occurrence at Kharoumes is believed to be its first record from a Pleistocene deposit. From available evidence it appears not now extant in Crete.

[2] Specimens now in Geological Department, British Museum.



G. M. Woodward del. et lith. West, Newman imp.

Mollusca, Bryozoa & Foraminifera from Crete.

FORAMINIFERA.

Biloculina elongata (D'Orb.). Pleistocene mammalian bone, cave, Kharoumes.

Dentalina sp.

Discorbina globularis (D'Orb.). Ditto.

D. opercularis (D'Orb.). Ditto.

D. orbicularis (Terquem). Ditto.

D. turbo (D'Orb.). Ditto.

Globigerina bulloides [1] (D'Orb.). Ditto.

Miliolina seminulum (Linn.). Ditto.

M. oblonga (Montagu). Ditto.

M. bicornis (Walker & Jacob). Ditto.

M. subrotundata (Montagu). Ditto.

M. valvulata [2] (Reuss). Ditto.

M. tricarinata (D'Orb.). Ditto.

M. reticulata (D'Orb.). Ditto.

M. circularis (Bornemann). Ditto.

Orbitolites complanata (Lamk.). Ditto.

Peneroplis pertusus (Förskal). Ditto.

Planorbulina mediterranensis, D'Orb. Ditto.

Polymorphina lactea [2] (Walker & Jacob). Ditto.

Polystomella macella (Fichtel & Moll.). Ditto.

Rotalia becarii (Linn.). Ditto.

Rotaline form undetermined. Ditto.

Spiroloculina grata, Terquem. Ditto.

S. limbata, D'Orb. Ditto.

Truncatulina lobatula (Walker & Jacob). Ditto.

T. ungeriana (D'Orb.). Ditto.

Vertebralina striata (D'Orb.). Ditto.

V. sp.[3] Ditto.

I have the pleasure of thanking the friends mentioned in the paper for help, also Mr. R. Bullen Newton, F.G.S., for submitting the material from Kharoumes to Mr. R. Holland, and Professor T. Rupert Jones, F.R.S., for critically reading my MS.

EXPLANATION OF PLATES.

PLATE XVIII: MOLLUSCA, BRYOZOA, FORAMINIFERA, ETC., FROM CRETE.

FIG.

1. Mollusca: *Helix pellita.* × 2½.
2. ,, *Calliostoma Laugieri.* × 3.
3. Crustacea: Valve of Entomostracan, *Loxoconcha* sp.
4. Bryozoa: *Bugulopsis* sp. × 25.
5. ,, *Crisia eburnea.* × 25.
6. Foraminifera: *Biloculina elongata.* × 35.
7. ,, *Miliolina seminulum.* × 25.
8. ,, *M. oblonga.* × 35.
9. ,, *M. bicornis.* × 25.
10. ,, *M. subrotunda.* × 35.

[1] With abnormal aperture (Holland).

[2] Striate variety (Holland).

[3] With spiroloculine early chambers (Holland).

Fig.			
11.	Foraminifera:	*M. valvulata.*	× 45.
12.	,,	*M. tricarinata.*	× 35.
13.	,,	*M. reticulata.*	× 25.
14.	,,	*Spiroloculina grata.*	× 25.
15.	,,	*S. limbata.*	× 25.
16.	,,	*Vertebralina* sp.	× 30.

PLATE XIX: FORAMINIFERA FROM CRETE.

1.	Foraminifera:	*Peneroplis pertusus.*	× 25.
2.	,,	,,	× 35.
3.	,,	,,	× 25.
4.	,,	,,	× 35.
5.	,,	*Dentalina* sp.	× 25.
6.	,,	*Orbitolites complanata.*	× 25.
7.	,,	,,	× 50.
8.	,,	*Polymorphina lactea.*	× 25.
9.	,,	*Globigerina bulloides.*	× 30.
10.	,,	*Planorbulina mediterranensis.*	× 30.
11.	,,	*Discorbina globularis.*	× 45.
12.	,,	*D. opercularis.*	× 45.
13.	,,	*D. orbicularis.*	× 45.
14.	,,	*D. turbo.*	× 45.
15.	,,	*Truncatulina lobatula.*	× 45.
16.	,,	*T. ungeriana.*	× 45.
17.	,,	*Rotalia becarii.*	× 45.
18.	,,	*Polystomella macella.*	× 45.

III.—SEDGWICK MUSEUM NOTES.

NEW FOSSILS FROM THE HAVERFORDWEST DISTRICT.

By F. R. COWPER REED, M.A., F.G.S.

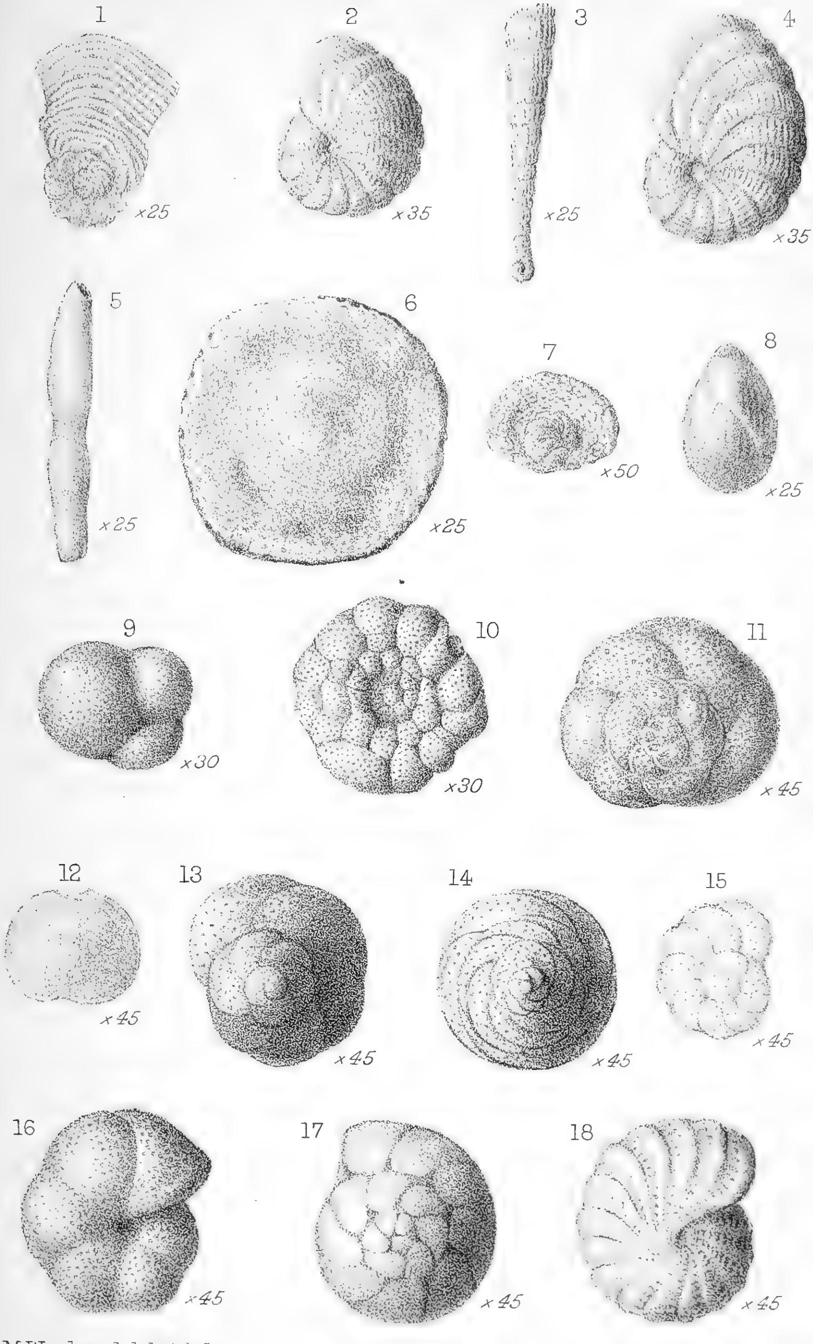
(PLATE XX.)

GASTEROPODA.

A FEW Gasteropoda were recorded by Messrs. Marr and Roberts[1] from the *Trinucleus seticornis* Beds, principally from the Redhill stage, but Mr. Turnbull has been fortunate in obtaining a comparatively large number of species. The specimens are not usually well preserved, and the specific or even generic determination of all is not possible with the present material. Some interesting new forms, however, can be detected, and the following list can now be given:—

R.	*Eotomaria Robertsi*, sp. nov.
R.	*E.* cf. *elliptica*, His.
R.	*E.* sp.
R, S.	*Liospira* sp.
S.	*Lophospira* cf. *turrita*, Portl.
R.	*L.* sp.
R.	*Hormotoma* (?) sp.
S.	*Clathrospira* (?) sp.
S.	*Trochonema* sp.

[1] Marr & Roberts, Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476–490.



G.M. Woodward del. et lith

West, Newman imp.

R, Sh. *Holopea concinna*, McCoy.
S. *Holopella* sp.
R. *Loxonema* sp.
R. *Ophiletina* (?) sp.
R. *Eccyliomphalus minor*, Portl.
R. *Bellerophon* (*Sinuites*) *crypticus*, sp. nov.
R. *B.* (*Bucanopsis*) *secundus*, sp. nov.
R. *B.* (*Oxydiscus* ?) sp.
R. *B.* (s.g. ?) *multirugatus*, sp. nov.
Sh. *B.* (s.g. ?) sp.
S. *Conradella* (?) sp.
R. *Archinacella Prendergasti*, sp. nov.
R, S. *A.* aff. *rotunda*, Ulrich.

Of the foregoing those marked R. occur in the Redhill Beds those marked S. in the Slade Beds, and those Sh. in the Sholeshook Limestone.

EOTOMARIA ROBERTSI, sp. nov. (Pl. XX, Figs. 1–4.)

Shell low, conical, of 5–6 flat whorls; apical angle 90°–110°; base convex; periphery angular; mouth obliquely subrhomboidal, wider than high; umbilicus very small, deep, partly covered by reflexed inner lip of mouth. Band concave, narrow, with sharp raised borders, the lower edge forming the periphery of the whorls; lunulæ of band very faint. Surface of whorls nearly flat; ornamented with fine, simple, oblique, curved lines of growth, meeting suture-line above at about 75°, but curved strongly back near band so as to meet it at 20°–25°. Base of shell more or less swollen, especially towards mouth, and marked by strong growth-lines.

Dimensions average about 18 mm. in basal diameter.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane, Haverfordwest.

Remarks.—The genus *Eotomaria* was established by Ulrich[1] for a certain type of shell differing from *Pleurotomaria* in merely having a notch in the outer lip and no slit; in the lower edge of the band forming the periphery of the whorls; in the lines of growth curving more or less forward beneath the band; and in the surface being marked by simple lines of growth only. The complete definition of the genus was given as follows: "Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-height; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band of moderate width, concave, sharply defined, oblique or horizontal, lying upon the apical side of the periphery. The surface markings consist of fine lines of growth only. These curve

[1] Ulrich & Scofield: Final Rep. Geol. and Nat. Hist. Surv. Minnesota, vol. iii (1897), pt. 2, pp. 954, 1000.

backward more or less strongly toward the band on both the upper and lower sides of the whorls. Type, *E. sublævis*, Ulrich."

The specimens from the Redhill Beds occur only as internal casts or external impressions of the shell, and are generally more or less crushed and distorted. They are the commonest gasteropods on this horizon, and from the examination of a large series of specimens the above description has been drawn up. The characters of the base, umbilicus, and inner lip are always distinct, and the position and peculiarities of the band and surface-markings are clearly preserved on two or three shells.

A comparison with Ulrich's figures and descriptions of American species suggests that our Redhill form is closely allied to *E. canalifera*, Ulrich,[1] and *E. labiosa*, Ulrich,[2] from the Stones River Group of Tennessee. The well-known species generally known as *Trochus ellipticus*, Hisinger, from the Ordovician of Northern Europe is a much more elevated and conical shell with a smaller apical angle. The subgenus of *Pleurotomaria* which has been named by Miss Donald *Palæoschisma*[3] is said to differ from *Eotomaria* in having "a distinct though short slit, instead of a sinus in the outer lip." In the case of our Haverfordwest specimens of *E. Robertsi*, the state of preservation has not permitted me to determine whether a sinus or slit is present, but they differ much more from the type and only species of *Palæoschisma* (*P. girvanense*) in all other observable characters than they do from the above-mentioned species of *Eotomaria*, so that their reference to the latter genus appears fairly certain.

Eotomaria cf. elliptica (Hisinger).

In addition to *E. Robertsi*, a taller, more conical species of *Eotomaria* occurs which, so far as it is preserved, appears to be comparable to the Ordovician form described by Hisinger as *Trochus ellipticus*.[4] One specimen from the Redhill Beds of Prendergast Place has an apical angle of 60°, a height of 18 mm., and a basal width of about 15 mm. The species was believed by Portlock[5] to occur in the Ordovician of Tyrone, but Miss Donald (op. cit., p. 337) declares that it is a distinct species, and she would apparently place Hisinger's shell in her subgenus *Palæoschisma*.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane, Haverfordwest.

Lophospira cf. turrita, Portlock. (Pl. XX, Figs. 6, 6*a*.)

Shell elevated, turreted, composed of about 5 (?) whorls with subangular periphery above middle and rather rapidly increasing in size to base; basal whorl ventricose, high. Apical angle 50°. Upper surface of whorls with one prominent carina about two-thirds the

[1] Ulrich: op. cit., p. 1002, pl. lxix, figs. 9–14.

[2] Ulrich: op. cit., p. 1003, pl. lxix, figs. 15–17.

[3] Donald: Quart. Journ. Geol. Soc., vol. lviii (1902), p. 335, pl. ix, figs. 11, 11*a*.

[4] Hisinger: Leth. Suec., 1837, p. 35, pl. xi, fig. 1. Lindström: Silur. Gastrop. Pterop. Gotland, p. 104, pl. viii, figs. 10–14. Koken: Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. vii (1897), No. 2, p. 152.

[5] Portlock: Geol. Rep. Londond., p. 414, pl. xxxi, fig. 1.

distance from band to suture, and one weaker one nearer the suture. Band peripheral (submedian on upper whorls), rather wide, trilineate with raised linear margins and stronger submedian raised line; lunulæ frequent, rather strong. Outer face of whorls with faint revolving carina below band at about twice its width, and another fainter one at same distance below. On outer and lower surface of basal whorl below the band there are in addition distinct spiral revolving lines regularly and closely placed. Upper surface of whorls crossed by regular, strong growth-lines meeting band at 60°, and continued below it on outer and lower surface of whorls.

Dimensions:

Height	about	18 mm.
Basal width	,,	12·5 mm.

Horizon.—Slade Beds.

Locality.—Lane between Slade Hall and Pelcombe Bridge.

Remarks.—This species, though at present too imperfectly known to merit a distinctive name, undoubtedly belongs to the genus *Lophospira* as defined by Ulrich,[1] and it possesses many points of resemblance to *L. bicincta* (Hall),[2] but the band and carinæ are rather different. It is probably distinct from any British Bala species so far described, though *M. pulchra*, McCoy,[3] seems allied to it. But an examination of the supposed type of *Pleurotomaria turrita*, Portlock,[4] in the Jermyn Street Museum has convinced me that its nearest relation is found in this species, and it may best be compared with it, pending its specific separation.

LIOSPIRA sp. (Pl. XX, Figs. 7, 7*a*.)

Shell heliciform, low, depressed-conical, of 4–5 rounded whorls coiled into a low spire; base convex, rounded; whorls increasing in size rather rapidly to mouth; sutures more or less sunken; apical angle 130° or more; body-whorl higher than spire, with rounded periphery. Band of moderate width, not prominent, subperipheral, situated on body-whorl a little above middle, hidden on other whorls by their overlap. Ornamentation of shell consisting of fine, transverse lines of growth, curved back sharply to meet band, and continued on lower surface of body-whorl (base not well preserved).

Dimensions:

	I.	II.
Height	7·5	5 mm.
Diameter	11·5	8 mm.

Horizons.—Slade Beds (II); Redhill Beds (I).

Localities.—Roadside near St. Martin's Cemetery, Haverfordwest (II); Prendergast Place (I).

Remarks.—The specimens are not sufficiently well preserved to determine the species, but their reference to the genus *Liospira* as defined by Ulrich[5] is indisputable. So far as this form can be

[1] Ulrich: op. cit., pp. 951, 960.
[2] Hall: Palæont. N.Y., vol. i, p. 177, pl. xxxviii, figs. 5*a*–5*f*.
[3] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 294, pl. i*k*, figs. 42, 42*a*.
[4] Portlock: op. cit., p. 413, pl. xxx, figs. 7*a*, 7*b*.
[5] Ulrich: op. cit., pp. 953, 992.

compared with others, we may mention *Pleurotomaria helicina*, Lindström,[1] and especially *Pl. æquilatera*, Wahlenb.,[2] as bearing much resemblance to it.

TROCHONEMA sp.

There is one fairly good but compressed specimen from Upper Slade in Mr. Turnbull's collection which must be referred to this genus. The shell is conical, of 4–5 whorls (only 3 are preserved); the whorls are rather low, with their upper surface more or less flattened and horizontal, their periphery angular and carinate, and their outer face nearly vertical to the suture; the base of the shell is more or less convex and rounded. On the upper surface of the whorls there is a shoulder-like, flat space round the suture; a weak carina separates it from the rest of the upper surface, which is slightly concave. The peripheral carina is strong and prominent, and the outer side of the whorl below it is nearly at right angles to the upper surface, and bears, low down, traces of one or two faint revolving carinæ. The whole surface of the whorls is crossed by coarse, oblique, continuous growth-lines, meeting the peripheral carina at about 45°, and passing over it and over the upper surface of the whorls without deflection. Apical angle of shell 100°–120°. Height about 21 mm.; basal width about 17 mm.

Horizon.—Slade Beds.

Locality.—Quarry at Upper Slade.

Remarks.—This imperfectly-known shell resembles in many respects *T. umbilicatum*, Hall,[3] but the obliquity of the growth-striæ is a distinguishing feature.

ARCHINACELLA PRENDERGASTI, sp. nov. (Pl. XX, Figs. 8, 8*a*, 9.)

Shell subcircular or subelliptical, equally rounded at both ends, convex, rounded, subconical, rather high, with highest point situated subcentrally behind apex; apex submarginal, incurved, sharp, not overhanging margin, but surface of shell below it steep and more or less excavated. Rostral scars large, oval, with traces of a small circular pair behind them and more closely placed together. Muscular band forming small, continuous loop, extending back a little over two-thirds the distance from apex to posterior end. Surface of shell marked by concentric, slightly wavy growth-lines, strongest near margin.

Dimensions (both specimens are somewhat crushed):

	I.	II.
Length	13·50	22·0 mm.
Width	17·30	13·5 mm.
Height	7·75	8·5 mm.

Horizon.—Redhill Beds.

Locality.—Prendergast Place, Haverfordwest.

[1] Lindström: op. cit., p. 124, pl. xi, figs. 34–37.

[2] Lindström: op. cit., p. 111, pl. ix, figs. 20–29.

[3] Hall: Palæont. N.Y., vol. i (1847), pp. 43, 175. Ulrich: op. cit., p. 1047, pl. lxxvii, figs. 1–8.

Remarks.—There are only two specimens of this shell in Mr. Turnbull's collection, and one (No. II) is somewhat laterally compressed and the other rather crushed. But sufficient characters are preserved to show we have to deal with a new species. The character by which the genus *Archinacella*[1] is principally distinguished from *Tryblidium*[2] is the possession of a continuous muscular loop instead of separate pairs of muscles arranged round the shell. The definition of the genus *Archinacella* is given by Ulrich, its founder, as follows (op. cit., p. 821):—"Shell patelliform, ovate to subcircular, usually widest anteriorly, forming a low cone with the apex in front of the centre and often submarginal. Muscular scars forming a continuous band. Surface markings concentric only. Type, *A. powersi*, Ulrich."

A species which seems deserving of comparison with our Redhill form is *A. valida* (Sardeson)[3] from the Trenton Group of Minnesota; and Billings' *Metoptoma simplex*[4] from the Calciferous formation appears to have precisely the same contour and shape.

ARCHINACELLA aff. ROTUNDA, Ulrich. (Pl. XX, Figs. 10, 10*a*.)

There is a smaller and apparently distinct species of *Archinacella* occurring in the Redhill and Slade Beds, which is, however, scarcely sufficiently known at present to warrant a new specific name. It is nearly circular in shape, strongly convex, with the sharp pointed apex vertically above and slightly overhanging the anterior margin; the shell is highest in the middle, and the apex is rather depressed and incurved, being only about half the maximum height of the shell above the margin. No surface-markings are distinguishable. This species appears to resemble Ulrich's *A. rotunda*[5] from the Utica Group of Iowa.

Dimensions :

Length	...	...	5·5 mm.
Width	...	...	5·5 mm.
Height	...	...	3·0 mm.

Horizons.—(I) Redhill Beds; (II) Slade Beds.
Localities.—(I) Redhill Quarry; (II) Quarry at Upper Slade.

BELLEROPHON (SINUITES) CRYPTICUS, sp. nov. (Pl. XX, Figs. 12–14.)

Shell involute, closely coiled, subglobose, sides somewhat flattened, greatest thickness at umbilicus, back narrowly rounded; outer whorl completely embracing and hiding inner whorls, and increasing rather rapidly in size to mouth; umbilicus minute (exposed in casts); section of whorls semi-elliptical to parabolic; aperture higher than wide, not expanded laterally; outer lip thin; inner lip more or less reflexed and thickened; dorsal sinus moderately deep, broadly V-shaped; apertural lobes rounded gently to sinus, where margin is rather suddenly and sharply curved inwards. Surface of

[1] Ulrich: op. cit., p. 828.
[2] Lindström & Angelin: Fragmenta Silurica (1880), p. 15.
[3] Ulrich: op. cit., p. 832, pl. lxi, figs. 14, 15.
[4] Billings: Palæoz. Foss. Canada, vol. i (1865), p. 346, fig. 334.
[5] Ulrich: op. cit., p. 835, pl. lxi, figs. 24, 25.

shell ornamented with rather strong concentric growth-lines and ridges on apertural lobes, and generally with one rather strong, broad constriction a little inside margin of mouth; general surface of shell ornamented with a minute, regular cancellation composed of equal-sized, fine, revolving striæ closely placed and crossed by similar transverse, slightly flexuous striæ.

Dimensions:

Height (average)	...	...	about 20 mm.
Diameter ,,	...	...	,, 8–10 mm.

Horizons.—(I) Redhill Beds; (II) Slade Beds (?).

Localities.—(I) Prendergast Place and Lane; (II) lane near Crundale, and Robeston Wathen.

Remarks.—The specimens of this shell are usually only preserved as internal casts, which are generally somewhat crushed and distorted. In a few instances the aperture and external ornamentation are fairly well seen. It is a rather abundant fossil in the Redhill Beds, but examples in anything approaching a perfect condition are rare.

The close resemblance of this form to the well-known but frequently misunderstood *Bellerophon bilobatus*, Sow.,[1] is obvious, and it undoubtedly belongs to the same group of species, which was named *Sinuites* by Koken (1896),[2] and subsequently *Protowarthia* by Ulrich (1897)[3] in apparent ignorance of Koken's name, the former choosing *B. bilobatus* as the type and the latter *B. cancellatus*, Hall, which has frequently been regarded as identical. Our shells, however, differ from typical examples of Sowerby's species in having a more narrowly rounded back, a less subquadrate section of the whorls, a less broad and less globose shell, a more rapidly increasing outer whorl, and a constriction near the mouth. The fine cancellation of the surface, though not mentioned or figured by Sowerby in his original description of *B. bilobatus*, was observed by McCoy[4] and Salter[5] in specimens which they attributed to that species. Koken's[6] *Sinuites bilobatus*, mut. *macer*, may be identical with our form, but his description is too brief, and no figure has been published. Portlock's *B. bilobatus*,[7] var. *compressus*, is founded on too crushed a specimen to determine its original shape and characters. But his *B. elongatus*[8] closely resembles our Redhill form in shape, though certainly devoid of the peculiar fine cancellation on the surface. Through the kindness of Dr. Kitchin I have had access to Portlock's types, and it is much to be regretted that they are in such a wretched state of preservation that his specific names are practically worthless. Accordingly, I feel

[1] Sowerby: in Murchison's Silur. Syst., p. 643, pl. xix, fig. 13.

[2] Koken: Die Leitfossilien (Leipzig, 1896), p. 392; id., Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. vii (1897), No. 2, p. 117.

[3] Ulrich: op. cit., pp. 848, 867.

[4] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus. (1854), p. 309.

[5] Salter: Cat. Camb. Silur. Foss. Woodw. Mus. (1864), p. 67.

[6] Koken: Die Leitfoss., p. 393; id., Bull. Acad. Imper. Sci. St. Petersb., ser. v, vol. viii (1897), No. 2, p. 118.

[7] Portlock: op. cit., p. 397, pl. xxix, figs. 2*a*, 2*b*.

[8] Ibid., p. 397, pl. xxix, figs. 4*a*, 4*b*.

justified in giving a new specific name to this Haverfordwest fossil, as its characters are well marked, though individual specimens showing all of them are rare.

There can be no doubt that Koken's and Ulrich's groups *Sinuites* and *Protowarthia* are completely synonymous. The earlier classification and group typified by *B. bilobatus*, which Koken proposed in 1889,[1] were abandoned by him in 1896 and rejected by Ulrich in 1897. Koken's subsequent definition of *Sinuites* is much shorter than that given by Ulrich for *Protowarthia*, and he is doubtful about the distinction of the species which he mentions. The diagnosis is as follows:—"Mündung mit breiter Bucht, die kein Schlitzband hinterlässt. Nabelgegend mit nach vorn abgegrenzter Runzelschicht. Aussenseite der Windungen innerhalb der Mündung mit derben Runzeln. Nabel verdeckt. *Bellerophon bilobatus*, Sow." Ulrich defines *Protowarthia* as follows:—"Aperture large, but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus, but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striæ. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl, and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. Type, *Bellerophon cancellatus*, Hall." The ornamentation of *B. cancellatus*[2] is indistinguishable from that of our form, but Ulrich denies that this species is identical with *B. bilobatus*, Sow., and considers that his *Protowarthia obesa*[3] should rather be compared with it.

BELLEROPHON (?) MULTIRUGATUS, sp. nov. (Pl. XX, Figs. 11, 11*a*.)

Fragments of a large *Bellerophon*-like shell occur in the Redhill Beds of Prendergast Place and Mill Lane with peculiar characters which mark it off from all the other species. The shell seems to be involute, with the outer whorl embracing the inner ones and the umbilicus absent or minute; the back is broad with a low but distinct carina, but apparently no slit-band; the outer whorl enlarges rapidly towards the mouth, which is transversely expanded and has a reflexed inner lip. The margin of the mouth is not preserved, so that the sinus, if present, cannot be seen. The shell is specially remarkable for its ornamentation, which consists of regularly-arranged, strong, subequal, rounded to subangular, broad, transverse ribs, separated by shallow grooves of the same width. These ribs curve backwards towards the keel, over which they pass without interruption, the opposite ones uniting in a broad V enclosing an angle of about 150°. The ribs die out on the expanded margins of the mouth, and are weaker on the lower sides of the whorls. Fine, spiral, revolving, equidistant striæ cross the

[1] Koken: Neues Jahrb. f. Mineral., Beil., Bd. vi (1889), p. 377.
[2] Hall: Palæont. N.Y., vol. i (1847), p. 307. Ulrich: op. cit., p. 872, pl. lxiii, figs. 1–14.
[3] Ulrich: op. cit., p. 874, pl. lxiii, figs. 45–47.

ribs parallel to the keel, but become sinuous, broken, and irregular near the mouth. The shells are mostly crushed, but must have reached a rather large size, some measuring 50–70 mm. across the mouth. The true position and affinities of this form are doubtful.

Bellerophon (Bucanopsis) secundus, sp. nov. (Pl. XX, Figs. 15, 15*a*.)

Shell subglobose, with broad, rounded back; of few volutions; whorls transversely subquadrate in section, broader than high; umbilicus moderately large, deep, with subangular margins, exposing inner whorls; aperture transverse, more or less expanded; inner lip reflexed on inner end of last whorl; band rather broad, with narrow, raised margins, not depressed, with fine, gently curved lunulæ; surface of shell on each side of band marked with rather strong, regular, straight, parallel, subequal, revolving raised lines, about 24 in number, closely crowded near band, but becoming more widely separated laterally, crossed at right angles by very fine, transverse, slightly wavy striæ.

Dimensions.—Height about 15 mm.

Horizon.—Redhill Beds.

Localities.—Prendergast Place and Lane.

Remarks.—The true generic position of this species in Ulrich's classification seems to be in *Bucanopsis*.[1] But our specimens are so crushed and distorted that it is upon the characters of the ornamentation and slit-band that we must chiefly depend; and these are sufficiently definite and important to mark the species.

The term *Bucania* is employed by Ulrich in a much more restricted generic sense than Hall originally intended, and than later authors (Waagen, Koken, etc.) have used it, and some of the species now placed in *Bucanopsis* have been included in it by them. Ulrich points out that in *Bucanopsis* the spiral surface-markings are straight and parallel with the direction of the whorls, while in *Bucania* sens. str. they are wrinkled, interrupted, and more or less oblique in direction. He would provisionally include in *Bucanopsis* all the Palæozoic spirally striated shells which agree in other respects with *Bellerophon*. The type is *B. carinifera*, Ulrich, from the Trenton Group.[2] The full definition of the genus is as follows: "Shells agreeing in all respects with *Bellerophon*, excepting that their surfaces are cancellated by regular, revolving, and transverse striæ. The volutions enlarge rapidly, giving a broadly expanded aperture; the umbilicus is of moderate size, and may be closed entirely, while the inner lip is always somewhat thickened. The revolving lines are never oblique nor wrinkled."

Our Redhill species may be compared with the type species, which is the only Ordovician form previously known; but the band appears to be less prominent and the back broader, and the spiral lineation slightly different.

[1] Ulrich: op. cit., pp. 853, 922.
[2] Ulrich: op. cit., p. 925, pl. lxii, figs. 56–61.

CONRADELLA (?) sp. (Pl. XX, Figs. 5, 5*a*, 5*b*.)

There is a small shell occurring in some abundance in the Slade Beds of Upper Slade which may possibly belong to the genus *Conradella* established by Ulrich,[1] but its state of preservation is not quite satisfactory. It seems to consist of a few rapidly enlarging whorls coiled in the same plane, like *Cyrtolites*; the whorls are higher than wide and more or less sharply carinated on the back, below which they are somewhat compressed, swelling out to their maximum diameter near their middle. The keel appears to carry a slit-band crossed by rather distant, strong lunulæ. The ornamentation consists of rather coarse, raised, fimbriated lines, equidistant and equal in size, and connected by less prominent, short, straight lines at right angles to them and alternately arranged, so as not to form true revolving spirals. No other details can be made out. The ornamentation recalls that found in *C. Dyeri*, var. *cellulosa*, Ulrich,[2] and the shape is apparently similar. The height of our little shells averages about 6 mm.

Horizon.—Slade Beds.

Locality.—Upper Slade, Haverfordwest.

EXPLANATION OF PLATE XX.

FIG.

1. *Eotomaria Robertsi*, sp. nov. Impression of exterior of shell. × 2. Redhill Beds, Prendergast Place, Haverfordwest.

2. Ditto. Side view of internal cast of another specimen. × 1½. Same horizon and locality.

2*a*. Ditto. Base of same specimen. × 1½.

3. Ditto. Base of another specimen, showing reflexed lip. × 1½. Same horizon and locality.

4. Ditto. Internal cast of a young individual. × 4. Redhill Beds, Prendergast Mill Lane.

5. *Conradella* (?) sp. × 4. Slade Beds, Quarry at Upper Slade.

5*a*. Ditto. Transverse section through shell.

5*b*. Ditto. Portion of surface of same specimen enlarged to show ornamentation. × 8.

6. *Lophospira* cf. *turrita*, Portlock. × 2. Slade Beds, lane between Slade Hall and Pelcombe Bridge.

6*a*. Ditto. Band of same specimen enlarged. × 5.

7. *Liospira* sp. × 2. Redhill Beds, Prendergast Place, Haverfordwest.

7*a*. Ditto. Same specimen, viewed from above. × 2.

8. *Archinacella Prendergasti*, sp. nov. Top view. × 1½. Redhill Beds, Prendergast Place.

8*a*. Ditto. Side view of same specimen. × 1½.

9. Ditto. Another specimen, laterally compressed. × 1½. Same horizon and locality.

10. *Archinacella* aff. *rotunda*, Ulrich. Top view. × 3. Redhill Beds, Redhill Quarry.

10*a*. Ditto. Side view of same specimen. × 3.

11. *Bellerophon* (?) *multirugatus*, sp. nov. Crushed and distorted specimen. × 1½. Redhill Beds, Prendergast Mill Lane.

11*a*. Ditto. Portion of back of same specimen enlarged to show ornamentation. × 4.

[1] Ulrich: op. cit., p. 904.

[2] Ulrich: op. cit., p. 910, pl. lxvii, figs. 27–29.

12. *Bellerophon* (*Sinuites*) *crypticus*, sp. nov. Side view of internal cast. × $1\frac{1}{2}$. Redhill Beds, Prendergast Place.
12*a*. Ditto. Dorsal view of same specimen. × $1\frac{1}{2}$.
13. Ditto. Another specimen, showing apertural margin and reflexed lip. × $1\frac{1}{2}$. Same horizon and locality.
13*a*. Ditto. Portion of surface of same specimen enlarged to show ornamentation. × 5.
14. Ditto. Portion of another shell, showing apertural margin and dorsal sinus. × $1\frac{1}{2}$. Same horizon and locality.
15. *Bellerophon* (*Bucanopsis*) *secundus*, sp. nov. Dorsal view of imperfect specimen. × $1\frac{1}{2}$. Redhill Beds, Prendergast Place.
15*a*. Ditto. Portion of back of another specimen enlarged, showing band and ornamentation. × $1\frac{1}{2}$. Same horizon. Prendergast Mill Lane, Haverfordwest.

IV.—On a Section of Middle and Upper Lias Rocks near Evercreech, Somerset.

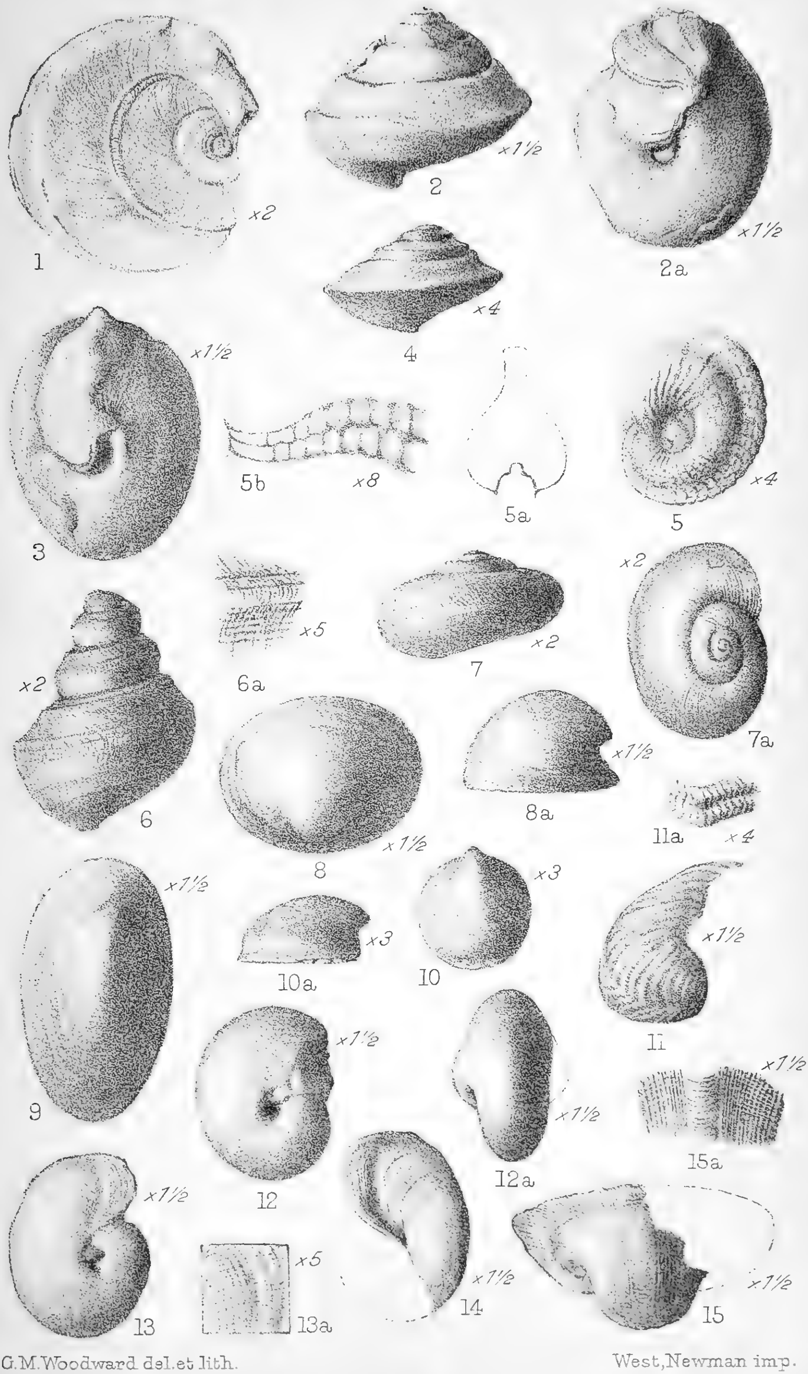
By L. Richardson, F.G.S.

During a brief survey of the Inferior Oolite in the neighbourhood of Doulting, Somerset, in 1905, I visited a disused quarry on the hill a mile and a half north of Evercreech, and situated where the boundary-line between the Inferior Oolite and Midford Sands is shown on the Geological Survey Map, Sheet xix. I was surprised to find that instead of the somewhat massive rock exposed in the quarry being Inferior Oolite, it was Marlstone, capped with Upper Lias clays and limestones. Since the section is becoming rapidly overgrown, it appears desirable to record the details obtained for the benefit of those who will survey the district in the future for the New Series Maps.

Quarry near Evercreech.

			ft.	ins.	
Upper Lias (Toarcian).		1. Clay, brown and bluish.			
	bifrontis.	2. Limestone, dark-green, earthy, with dark-yellow specks resulting from the decomposition of the ferruginous granules ...	1	4	*Hildoceras bifrons* (Brug.), *Dactylioceras* cf. *Hollandrei*, Wright, *non* D'Orb., *Rhynchonella* cf. *jurensis* (Quenstedt), and *Pecten substriatus*, Roemer.
	falciferi.	3. Limestone, brownish-grey, with a few ferruginous granules 2 in. to 6 in.	0	4	
		4. Clay, dark-purplish ... about	1	6	
		5. Limestone, brownish-grey, somewhat earthy, but hard in places, devoid of ferruginous granules	0	$2\frac{1}{2}$	*Polyplectus capellinus* (Quenstedt), *Cryptaulax scobina*? (Deslongchamps).
		6. Clay, grey and brown	0	4	
Middle Lias (Pliensbachian).	*spinati.*	7. Limestone, pale-brown, ironshot	0	3	*Paltopleuroceras spinatum* (Brug.).
		8. Clay, brown	0	3	
		9. Limestone, hard, dark, ironshot, top layer crowded with belemnites ... ... (seen)	10	0	*Belemnites paxillosus*, Schlotheim, *Terebratula punctata*, Sow., *Rhynchonella tetrahedra* (Sow.), *Cypricardia pellucida*, Moore (= *C. intermedia*, Moore).

I am indebted to Mr. S. S. Buckman for approximately identifying the ammonites. The precise date of beds 3 and 4 could not be



G. M. Woodward del. et lith. West, Newman imp.

Ordovician Gastropoda from Haverfordwest.

ascertained, but the limestone-band agrees in lithic structure with bed 5 rather than with 2, hence I have provisionally grouped it with the *falciferum*-deposits. The clay overlying the rock of *spinati* hemera occupies the stratigraphical position of the *acutum*-bed.

On the Geological Survey Map the Middle Lias is shown to occupy a narrow zone on both sides of the valley running north from Batcombe; but westwards, in the neighbourhood of Chesterblade, it was thought to be overlapped by the Midford Sands; in other words, that the 'Sands' rested directly and non-sequentially upon the Lower Lias. This, however, is not the case: the Marlstone is well-developed, but how much farther north it extends I was unable to find out. Probably in that direction the Middle Lias is overlapped by the Upper Lias clays, and these in turn by the Inferior Oolite.

In considering the geographical distribution of the component beds of the Liassic and Inferior-Oolite Series, it is necessary to bear in mind that in tracing the beds from south to north we are approaching a tract of country, the Mendips, along which (there is ample evidence) movements of subsidence and elevation have occurred time after time. Beds may have been deposited, uplifted, and partially or wholly eroded. Thus, although the Marlstone is present in this quarry at Mays Down, a mile and a half to the north of Evercreech, it by no means follows that it extends as far north as Doulting. It may be present there; or it may have been deposited, elevated, and removed. Likewise with the Midford Sands. In the railway-cutting at Doulting, the peculiar conglomeratic limestone forming the base of the Inferior Oolite rests directly upon bluish, micaceous, and arenaceous clays, from which water is thrown off. Thus there is no deposit there worthy of the name of 'Sands.'

REVIEWS.

I.—The Dead Heart of Australia: A Journey around Lake Eyre in the Summer of 1901–1902, with some account of the Lake Eyre Basin and the Flowing Wells of Central Australia. By J. W. Gregory, D.Sc., F.R.S., F.G.S., Professor of Geology in the University of Glasgow. 8vo; pp. xvi and 372, with 38 illustrations and maps. (London: John Murray, 1906. Price 16*s*. net cash.)

PROFESSOR GREGORY has just presented us with a most interesting volume of travels in the interior of Australia, dealing with the geology and physical geography of the Lake Eyre region, and giving most graphic and lively descriptions of the 'Aboriginee' at home. Those who recall the author's African experiences as given in his history of "The Great Rift Valley"[1]

[1] See Geol. Mag., 1896, Dec. IV, Vol. III, pp. 324–327, Pl. XI.

(1896) will enjoy the perusal of this new book with even greater pleasure than the last.

The Australian Continent may be not unfitly compared to the trunk of one of those 'Giant trees' of the Sierra Nevada, or the equally colossal 'Australian gum-trees,' whose age may be reckoned by at least twenty centuries, their centre dense and almost inanimate, but the periphery alive and growing still, receiving beneath its bark a ring of new tissue year by year.

Once the centre of the great Australian Continent throbbed with the vigorous circulation of youth; animals abounded over its vast and well-wooded plains: now all is arid and apparently waterless; only along its external border do we find that energetic display of vitality which marks the living world. Its heart, like that of the great *Sequoia* or the giant *Eucalyptus*, has, seemingly, almost ceased to pulsate; but down, deep down, beneath the surface of its dried-up plains, vast springs of sweet waters exist, and may still be reached, like the invisible sap-flow of the 'big trees,' rich in stored-up supplies of life-giving energy, which need only to be touched, as was the stony rock of old—not by the magic rod of any modern water-finding Moses, but by the practical, intelligent 'artesian well-borer'—to make it overflow at the surface, and bring back again abundant vegetation and animal life to its now arid and deserted plains.

Let us, however, make way for the author, and he will tell us in his own words "how the 'Kadimakara' came down from the skies." The story is delightful, and has all the freshness of novelty to recommend it:—

"According to the traditions of some Australian aborigines, the deserts of Central Australia were once fertile, well-watered plains. Instead of the present brazen sky, the heavens were covered by a vault of clouds, so dense that it appeared solid; where to-day the only vegetation is a thin scrub, there were once giant gum-trees, which formed pillars to support the sky; the air, now laden with blinding, salt-coated dust, was washed by soft cooling rains, and the present deserts around Lake Eyre were one continuous garden.

"The rich soil of the country, watered by abundant rain, supported a luxuriant vegetation, which spread from the lake-shores and the river-banks far out across the plains. The trunks of lofty gum-trees rose through the dense undergrowth, and upheld a canopy of vegetation, that protected the country beneath from the direct rays of the sun. In this roof of vegetation dwelt the strange monsters known as 'Kadimakara' or 'Kadimerkera.'

"Now and again the scent of the succulent herbage rose to the roof-land, and tempted the inhabitants to climb down the gum-trees to the pastures below. Once, while many Kadimakara were revelling in the rich foods of the lower world, their retreat was cut off by the destruction of the three gum-trees which were the pillars of the sky. They were obliged to roam on earth, and wallow in the marshes of Lake Eyre, till they died, and to this day their bones lie where they fell. After the destruction of the gum-trees the small holes in the forest-roof increased in number and size, until they touched one another, and all the sky became one continuous hole; wherefore the sky is called 'Puri Wilpanina,' which means 'Great Hole.'

"At times, when the country is wasted by prolonged drought, or the floods from the Queensland hills lie too long upon the hunting-grounds, the aborigines make pilgrimage to the bones of the Kadimakara. There corroborees are held, at which blood sacrifices are offered and dances performed to appease the spirits of the dead Kadimakara, and persuade them to intercede with those who still dwell in the sky and control the clouds and rain.

"This legend is part of the folk-lore of the Dieri, a tribe found in the country along Cooper's Creek, eastward of Lake Eyre. The same legend is told by other tribes in the same district of Central Australia, with variations in the form of names and in other details. It may have arisen as a pure fiction, invented by some imaginative, story-telling native, to explain why large bones are scattered over the bed of Cooper's Creek. It may, on the other hand, be a shadowy reminiscence of the geographical conditions which existed in some distant ancestral home of the aborigines, or of those which prevailed in Central Australia at some remote period.

"What geographical conditions, it may be asked, could have given rise to such a legend?

"To the dweller in the open down or moorland, the idea that the vault of heaven could be upheld by trees, or that the open, transparent sky could support heavy animals of flesh and bone, seems the idlest fancy. But to a man who knows the tropical forest, it appears inevitable that the first attempts by primitive forest-people to explain the world around them must closely follow the lines of the Kadimakara legend.

"If the pygmies of the East African forests have any theory of the limited universe known to them, they probably regard it as a two-storied structure in which they occupy the lower floor. They live in a jungle of bamboos and dense undergrowth, while high above them is a thick, felted layer of foliage and creepers, upheld by the trunks of lofty junipers, which rise straight to a great height before they branch. The tangled layer of vegetation overhead deprives the natives of any knowledge of the world above the tree-tops. They are covered by a sheet as opaque and as continuous as a roof slightly out of repair. In that roof live monkeys and birds and beasts, that never descend to the ground below; while the animals that live and move and have their being in the undergrowth are equally cut off from the world above. The primitive hunter has some slight knowledge of the jungle roof above him. He hears the harsh halloa of the colobus, the shrill cry of the birds when they fall a prey to snakes or monkeys; his keen eye can detect the prized fur of the colobus despite its close resemblance to the long, hanging masses of grey bearded lichen that drape the black branches of the trees. But the dweller in the underlying jungle knows nothing of the region above the tree-tops. In the dry season, when the forest is not covered in mist, he may see the stars slowly crossing the holes in the roof; but he knows nothing of their distance, and probably thinks of them only as fire-flies with an unusually slow and steady flight. The roof above him is his highest heaven, which supplies him the rain that drips heavily from the sodden foliage. The occasional fall of a dead bird or a monkey is to him as much a gift from the gods as were the sky-stones that supplied the Siberians and Eskimo with iron. The change from the dark of night to the dull gloom that pervades the lower forest at midday is clearly due to some change in or above the roof. But the forest-dweller has no clue to distance, so he flattens the whole universe above him into one solid floor, supported by the tree-trunks, just as the Greeks projected all the star-zones into one solid firmament.

"Those who interpret the Kadimakara legend by the light of a knowledge of tropical forests, naturally see in it either a reminiscence of the time when the geographical conditions of Central Australia were different from those that prevail at present, or a reminiscence of the country whence the aborigines migrated to Australia. If, therefore, the geologist can determine whether the bones of the extinct monsters of Lake Eyre[1] correspond to those described in the aboriginal traditions, he can throw light on several interesting problems. If the legends attribute to the extinct animals characters which they possessed, but which the natives could not have inferred from the bones, then the legends are of local origin. They would prove that man inhabited Central Australia at the same time as the mighty *Diprotodon* and the extinct giant kangaroos. If, on the other hand, there is no such correspondence between the legends and the fossils, then we must regard the traditions as due to the habit of migratory peoples of localising in new homes the incidents recorded in their folk-lore.

"The geologist may therefore hope to help the student of the Australian aborigines by explaining some of their traditions, by throwing light on their migrations, and by showing the date of their arrival in Australia."

Part ii (pp. 17–142) of Dr. Gregory's book is devoted to the narrative of the expedition, which gives the reader a very good insight into desert travelling with camels and native guides, and the joys and sorrows of dust- and rain-storms, water-holes, and soakages, and the finding of *Diprotodon* bones, etc., also some excellent traits in character amongst the natives.

Part iii (pp. 145–267) gives us an interesting description of the Lake Eyre Basin, "The Dead Heart of Australia," the charm of desert life, a good deal about the 'Aboriginee' of Lake Eyre, and how the present condition of the lake has come to pass.

Part iv (pp. 271–352) treats of the chances of the revival of the 'Dead Heart' of Australia, of its subterranean waters, the nature of flowing wells, the great east-central artesian basin, why the water rises in the Australian wells, and many wise observations, based on careful geological study; much also as to the error (common throughout the country) of assuming the *permanent* nature of the

[1] The *Diprotodon*, the giant species of kangaroos, and the *Genyornis*.

supply from artesian sources, and the danger consequent upon the present wanton waste of such water at the surface. A chapter is devoted to the gigantic proposal to flood Lake Eyre from the sea; but a few carefully prepared statements given (on p. 347) by Mr. A. S. Kenyon, Sir Charles Tod, and others, show the futility of such an attempt, at least so far as human agency is concerned. At p. 148 Dr. Gregory gives us an epitome of the changes that must have taken place in this inland sea basin.

The region of Lake Eyre in Secondary (Jurassic) times must have been slowly sinking till it was flooded by the sea, which steadily encroached from the Gulf of Carpenteria in the north to Stuart's Creek and Lake Torrens in the south.

The sea subsequently retreated, and the great basin of Central Australia again became land. A great uplift then occurred in Eastern Queensland. The sea, after withdrawing from Northern Australia, began to encroach upon the south, covering much of what are now the coast lands of South Australia and Victoria, and extended in gulfs thence far inland, especially up the Murray, so that the Darling, the Murrumbidgee, and the Hume entered the sea as independent rivers.

The earth-movements which followed impressed upon South Australia its main existing geographical features. The great valley of South Australia was formed. The lower part of this valley foundered beneath the sea and formed Spencer's Gulf, the northern became the long basin of Lake Torrens.

The Lake Eyre country also began again to sink, till the lake-margin was, as now, thirty-nine feet below sea-level. Previously the rivers, which now flow towards Lake Eyre, flowed south-eastward to the Darling or had an independent course to the sea, which then ran up the Murray River. As the depression of Lake Eyre continued, the Cooper and the Diamantina were diverted to its basin, where they accumulated as a vast inland sea. Round such a sheet of water there must have been a heavy dew, and probably also the rainfall was considerable, for the adjacent steppes were well grassed and fertile, and large trees—now represented by their petrified trunks—grew on the plains. The water of this lake was fresh . . . . and was probably at least three times the size of its present bed, and on its shores lived many giant kangaroos, giant wombats, as well as wallabies, bandicoots, and marsupial rats.

Crocodiles swarmed in the lake and its estuaries, and preyed upon the primitive Queensland mudfish (*Ceratodus*) and on huge bony fish, all of which have long since disappeared from the waters of the Lake Eyre basin. This condition of affairs did not endure. The rainfall dwindled, the water-level sank, and the lake decreased in size; the discharge from the lake could no longer keep open its channel, and Lake Eyre lost its outlet; its waters were henceforth removed by evaporation; the mineral matters carried into the lake by the rivers were concentrated until the waters became salt, and the fish and crocodiles were all destroyed. As the lake shrank in area, less and less rain fell upon its shores; the vegetation withered; the once green succulent herbage was replaced by dry spiny plants; the giant marsupials died of hunger and thirst; hot winds swept across the dusty plains, and the once fertile basin of Lake Eyre was blasted into desert (p. 151).

As to the flooding of Lake Eyre, the distance to Port Augusta (at the head of Spencer's Gulf) is 260 miles, and the surface of Lake Eyre is 39 feet below sea-level; this would give a fall of one inch and a fifth to the mile to a canal, so that the water would doubtless flow through such a channel. It is the enormous loss by evaporation which offers the most insuperable obstacle to any project for the improvement of this great area.

"The quantity of water carried into Lake Eyre by the Diamantina and the Cooper is enormous. The Diamantina rushes along like a mill-race; the Cooper flows in a broad sheet, in places twelve miles wide; and both rivers sometimes flow for months. Nevertheless, though the southern part of Lake Eyre frequently holds water, no man has yet seen the lake either full or nearly full. And if these two large rivers cannot fill Lake Eyre basin, a sluggish fifty feet wide canal would be as successful as a Melbourne water-cart trying to induce one of its broad thoroughfares to lie quiet in a dust-storm" (p. 349).

We should like to give our readers a specimen of the author's vivid descriptions of the Australian natives; space does not, however, admit; but they must certainly get the book and read about the so-called 'Aboriginee.' We feel sure that those who take up Dr. Gregory's book will not lay it down again until they have read it through, and that they will enjoy it in the process as thoroughly as we have done.

II.—Geology: Processes and their Results. By T. C. Chamberlin and R. D. Salisbury. pp. xix and 654, with 24 plates (maps) and 471 text-figures. (London: John Murray, 1905. Price 21*s.* net.)

THE first volume of this new Textbook of Geology by Professors T. C. Chamberlin and Rollin D. Salisbury, of the University of Chicago, strikes us as a serious and conscientious attempt to grapple with the first principles of earth-knowledge in its entirety, and the attempt has been as successful as any such comprehensive attempt can expect to be. Everything is classified and well ordered, and the essence of the available information on the various branches of the subject is condensed into pithy generalized statements with only just sufficient exemplification to illustrate the argument. Everywhere we are made to feel that the work is the product of men with a practical grasp of their material, who have striven to express in their own way all that they have learnt. Therefore this is not a textbook made in the too frequent way, "as apothecaries make new mixtures, by pouring out of one vessel into another." We find in consequence that even when the authors lead us over familiar ground we are frequently brought to fresh view-points. It must be admitted, however, that sometimes the new aspect has no particular advantage over the old, and indeed is less impressive. For the matured geologist the discussion of difficult problems by the method of "multiple hypotheses," elsewhere advocated by the senior author and here adopted, has many advantages; but it may be doubted whether the method will commend itself to the geologist in the making, for whom a single aspect of an uncertain question is usually more than sufficient. The book, in fact, possesses the characteristic of much American geological literature, in uniting a mass of simple elementary matter with discussions that demand wide-reaching knowledge of the facts of the science for their proper appreciation. As the authors state, however, that while the work is intended primarily for mature students, it has been framed also for the reader without systematic antecedent knowledge of the subject, the combination of elementary and advanced material is, in this case, unavoidable. Some of the problems raised in the book—as, for example, the discussion of the original composition and internal structure of the earth and its relation to the origin of the igneous rocks and volcanoes; that relating to the geological history of the atmosphere; and that dealing with the physics of glacier-movement—embody recent views of the senior author which necessitate considerable modifications in the prevalent conceptions of geological physics. Into these abstruse questions we shall not venture to enter, but we heartily commend them to the attention of philosophical geologists, who will find them conveniently brought together and summarized in this book. All that we can attempt is briefly to indicate the contents of the volume.

The work begins boldly with a "Preliminary Outline" (chap. i, pp. 1–19), which, under the heading of "Astronomic Geology," starts by considering the earth as a planet, with a discussion of the astronomical conditions that may have produced geological effects. Next, under "Geognosy," the atmosphere, hydrosphere, and lithosphere are successively outlined, their relative proportions illustrated by some striking numerical data, the relation of the ocean basins to the land-surfaces discussed, and the origin of the rock-masses tersely indicated. In chap. ii (pp. 20–52), dealing with "The Atmosphere as a Geological Agent," the work of the wind is fully considered, along with other atmospheric effects, including even the occasional influence of lightning.

Then follows the longest and most richly illustrated chapter in the book (chap. iii, pp. 53–201), on "The Work of Running Water," wherein all the recent ideas with respect to physiographic development are conveniently brought together and supported by appropriate examples from all parts of the United States. The broad generalizations on this subject are illustrated by some geometrical and other designs (figs. 45–51) of remarkable aspect, that look as though they had wandered out of textbooks of crystallography and biology. In the next chapter (iv, pp. 203–231) "The Work of Ground- (Underground) Water" receives treatment, the solvent and other effects of such waters being duly considered.

The chapter (v, pp. 232–308) on "The Work of Snow and Ice" contains much information that has not hitherto filtered into geological textbooks, and is embellished, both pictorially and verbally, with the results of the authors' personal observations in North Greenland. We note that the thickness of the Greenland ice-dome at its centre is estimated at 5,000 feet or more, and we recommend the statement to the attention of the writer in this Magazine (March, 1906, p. 120) who has recently, on hypothetical grounds, revived the idea that ice cannot attain a greater thickness than about 1,600 feet. The discussion of the physics of ice-movement in this chapter contains much new and suggestive matter.

"The Work of the Ocean" is dealt with in chap. vi (pp. 309–374), and this, we think, is one of the weaker chapters of the book. In adhering to their plan of selecting pictorial illustrations chiefly from American sources, the authors fall back upon examples from the beaches and cliffs of the great lakes, although these are not marine and lack the essential feature of a tidal flat. But it is indeed remarkable how small is the proportion of sea-cliff in the coastline of the United States.

The account of "The Origin and Descent of Rocks" in chap. vii (pp. 375–462) covers a very wide range, and contains some original features. Divided like the rest into numerous sections, subsections, and titled paragraphs, it begins with an outline of the chemical conceptions regarding rock-structure and molten magmas, and next discusses the varied products derived from these magmas by cooling under different conditions. In describing the "general names"—greenstone, trap, basalt, etc.—that may be applied to igneous rocks, it is stated that the name 'trap' "refers to the step-like arrangement which the edges of the superimposed sheets of lava often take" (p. 399), but this statement as it stands seems somewhat misleading, as it might be taken to imply that the step-like arrangement in question was originally present, instead of being, in most cases, produced during subsequent denudation.

The 'secondary' (a somewhat ambiguous term for the 'sedimentary') rocks are then dealt with; after which we are led to the consideration of the 'internal alterations' of rocks, especial attention being given to 'carbonation and decarbonation,' to which processes one of the authors, as is well known, ascribes wide-reaching results. The processes as a whole are classed as 'descensional' and 'reascensional,' the former being those concerned in the breaking down of rocks, and the latter those concerned in their renovation. An outline is then given (in smaller type) of the new system of rock-classification and nomenclature proposed by American petrographers, and the chapter ends with a discussion of ore-deposits. As the book is remarkably free from printers' errors, we may call attention, in passing, to "the surface-water shave" on p. 459.

The chapter (viii, pp. 463–501) on "Structural (Geotectonic) Geology" does not particularly impress us, and seems to lack balance. For example, the abnormally symmetrical calcareous concretions, though very curious and though beautifully illustrated in figs. 371–373, are not of sufficient geological consequence to deserve the two pages of the textbook devoted to them, and the same remark applies to the septarian nodules, figs. 375–377, while such an important feature as the igneous dyke is illustrated by a sand-filled fissure which is not a true dyke.

In the statement on p. 478—"Since the strike is always at right angles to the dip, the strike need not be recorded if the direction of dip is. Thus dip 40°, S. 20° W. is the same as dip 40°, strike W. 20° N."—it seems to be forgotten, in the last sentence, that the dip may be away from the strike-line in two directions. The definition of an isoclinal fold takes the form of a simple reference to a figure (fig. 393), which shows the beds folded vertically—surely a misleading and insufficient definition for the student! We thought that the term 'pitch' had been introduced and adopted in America to express the inclination of the crests and troughs of folds; but we find on p. 483 that a circumlocution, introducing the word 'plunging,' is used in this sense.

In the next chapter (ix, pp. 502–562) on "The Movements and Deformations of the Earth's Body (Diastrophism)" the authors again take a stimulative plunge into the philosophical aspects of the science. Earthquakes and their effects are discussed at some length; and then the 'slow massive movements' are brought under consideration, including the 'nearly constant small movements' or gentle warpings, the 'great periodic' or 'mountain-forming' movements, and the 'plateau-forming' and 'continent-forming' movements. Some suggestive ideas are broached in comparing the relative values and effects of these various deformations; and then we are carried deeply into hypothetical physics in speculating upon the causes of movement and the probable condition of the earth's interior. In this, and in the following chapter (x, pp. 563–607) on "The Extrusive Processes," free play is given to the method of 'multiple hypotheses' already alluded to; and among these hypotheses the theory of the growth of the earth by solid accretion, recently brought forward by the senior author, receives full consideration and leads to the introduction of some novel ideas, whose appraisement must be left to the physicist. He will be a tough student, and far removed from the average hammer-wielder, who shall set himself conscientiously to fathom the profundity or otherwise of these speculations.

The discussion of terrestrial vulcanism (with a side-glance at the mountains of the moon) includes a description of the different types of eruptive activity and their products; and it closes with a review of seven different hypotheses, arranged under two leading assumptions, as to the origin and mode of extrusion of lavas and their accompanying gases, the theory of accretion here receiving further development.

The final chapter (xi, pp. 608–641), dealing with "The Geologic Functions of Life," embraces a brief statement of Professor

Chamberlin's views regarding the probable fluctuations of atmospheric composition, especially in the proportion of carbon dioxide, during geological time and their effect upon climate. It also touches suggestively upon the material results of the 'mental element' in modifying the earth's surface, regarding which it is noted that "man may well be regarded not only as a potent geological agent, but as dangerously so to himself" (p. 619). The contributions of the various branches of the vegetable and animal kingdom to the geological record are set forth; and the book ends with some philosophical remarks upon the evolution, distribution, and mutual relations of organisms.

The trilobites seem to be special favourites of the authors:—"These were probably the most highly developed organisms of their times, and give the clearest hints of the stage of psychological and sociological development that had been reached when first the record of life is opened to us" (p. 632).

The authors have evidently spared no pains in the preparation of the book, which is clearly and carefully written throughout, though the style becomes somewhat ponderous and didactic at times. There is a marked absence of American idioms, and even the American methods of spelling are not obtrusive. We note, however, in at least two places, the discredited usage of 'phenomenal,' which should not occur in scientific literature. The illustrations are very numerous, well selected, and beautifully printed; and although many of them have appeared before in American geological literature, they bring a sense of breadth and freshness to the British reader wearied with the time-worn clichés of his native land. But the book is of the densest paper, and so uncomfortably heavy that even its strong neat binding cannot be expected long to stand the strain. With its two succeeding volumes of equal or still greater weight, we fear that, muscularly, the student will sometimes find the trio to be a weary load.

III.—The Coal Deposits of Batan Island, with Notes on the General and Economic Geology of the adjacent region. By Warren D. Smith, B.S., M.A., Geologist, Mining Bureau. Bulletin No. 5, Department of the Interior: The Mining Bureau, Manila. 8vo; pp. 56, and 21 plates (maps, sections, photomicrographs of rocks and fossils). (Manila: Bureau of Printing, 1905.)

THE occurrence of coal deposits in the Island of Batan, as well as in the Philippines generally, has already been referred to by Mr. George F. Becker in his comprehensive "Report on the Geology of the Philippine Islands," published at Washington in the 21st Annual Report of the United States Geological Survey, during 1901. More detailed work has now been accomplished in Batan Island, and Mr. Warren D. Smith is to be congratulated on the very complete manner in which he has surveyed that particular area and the region immediately surrounding it. The account he presents to us in this report includes some geographical remarks bearing upon the climate, vegetation, population, hydrography, etc. On the economic subject, particulars are given of the history of the district; the coal-seams as they occur at Liguan, Chifladura, Bilbao, and Batan; the present methods of mining, cost, labour, etc.; exploratory work on military reservation; and the classification and value of the Batan coals. Then the author passes on to a description of the general geology of the district, comprising observations on Batan Island, Rapurapu Island, Caeraray, and San Miguel, and the adjacent coast of Albay Luzon, which is followed by a more detailed statement respecting the geology of Batan Island in connection with its igneous base, the iron formation and its origin, the coal-measures, the limestone series, and the Galicia sandstones and shales. Finally, a chapter on the palæontology of Batan Island adds a further interest to the work. Three or four sets of limestone have been observed in the island rising to 1,330 feet above sea-level and 345 feet below the level of the sea: the lowest is bluish-grey and contains coral fragments, the next is more regularly bedded but with fewer fossils, whilst an uppermost limestone occurs above the coal-measures at Bilbao on Mount Bilbao and has yielded some fossils. From the highest to the lowest these limestones are said to be of coralline character, containing forms almost identical with living species. The bluish-grey material is full of Foraminiferal remains, particularly *Operculina complanata* and a Bryozoan resembling *Cellepora formosensis* of Newton & Holland (Journ. Sci. College Imp. Univ. Tōkyō, Japan, 1902, vol. xvii, article 6, pls. ii–iv, p. 6), this latter having been originally described from the Miocene formation (Orbitoidal limestone) of the Islands of Formosa and Riu-Kiu, and the former reported by the same authors as occurring in the Post-Pliocene deposits (raised coral-reef beds) of Riu-Kiu. Molluscan remains are found in the shales of the coal-measures, including a species of *Tellina*, and an *Arca* like *diluvii* of Lamarck; leaf-impressions are also met with. Further information respecting these fossils is to be given in a later memoir when more fully studied, but in the meantime the author recognises both Miocene and Pliocene rocks in Batan Island, and with regard to the age of the coal deposits he considers it possible that they may be of later age than Eocene. Microphotographs of diorite from Rapurapu and serpentine from Batan are given on plate xix; and plate xx contains similarly prepared figures of *Operculina complanata* and *Amphistegina* (?).

R. B. N.

IV.—Short Notices.

1.—Geological Survey and Museum.

We have omitted to notice one of the most useful, interesting, and important publications of this Department, issued moreover last year. It is entitled "A Handbook to a Collection of the Minerals of the British Islands, mostly selected from the Ludlam Collection in the Museum of Practical Geology," and it is the work of Mr. F. W. Rudler, I.S.O., the former Curator. Clearly and concisely written, it conveys in readable form an astonishing amount of accurate information, with abundant references to further original sources of knowledge. It is especially rich in observations on the mode of occurrence, origin, and economic uses of our minerals. The volume extends to 241 pages, including a good index, and the price is 1*s*.

2.—Notes on Cambrian Faunas. By G. F. Matthew, D.Sc., F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, vol. v, part 4, p. 406.

THIS article relates to the characters of certain Ostracoda and Trilobita of the *Paradoxides* and *Protolenus* zones of New Brunswick in Eastern Canada, and is based on additional material of species already described. There is also in this article a discussion of certain Cambrian forms from the locality at Anse au Loup, the fossils of which were studied by the late E. Billings; the opinion is expressed that the genus *Salterella* is based on ensheathed examples of *Hyolithes* and *Orthotheca*. Walcott has referred one species to *Hyolithes*; Dr. Matthew would refer the other two to *Orthotheca*.

3.—New Species and a New Genus of Devonian Plants. By G. F. Matthew, LL.D., F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, vol. v, part 4, p. 393.

A NEW genus and new species and a mutation of a Carboniferous species from the plant-bearing strata near St. John, New Brunswick, Canada, are described in this article. The former is a fern of peculiar aspect, with thick, smooth, barren pinnules and fertile pinnules that bore pods or similar receptacles; the barren pinnules are compared with the Ginkgoale genus *Baiera* of the Secondary rocks, the fertile ones to *Palæopteris*. The other fossil described in this paper is considered to be a mutation of Brongniart's *Annularia longifolia*; it has wider leaves and longer internodes than the typical forms of the Coal-measures.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 27th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The President announced that the Foreign Secretary had, on behalf of the Officers and Council, addressed a letter of congratulation to Commendatore Prof. Arturo Issel, For. Corr. G. S., on the occasion of the fortieth anniversary of his professorate in Genoa University.

The following communications were read:—

1. "Interference Phenomena in the Alps." By Mrs. Maria M. Ogilvie Gordon, D.Sc., Ph.D., F.L.S. (Communicated by Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., P.G.S.)

In former papers[1] the authoress pointed out that, while the leading axis of the Alpine mountain system extended in an east and west direction, and it was generally accepted by Alpine geologists that Alpine areas had endured horizontal compressive stresses in a north-and-south direction, her own studies of Alpine geology had led her to the conclusion that there had also been cross deformation throughout the whole region, including both plicational and overthrust effects; and that this cross deformation had been induced in relation to horizontal pressures which had acted from the Hungarian Basin westward over Alpine areas. In a quite similar way, radially directed horizontal pressures had acted round the northern, eastern, and southern periphery of the Hungarian Basin, and had originated the deformational systems of the Carpathian Mountains.

On the Alpine side of the Hungarian Basin, owing to the resisting character of the previously plicated rocks composing the Palæozoic Alpine chain, the ancient chain had been broken up by the east-and-west compression into a series of cross segments or fault blocks, and there had been a general westward crush of the series. The leading cross segments named by the authoress were—(1) the Western Alps, (2) the Engadine, and (3) the Styrian Alps.[1 (2)] Overthrust effects had been produced not only at the western margins of the segments, but also in some cases at the eastern margins, e.g. notably in the Western Alps and at the Judicarian Fault in the Eastern Alps. Further, these same cross segments in the Central Alps had been, from their first initiation, interrupted on the north and south by ancient leading east-and-west faults, in relation to which sagging or downthrow movements took place towards the Central Alpine band, and overthrust movements occurred in opposite directions.

The present paper, so far as it deals with the general structure of the Alps, was completed in April, 1905; but, acting on the advice of Sir Archibald Geikie, the authoress has since endeavoured to strengthen her line of argument by taking as a type the series of structural changes undergone in the largely igneous mountain-massive of Bufaure in the Dolomites, and elucidating the successive phases from the point of view of historical geology.

After describing in detail the geology of the Bufaure Massive, the authoress discusses the structural relation of the Western Alps and the Engadine to one another and to the whole mountain system. From the particular arrangement of overthrusts, as well as from the distribution of the igneous intrusions in the Western Alps and in the Engadine, the authoress concludes that these were areas where

[1] M. M. Ogilvie Gordon: (1) "Torsion-Structure in the Alps," *Nature*, September 7th, 1899, vol. lx, pp. 443–446; (2) "The Crust-Basins of Southern Europe," Seventh International Geographical Congress, Berlin, 1899 (Proceedings of the Congress, part ii, pp. 167–180, pl. vii); and (3) "The Origin of Land-Forms through Crust-Torsion," Geogr. Journ., vol. xvi (1900), pp. 457–469.

leading cross faults intersected the east-and-west Central Alpine band, and shows how the coalescence of these cross faults with E.N.E.–W.S.W. faults on the north side and W.N.W.–E.S.E. faults on the south side defined two leading fault curves, the one passing through the Engadine and continuing in the Dalmatian Alps, the other passing through the Western Alps and continuing in the Apennines. These strike curves are essentially peripheral to the western side of the Hungarian Basin.

The cross segment comprising the Rhine-Ticino district between the Western Alps and the Engadine is, according to the authoress's interpretation, anticlinal in character, segments having been downthrown from it both towards the west and towards the east, and overthrust masses having crept eastward and south-eastward from the Western Alps, and westward from the Engadine.

The authoress then discusses the relation of the French Jura Mountains to the Alpine System, pointing out that the Swiss-French Plain flanking the Western Alps presents the same essential features of structure, in relation to the Western Alps on its east side and the French Jura Mountains on its west, as those that she has elucidated for the Rhine-Ticino cross segment. She consequently interprets the strike-curve round the west formed by the Jura Mountains and the ranges of Dauphiné as the outermost peripheral plicational system in the Alps, showing that the whole region between the Hungarian Basin and the ancient mountain groups of Central France has been under the influence of the westward thrust.

The general principle of structure treated of above—namely, the sagging of crust-blocks by means of normal faults towards bands or localities of crust-weakness or subsidence, and the reverse or overthrust movements which may take place from within these bands or localities—is that which the authoress demonstrated in the Dolomite Massives in 1893, and has ever since advocated as a leading principle in the interpretation of Alpine structures, the important consideration being that where, as in the Alps, the principle is applicable in relation to two intersecting axes of deformation, the phenomena produced must necessarily be of the nature of 'interference phenomena.'

A leading feature of the paper is the evidence that it affords of differential rates of movement in different parts of a thrust-mass, or fault-block undergoing horizontal displacement, both in respect of the laterally adjacent parts of a thrust-mass and also of the subjacent layers. The writer's maps and sections show that the actual deformations which characterize a thrust-mass have a different direction of strike on either side of an axial band of maximum horizontal displacement; for example, if the horizontal movement of a thrust-mass is westward, the deformational phenomena (faults, folds, etc.) in the western front of the thrust-mass curve on the north side towards some S.W.–N.E. or W.S.W.–E.N.E. direction, and on the south side towards some N.W.–S.E. or W.N.W.–E.S.E. direction. The authoress interprets these observations on the basis of the deflection of the general movement of the thrust-mass by the strains set up between the axial region of maximum horizontal displacement and the lateral regions where from any cause the horizontal displacement is less.

Another feature which may be mentioned is her description of several examples in the Dolomites where there had apparently been a local reversal of the regional westward movement, and her reference to the familiar examples of eastward overthrusts in the Judicarian district, and on the eastern and south-eastern front of the grander mountain massives of the Swiss and French-Italian Alps. While each individual case demands special examination, she indicates an explanation that satisfies certain cases which she has examined. At localities where the base of the thrust-mass is open to inflows of igneous rock, the igneous material may ascend and be carried onward with the gliding mass, undergoing consolidation during the movement, and inducing contact changes in neighbouring rock material. After consolidation of such igneous inflows, they present resisting bodies within the thrust-mass, which, in the same way as any massive developments of hard sedimentary material, impede the advance of rock material in the same direction as before, and thus cause local deflections. The tendency is for the material of the thrust-mass to be strongly plicated and faulted as it is driven against any such resisting body, widening out in a direction roughly parallel with the resisting mass, and piling up the material in front to such an extent that local reversal of the direction of overlapping is produced.

2. "The Influence of Pressure and Porosity on the Motion of Sub-Surface Water." By William Ralph Baldwin-Wiseman, M.Sc., Assoc. M. Inst. C. E., F.G.S.

The author commences the paper with a brief historical summary of the researches which have been conducted since 1830 on the motion and behaviour of underground water, more especially dealing with the question of sub-surface flow and the delimitation of cones of depletion.

In the second part of the paper, in discussing the influence of the porosity of a rock, on the rate of flow of water through it, he describes in detail the variations in porosity which may occur in restricted areas of the same rock, due to superincumbent pressure, faulting, and the intrusion of dykes, illustrating the various points with data collected in the field. He also discusses and describes experiments on the rate of desiccation and soakage of various rocks.

He then describes a lengthy series of laboratory experiments, which he conducted with specially devised apparatus of his own design to afford a constant pressure and to eliminate all possible errors due to lateral flow, and in which he demonstrates that there is not a uniform relation between flow and pressure in various rocks over a considerable range of pressure, and discusses the various phenomena which were manifested.

In the third portion of the paper he describes the various attempts at determining the range of the cone of depletion in various strata, and then proceeds to outline a method based upon an experimental determination of the variation of internal pressure in a rock mass when charged with water and subjected to a considerable difference of pressure on the two faces; and in further elaboration of the theory, he outlines a method of estimating the percentage interference of two contiguous wells in the same strata.

In the concluding portion of the paper he discusses data collected during various hydrological surveys, and points out the influence of surface configuration and stratigraphical sequence on the sub-surface water contours.

The next meeting of the Society will be held on Wednesday, November 7th, 1906.

OBITUARY.

PROFESSOR J. F. BLAKE, M.A., F.G.S.

WITH deep regret we have to record the death of this well-known geologist, which occurred on Saturday, 7th July, in his 67th year, at 35, Harlesden Gardens, N.W.

We shall give some account of his life and writings in our September number.

GEORGE FREDERICK HARRIS, F.G.S.

WE have to announce the loss of another able geologist and contributor to this Journal. Mr. George Frederick Harris, F.G.S., who died on 16th July at his residence, 20, Parchmore Road, Thornton Heath, Surrey, after prolonged illness, was one of the founders of the Malacological Society of London, and served the office of Treasurer for some time; he also contributed several papers to its Proceedings. He was for nearly 20 years Lecturer on Geology at the Birkbeck College.

We shall give a fuller account of Mr. Harris's life and work in the September number.

PERCY EMARY, F.G.S.,

Honorary Secretary of the Geologists' Association, Assistant Lecturer on Geology to the Birkbeck College.

THE unexpected death of this young and most energetic geologist, who for nine years filled the office of Secretary to the Geologists' Association, took place on May 25th, after only a month's illness, at 20, Turle Road, Tollington Park, N.

His work for the Geologists' Association was of the greatest value, and by his early decease he leaves a widow but very inadequately provided for. In recognition of his services to science, a Fund, to be called "The Percy Emary Fund," is being raised by geologists and others for Mrs. Emary's benefit; and Mrs. R. S. Herries, 24, Gloucester Street, Belgrave Road, S.W. (wife of the President of the Geologists' Association), has consented to act as Treasurer and receive subscriptions. Miss Mary C. Foley (51, Elm Park Mansions, Park Walk, Chelsea, S.W.) is acting as Secretary. Cheques and postal orders should be made payable to "The Percy Emary Fund," and crossed "Lloyds' Bank, Belgrave Road Branch."

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SEPTEMBER, 1906.

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THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. III.

No. IX.—SEPTEMBER, 1906.

ORIGINAL ARTICLES.

I.—The Carboniferous Succession below the Coal-Measures in North Shropshire, Denbighshire, and Flintshire.[1]

By Wheelton Hind, M.D., B.Sc., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

(With Plates XXI and XXII and five Woodcuts.)

1. Introduction: Description of the Area Examined.

It requires but little imagination to conceive that a very slight subsidence of the country in North Wales lying between the Vale of Clwydd and the estuary of the River Dee would convert it into a peninsula consisting of Carboniferous rocks skirting to the north, and to the east a strip of Silurian ground. The backbone of this peninsula is composed of Lower Carboniferous rocks, forming the high range which starts from the bold cliffs that border the sandy flats of the north shore of Flint from Dyserth to Talacre. Stretching southwards by way of Halkyn Mountain, Moel Findeg, Nerquis Mountain to Minera and Llangollen, this range, in the main, forms an anticline, off whose eastern flanks the higher divisions of the Carboniferous system dip in natural sequence towards the River Dee.

Rising up from beneath the Vale of Clwydd, the Lower Carboniferous rocks reappear to the west, from the north coast at Colwyn Bay, Colwyn, and Llandulas to south of Ruthin, and in this

[1] This paper was read at the Geological Society on April 4th, 1906. Subsequently the Publication Committee notified us, that unless we were prepared to omit all separate lists of fossils, and show their distribution in one large table at the end of the paper, they could not recommend the paper for publication. As the main object of the paper is to work out the palæontological succession, and as we establish five life zones, we felt strongly that such a course was unfair to us as authors, that it would render the paper useless to those who went over the ground with it. We could not conceive a satisfactory table which would clearly indicate five zones from some hundreds of species collected from some sixty localities. As copious fossil lists had been published in very recent papers in the Quarterly Journal on Carboniferous zones in other localities, we demurred to the differential treatment and withdrew our paper under the conditions required. The paper is in the exact form in which it was read at the Geological Society, with the addition of a discussion on the horizon of the cherts, the interpolation being plainly indicated.

area some of the sections disclose the unconformity between Carboniferous and Silurian rocks. An interesting outlier of Carboniferous Limestone also occurs at Corwen. All the exposures examined by us will be observed to lie in the counties of Salop, Denbigh, and Flint, with the exception of the district of Llysvaen, which is part of Carnarvon.

Usually, the best facilities for collecting were afforded by the numerous quarries which are being, or have been, worked for road metal, iron manufacture, lime, cement, chert, or building stone.

The natural exposures of Carboniferous Limestone forming the picturesque contours of the hills are so completely covered with lichen growth that the fossils are totally obscured, and thus for the purposes of systematic collecting they are not nearly so helpful as at first sight they might seem to promise. In the series of rocks overlying the Carboniferous Limestone the exposures and quarries are comparatively rare, and all those examined by us occur in the tract of country to the north and east of Halkyn Mountain in the county of Flint. At certain horizons the fossils were very abundant, and were of diagnostic value. The Carboniferous sequence of this district, worked out by the aid of palæontological data, has been a much simpler affair than was anticipated. It is not proposed in this paper to do more than indicate the main lines along which this interpretation has been developed; there is yet an immense amount of labour required in order to fill in the intervening details.

2. A Critical Account of Previous Geological Research in the Carboniferous Rocks of North Wales.

Much attention, during many years, was devoted to the study of the Carboniferous succession in North Wales by the late Geo. H. Morton. His various publications extend over the period from 1869 to 1901, when a posthumous paper on "The Carboniferous Limestone of Anglesey" was edited by his daughter.

His work was all done on palæontological lines, but unfortunately he did not recognise any method for the establishment of life zones in the Carboniferous rocks of North Wales. Eventually he established a subdivision of the series founded on the colour of the limestones. One of us had the opportunity, some years ago, of examining the very carefully labelled fossils in his collection, the majority of which are now in the Natural History Museum, Cromwell-road, South Kensington.

All Morton's papers contain elaborate lists of fossils, an examination of which demonstrates that he recognised the important fact that certain beds in various localities had a similar fauna.

His writings also make it very obvious that he had doubts as to the correlation of the peculiar calcareous grits, which, in the south of Flintshire, Llangollen, Sweeney, and Oswestry Racecourse, succeed or replace the purer limestones. There is no doubt that, to some extent, Morton had certain broad palæontological evidence for his subdivision of the thick limestone of North Wales into Upper Grey, Middle White, and Lower Brown, but he did not emphasize the fact.

The choice of the terms is indefinite, for it would lead one to expect the existence of a Lower Grey and an Upper Brown. As far as the nomenclature goes, it would have been much simpler to have inserted the word 'or' between the horizon and its indicative colour.

Moreover, the beds which lie on the Upper Grey Limestone he unfortunately termed 'Upper Black Limestone,' and to this the great source of error in the conception of the sequence, which the officers of the Geological Survey accepted from him, is almost entirely due. There are two or more horizons in North Wales at which Black Limestones occur, just as obtains in Derbyshire, each of which is characterised by a totally different fauna.

The lower set of Black Limestones is worked for hydraulic cement, and is locally misnamed 'Aberdo' Limestone. They are characterised by a fauna typical of the uppermost beds of the Carboniferous Limestone, and contain such characteristic fossils as *Productus giganteus, Lonsdaleia rugosa, L. floriformis, Cyathophyllum regium, Amplexi-zaphrentis* sp., and *Cyathaxonia* sp. These corals are only known in beds which form the uppermost division of the *Dibunophyllum* zone of the south-west of England.

The other set of Black Limestones do not yield a hydraulic lime, have peculiar physical characters, weather and fracture in a manner altogether different from the 'Aberdo' stone, and contain a typical Pendleside fauna, *Pterinopecten papyraceus, Posidonomya Becheri,* which at once definitely determines the age of the beds to be later than the Carboniferous Limestone Series, and therefore the equivalent of the Pendleside Series of the Midlands. Mr. Morton's lists show that he recognised the fact that *Cyathophyllum regium* and *Lonsdaleia floriformis* only occur in the Upper Grey Limestone in every locality which he examined.

Another important horizon seems to be indicated from Morton's lists. The base of the Lower Brown Limestone is characterised by the presence of that peculiar shell *Daviesiella* (*Productus*) *Llangollensis,* which appears under the name of *Productus comoides* in his lists. We found these two important facts of distribution to be universally true.

The Middle White Limestones we found to be characterised by the presence of *Dibunophyllum* ϕ and *Cyathophyllum Murchisoni,* fossils which indicate, in the Bristol area, the life zone which immediately underlies the *Lonsdaleia* beds. These two life zones have been named by Dr. Vaughan the Upper and Lower *Dibunophyllum* zones respectively. To a certain extent, therefore, Morton's division of the Limestone Series of North Wales does correspond with that indicated by the palæontological succession.

The Lower Brown Limestone is the lowest member of the series in North Wales, excepting the basement conglomerate, when present, and appears to correspond with the junction of the Upper *Seminula* and Lower *Dibunophyllum* beds of the Bristol area. The Middle White Limestones are practically the equivalents of the Lower *Dibunophyllum* zone of Bristol, but probably a portion of the Upper Grey measures belong to this division. Part of the Upper Grey, the

Upper Black (in part), and possibly some of the cherts equal the Upper *Dibunophyllum* zone of Bristol; while the Black Limestone and Shales of Teilia, Holywell, and Baggilt are the homotaxial equivalents of the Pendleside Series.

Morton classified all the beds which occur between the Carboniferous Limestone and the Coal-measures as Cefn y Fedw Sandstone. He acknowledged, in various writings, his doubts as to the exact correlation and homotaxial equivalents of the several members of the series. The base and the top of the series unfortunately are very variable from north to south, owing to the peculiar and rapid lithological changes which the upper beds of the Carboniferous Limestone Series undergo in this direction, and also to the fact that the Pendleside Series overlying the limestone, although 1,000 feet thick at Holywell, and the Gwespyr Sandstone Series, 300 feet thick, have, if represented near Llangollen, thinned out to a very few feet. Further, Mr. Morton did not recognise that the *Posidonomya Becheri* Limestones of Teilia and Holywell belonged to the same palæontological series, and classed the latter as Coal-measures, in spite of their fossil contents.

Morton, however, recognised the important fact that the basement conglomerate did not necessarily indicate the base of the Carboniferous Limestone in any but a very local sense, and that these beds were the true equivalents of beds fairly high in the sequence elsewhere. His carefully detailed work and estimates of thicknesses have been of great help to us, and with most of his palæontological work we are in accord. A very serious error was made by Mr. Walker (Proc. Chester Soc. Nat. Sci., p. 9, 1878) in referring to the Holywell shales as the equivalent of the Lower Coal-measures of Lancashire, a mistake unfortunately adopted by the Survey, who state on p. 62 of the Memoir (op. cit. sup.):—"The Holywell shales, which run through the country and form a convenient base for the Lower Coal-measures, resemble some black shales, with bands or nodules of argillaceous limestone, which occur in the Lower Coal-measures of Lancashire, and contain a similar fauna, composed chiefly of *Posidonomya*, *Aviculopecten*, *Goniatites*, *Bellerophon*, coprolites of fish and plant remains." The absence of specific determinations renders this argument of very little value. Unfortunately for their point of view, *Posidonomya* (*Becheri*) does not occur in the Coal-measures. The *Goniatites* are Lower Pendleside forms, and the plants are not Coal-measure species.

Moreover, the Holywell shales are below the Gwespyr Sandstone, which is the equivalent in North Wales of the Millstone Grit. The thickness of this sandstone, about 300 feet, should have opened the eyes of anyone who knew the Lower Coal-measures of Lancashire or the Midlands, where a sandstone at all approaching that thickness is unknown. Moreover, Morton shows that the Gwespyr Sandstone has a matrix of decomposed felspar similar to the 1st or Roaches Grit of North Staffordshire. As far as we know, felspar is not present in this manner in any known Coal-measure sandstone. The mistaken correlation ought not to have occurred, on purely lithological grounds. Nowhere in the Coal-measures of the Midlands or Lancashire does 1,000 feet of barren measures occur in the Lower Coal-measures free from workable coal-seams; the mistake would have been impossible if adequate study had been made of the fossils. Apparently the correlation was made simply on fossil evidence, but it does not appear that any steps were taken to officially check the accuracy of the views propounded. In "The History of the Parishes of Whiteford and Holywell" (1796), Thomas Pennant gives very clearly the relation of these shales to the limestone in this district: "The Holywell level was begun in 1774 . . . the entrance into the work (was) in Coed Cae Dentir, a field belonging to Sir Pyers (Mostyn) on the north side of a small dingle opening into the road opposite to the great cotton factory . . . The first forty yards . . . was arched with stone . . . when the arch ceased the roof was the natural rock of that species called shale . . . After passing in the shaley stratum about two hundred and twenty-six yards we find it is succeeded by that of Chert, at which spot the level enters my ground in the field called Coed Cae Norfa. There the height to the surface is eighteen yards. . . . The Chert continues to a little beyond the turnpike road, when we again enter the land of Sir Pyers Mostyn in a field called Brocknallt, where it stops. Hitherto the level has preserved a strait course, but in this field (where the lime-stone stratum begins) it turns and is continued to the end of the present working about five hundred yards" (pp. 249–250).

An excellent bibliography on the Geology of Denbighshire and Flintshire is to be found in the Memoir of the Geological Survey, "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn," 1885, drawn up by Mr. W. Whitaker, and only slight additions are necessary.

1885. A. Strahan. "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn": Mem. Geol. Surv.

1886. G. H. Morton, "Carboniferous Limestone and Cefn y Fedw Sandstone of Flintshire": Proc. Liverpool Geol. Soc., reprint in vol. i, pp. 1–78.

1887. —— "The Microscopic Characters of the Cefn y Fedw Sandstone of Denbighshire and Flintshire": Proc. Liverpool Geol. Soc., vol. v, pp. 271–280.

—— "Note on Carboniferous Limestone Fishes of North Wales": ibid., vol. v.

—— "On the Discovery of Sponge Spicules in the Chert Beds of Flintshire": Proc. Liverpool Biological Soc., vol. i, p. 69.

—— "Carboniferous Limestone of North Flintshire": Geol. Mag., Dec. III, Vol. IV, p. 120.

1889. R. Kidston, "On some Fossil Plants from Teilia Quarry": Trans. Roy. Soc. Edin., vol. xxxv, p. 419.

1890. A. Strahan & C. E. De Rance, "The Geology of the Neighbourhoods of Flint, Mold, and Ruthin": Mem. Geol. Surv.

G. H. Morton, "The Geology of the Country round Liverpool, including the North of Flintshire," pp. 287.

1897. —— "The Range of Species in the Carboniferous Limestone of North Wales": Geol. Mag., Dec. IV, Vol. IV, p. 132.

1897–8. —— "The Carboniferous Limestone of the Vale of Clwyd": Proc. Liverpool Geol. Soc.

1901. —— "The Carboniferous Limestone of Anglesey": ibid.

3. Description of the most important Sections.

For the sake of clearness, the exposures of the Carboniferous Limestone have been described according to their topographical arrangement rather than in their geological sequence. In this way, where several fossil horizons occur at any one locality, they have all been taken together as making up one section; the correlation of the individual horizons is dealt with in a later portion of this paper. It has, however, been found possible to treat the exposures in the Pendleside Series in their geological sequence, because of the accidental fact of each section being limited to one zone, which has enabled us to do this without involving any repetition or complicating the description as between horizon and locality.

Owing to the difficulty, in this sparsely populated district, in indicating localities with sufficient precision by reference to topographical names (which, by the way, are often subject to alteration), we have frequently resorted to their definition in terms of latitude and longitude, as marked off on the "1 inch Ordnance Maps," believing that this is the only way (unless personally conducted) in which other field geologists can in many instances locate the collecting-ground with tolerable certainty.

(a) *Carboniferous Limestone.*

(i) The romantic coast scenery in the neighbourhood of Llandulas is due to the irregular weathering of the Carboniferous Limestone forming the hills. The dip of the beds northwards to the sea may be beautifully seen in the series of long, parallel scars on both sides of the valley of the River Dulas, which has cut its way through the thick limestones. Ffernant Dingle was visited by us, but we have nothing to add to its description by Mr. A. Strahan, F.R.S., in the Geological Memoir of that district. At Llandulas, in a quarry by the roadside at the foot of Cefn hill (lat. 53° 19′ 5″ N., long. 3° 37′ 50″ W.), one of the limestones is characterised by the abundance of *Daviesiella Llangollensis* (Dav.). A little higher in the series another limestone bed contained great numbers of *Seminula* aff. *ficoidea*, Vaughan. On the south side of the hill, and south of the scattered village of Llysvaen (lat. 53° 16′ 20″ N., long. 3° 38′ 40″ W.), almost level with the road, a *Productus* Limestone may be seen, containing—

Productus aff. *Cora* (mut. D_1), Vaughan.
P. aff. *Cora* (mut. S_2), Vaughan.
P. hemisphericus, approaching in some characters *P. Cora.*
P. hemisphericus, Phill.

Following the same road further to the west, towards Bwlch-y-gwynt, a rather sandy limestone, with quartz-nodules, occurs somewhat higher in the series, with—

Cyathophyllum Murchisoni, E. & H. (Very common.)
Koninckophyllid—*Cyathophyllum.*
Lithostrotion aff. *Martini*, E. & H.
Syringopora cf. *distans*, Fischer.
Chonetes papilionacea, Phill. (Common.)

Above the preceding horizon is a very pure white limestone, containing—

Chonetes papilionacea, Phill. (Very common.)
Euomphalus pentangulatus, Sow. (Common.)

(ii) On the east side of the Vale of Clwydd, near the western base of Moel Hiraddug, at a quarry between Pentre-cwm and Pentre-bach, the so-called 'basement beds' (of the Geological Survey) are exposed, which here consist of alternating limestones and soft calcareous sandstones. The following list was obtained:—

Zaphrentis-like Coral.
Athyris expansa, Phill.
Chonetes papilionacea, Phill. (Convex form.)
Cliothyris glabristria (Phill.).
Productus sp.
Seminula aff. *ficoidea*, Vaughan. (Very common in one bed.)
Spirifer sp.
Archæosigillaria Vanuxemi (Göpp.).
Other plant-remains with *Spirorbis* attached.

The importance of this section lies in the abundance of *Seminula ficoidea*, which fixes the horizon in the series. The discovery of *Archæosigillaria Vanuxemi*, which was fairly common in the plant-bed, is of more than ordinary interest, since it has only been recorded hitherto "from the lower beds of the Mountain Limestone in the neighbourhood of Shap Toll-Bar, Westmoreland,"[1] and in that instance the horizon and locality are both somewhat vague; we are now able to give these particulars for the new find with precision.

(iii) In the next quarry, nearer to Dyserth, and 10 feet above the very thick bed of white limestone seen in its southern end, we collected—

Dibunophyllum sp.
Athyris expansa, Phill.
Chonetes papilionacea, Phill.
Spirifer. (With few thick and deep angular ribs.)
Euomphalus sp.
Fucoid (?).

(iv) Beds, higher in the series than the preceding, are exposed in a large quarry at Dyserth, bordering the south side of the Newmarket road, and in those constituting the floor of the quarry we obtained—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Chonetes papilionacea, Phill.
C. papilionacea, Phill. (Convex variety.)
Productus hemisphericus, J. Sow.
Martinia glabra (Mart.).

(v) A smaller quarry is being worked near Meliden (lat. 53° 18′ 50″ N., long. 3° 24′ 30″ W.), where the beds may be observed dipping north at 50°. On account of the high dip comparatively few beds are exposed, but these are very fossiliferous, as may be supposed from an inspection of the following list:—

[1] R. Kidston: Trans. Nat. Hist. Soc. Glagow (1899), p. 40.

Amplexus sp.
Densiphyllum sp.
Camarotoechia pleurodon (Phill.).
Dielasma hastata (Sow.).
Martinia glabra (Mart.).
Productus aculeatus (Mart.).
P. Cora, D'Orb.
P. elegans.
P. fimbriatus, Sow.
P. giganteus (Mart.).
P. hemisphericus, J. Sow.
P. latissimus, J. Sow.
P. Martini.
P. plicatilis, Sow.
P. punctatus (Mart.). (Common.)
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
P. spinulosus, Sow.
P. striatus, Fischer.
P. undatus, Defrance.
Pugnax pugnus (Mart.).
Reticularia lineata (Mart.).
Rhynchonella angulata, Linn.
Bisulcate—*Spirifer* (homœomorphic with *S. clathratus*).
Spirifer bisulcatus, Sow.
S. planicostata, M'Coy.
S. pinguis (?), Sow.
S. striatus (Mart.). (Very large.)
Aviculopecten fimbriatus (Phill.).
Conocardium aliforme (Sow.).
Edmondia M'Coyi, Hind.
Myalina or *Posidoniella*.
Parallelodon obtusus (Phill.).
Pinna flabelliformis (Mart.).
P. mutica, M'Coy.
Posidoniella vetusta (Sow.).
Protoschizodus æquilateralis (M'Coy).
Pseudamusium ellipticum (Phill.).
Pterinopecten semicircularis, M'Coy.
Sanguinolites striato-lamellosus, De Kon.
Solenomya sp.
Syncyclonema carboniferum, Hind.
Cyrtoceras sp.
Glyphioceras crenistria (Phill.).
Orthoceras. (Large.)
Euomphalus sp.
Straparollus Dionysii, Montf.
Capulus or *Pileopsis*.
Naticopsis sp.
Phillipsia sp.
Petalodont tooth.

(vi) Along the main road further to the east, in the large quarry at the base of the hill, nearly into the southern end of Prestatyn, the limestone beds are very dark in colour, and are observed dipping to the east. Those forming the floor of the quarry are rather disappointing to the collector. The only forms we observed were—

Productus longispinus, Sow.
Martinia glabra, Mart.
Campophyllum Derbiense.
Zaphrentis aff. *Enniskilleni*, Vaughan.

A little higher in the same quarry we found—

Fenestella sp.
Camarotoechia pleurodon (Phill.).
Chonetes papilionacea, Phill.
Productus, sp. nov.

And about 8 feet higher still we noted a *Productus*-bed with—

Orthotetes crenistria (Phill.).
Productus, sp. nov.
P. fimbriatus, Sow.

(vii) In taking the road from Prestatyn to Gwaenysgor, at the first rise of the hill there is an old quarry now being filled up with building débris, where the following list was obtained:—

Fenestella sp.
Chætetes tumidus.
Dibunophyllum sp.
Lithostrotion sp.
Crinoids.
Archæocidaris. (Spine.)
Athyris planosulcata, Phill.
Orthotetes crenistria (Phill.).
Productus costatus, J. Sow.
P. plicatilis, Sow.
P. punctatus (Mart.).
Productus. (Elegantly reticulated.)
P. striatus, Fischer.
Spiriferina cristata, Schloth.
Trilobite.

Near the top of the section is a Crinoid-bed, with *Michelinia tenuisepta* (?); about 6 feet higher up the hill is a compact limestone, with chert nodules, containing—

Lithostrotion Martini, E. & H.
Syringopora sp.
Archæocidaris. (Spine.)
Palæechinus. (Plates.)
Productus giganteus, Mart.
Spirifer sp.
Euomphalus sp.

(viii) At the top of the hill near Gwaenysgor (lat. 53° 19′ 25″ N., long. 3° 23′ 20″ W.) there is a disused quarry, containing a lime-kiln, where the beds are found dipping north-east at 15°, which yielded the following fauna:—

Dibunophyllum sp. (Not common.)
Lithostrotion Martini, E. & H.
Zaphrentid Coral.
Crinoids.
Athyris planosulcata, Phill.
Productus aculeatus (Mart.).
P., sp. nov.
P. giganteus (Mart.). (Rather rare.)
Camarotoechia pleurodon (Phill.).
Productus giganteus (Mart.) (var. *Edelburgensis*), Phill.
P. hemisphericus, J. Sow.
P. margaritaceus, Phill.
P. punctatus (Mart.).
P. semireticularis (Mart.).
Pugnax acuminata (Mart.).
Schizophoria resupinata (Mart.).
Spirifer duplicicostatus (?). (Broad-ribbed form with angular ribs.)
S. striatus (Mart.).
Spiriferina cristata, Schloth.
Pileopsis sp.

(ix) In a small quarry on the left-hand side of the road leading from Gwaenysgor to Teilia Farm we collected—

Cyathaxonia.
Crinoids.
Productus giganteus (Mart.).
Pugnax pugnus (Mart.).
Spirifer aff. *bisulcatus*, Sow. (Characteristic of D_2 zone in Bristol area.)
Martinia glabra (Mart.).
Spirifer planicostatus (variant).[1]
S. sp. (Angular-ribbed form.)

(x) An exposure at the foot of the hill (on the 200 feet contour-line), opposite the Nant Hotel, Prestatyn, and east of the road from that place to Gwaenysgor, yielded—

? *Cyathaxonia* sp.
Dibunophyllum sp.
Chonetes papilionacea, Phill.
Productus fimbriatus, Sow.
P. semireticulata-longispinus.
Martinia glabra (Mart.).

A little further to the south-east, in the wood, may be seen the upper beds of limestone, with *Productus giganteus* (Mart.) fairly common.

(xi) In a quarry at Pentre, near Gronant (see *infra*, Part II, paragraph xxxv), there is a magnificent section in the chert beds, of which there is not less than 70 feet exposed. They are largely worked for 'setts,' used in the grinding of china-stone, etc., for the manufacture of pottery. In these cherts we observed—

Productus longispinus, Sow.
P. punctatus (Mart.).
P. sp. (Very spinose.)

(xii) In an old, disused limestone quarry north of Axton Mine we noted—

Fenestella.
Athyris planosulcata, Phill.
Dielasma hastata (Sow.).
Martinia glabra (Mart.).
Productus giganteus (Mart.).
P. elegans.
P. punctatus (Mart.).
P. semireticulatus (Mart.).
Schizophoria resupinata (Mart.).
Spirifer sp. (With broad, angular folds.)

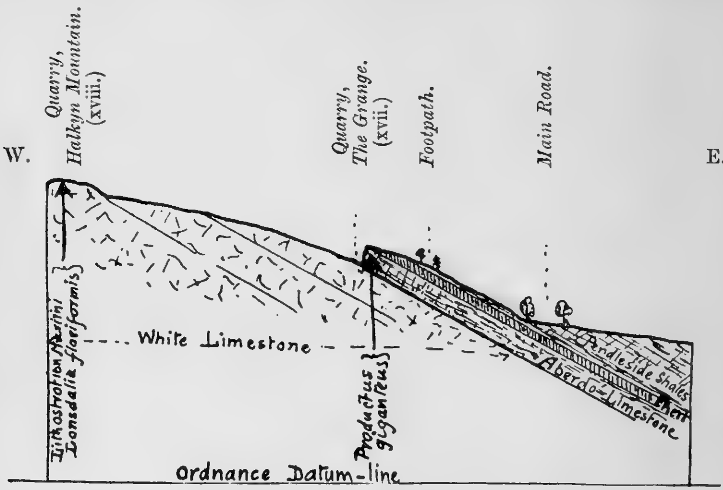
This, probably, is the quarry referred to by G. H. Morton.[2]

[1] A similar variety occurs at Curkeen according to Dr. A. Vaughan.
[2] G. H. Morton: Proc. Liverpool Geol. Soc., vol. v, p. 181.

(xiii) A limestone quarry in the next field to the Axton Mine is being worked at the present time, and from it we obtained—

Cyathophyllum Murchisoni, E. & H.
Monticuliporoid Coral.
Fenestella sp.
Dielasma hastata (Sow.).
Productus aculeatus (Mart.).
P. fimbriatus, Sow.
P. giganteus (Mart.).
P. punctatus (Mart.).
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
Rhynchonella sp.
Martinia glabra.
Spirifer grandicostatus, M'Coy.
S. striatus (Mart.).
Bellerophon sp.

(xiv) At Trelogan the uppermost beds of the Carboniferous Limestone have been very extensively quarried, and they are locally known as 'Aberdo' limestone—this appellation being reserved for limestones of exceptional value for the production of hydraulic cement. In one of the quarries at this place we are fortunately able



Horizontals, about $5\frac{1}{3}$ inches to a mile; verticals, 450 feet to an inch.

FIG. 1.—Diagram-Section Eastern flank of Halkyn Mountain.

to see the position of the limestones in conjunction with the cherts. A photograph of the section is shown in Plate XXI, where the erratic pinching-out of the bands of black limestone may be observed. The beds dip N.N.E. at 15°, forming the dip slope of the hill. The succession is:—

Cherts	20 feet +
Limestone and shales ...	35 feet +

The strata are singularly devoid of fossils, although several giganteid *Producti*, *P. costatus*, and *Campophyllum Murchisoni* were seen in the bed of limestone immediately below the chert.

(xv) A lower horizon is exposed at the surface at Garreg, where a large quarry in white limestone is being worked at the present time (lat. 53° 17′ 45″ N., long. 3° 18′ 10″ W.). The uppermost bed, 12 feet thick, is of a detrital character, consisting mainly of crinoids.

Trelogan Quarry, Halkyn Mountain.

In the bed forming the floor of the quarry the following fossils were obtained:—

Dibunophyllum sp.
Crinoids.
Productus giganteus (Mart.).
P. hemisphericus, J. Sow.
Reticularia lineata (Mart.).
? *Spirifer rotundatus*, Sow.

(xvi) On the eastern flank of Halkyn Mountain the upper beds have been worked in a series of quarries from Trelogan to Pentre Halkyn for 'Aberdo' limestone. The individual beds are never thick—2 feet or 2 ft. 6 in. being the maximum—and usually they are separated by thin shale-bands. As we go north the shale-partings constitute an increasing proportion of the sections, as may be seen by comparing the photographs, Plates XXI and XXII and Fig. 1. One of the quarries opened up in these beds was examined at Gorsedd (lat. 53° 16′ 50″ N., long. 3° 16′ 10″ W.), where the shales and limestones were all highly fossiliferous. Undoubtedly the most striking form, by reason of its numbers and the development of its individuals, was *Productus giganteus* (Mart.). The full list from this quarry was:—

Athyris cf. *planosulcata*, Phill.
Chonetes sp.
Lingula mytiloides, Sow.
Orbiculoidea nitida (Phill.).
Orthotetes crenistria (Phill.).
Productus giganteus (Mart.). (Very common.)
P. semireticulatus (Mart.).
P. Youngianus, Dav.
Reticularia lineata (Mart.).
Rhipidomella Michelini (L'Eveillé).
Schizophoria resupinata (Mart.).
Spirifer sp.
Phillipsia sp.

(xvii) About one and a half miles further south, on the road to Holywell, a very large quarry has worked beds at the same horizon and of the same quality (i.e. 'Aberdo' stone) at the Grange, Holloway (lat. 53° 16′ 30″ N., long. 3° 14′ 25″ W.). At this quarry we get an uninterrupted sequence from the limestone, through the cherts, into the lowest shales and thin black limestones of the Pendleside Series. Overlying the 'Aberdo' beds there is a white limestone, almost 7 feet thick, the lower portion of which is cherty and the upper portion is crinoidal; resting upon the latter is about 6 feet of lenticular dark limestone and thin shales, and these pass upwards into the cherts, which at this locality are thinly bedded, and as a series are attenuated. The cherts dip eastwards at 22° (Pl. XXI) In the limestones and intervening shales we collected—

Lithostrotion irregulare.
Amplexi-zaphrentis θ, Vaughan MS.
Caniniad—*Dibunophyllum*, Vaughan MS.
Dibunophyllum sp.
Favosites parasitica (Phill.).
Fenestella.
Athyris planosulcata, Phill.
Chonetes Buchiana, De Kon.
C. Laguessiana, De Kon.
C. papilionacea, Phill.
Orthotetes crenistria (Phill.).
Productus corrugatus,[1] Phill.
P. giganteus (Mart.). (Common.)
P. longispinus, Sow.
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
Reticularia lineata (Mart.).
Rhipidomella Michelini (L'Eveillé).
Spirifer, var. of *S. bisulcatus*, Sow.
S. ovalis, Phill.
S. planicostatus, M'Coy (not *S. crassus*, De Kon.).
Spiriferina sp.
Syringothyris cuspidata (Mart.).
Aviculopecten dissimilis (Flem.).
Orthoceras sp.
Phillipsia sp.
Petalodus acuminatus (Agass.).

[1] This form is characteristic of the Upper *Dibunophyllum* zone.

(xviii) Following the old wagon-way about 600 yards up the dip-slope of the hill from the preceding section, we reach a quarry in the white limestone, at the top of which is a *Productus*-bed about 10 feet thick, containing

Lithostrotion Martini, E. & H.
Lonsdaleia floriformis (Flem.).
Syringopora sp.
Crinoids.
Productus giganteus (Mart.).
P. hemisphericus (Mart.).
P. scabriculo-costatus, Vaughan MS.

(xix) South of Holywell, along the eastern margin of Holywell Common, a large number of quarries are being worked in the chert-beds, which here also overlie limestones of the 'Aberdo' quality. Some of the chert-bands contain numerous crinoidal casts. An old quarry near Pentre Halkyn, where the cherts were to a large extent desilicified, yielded the following fauna:—

Crinoids.
Dielasma hastata (Sow.).
D. ficus.
Orthotetes crenistria (Phill.).
Productus longispinus, Sow.
P. scabriculus (Mart.).
P. rugatus.
Spiriferina biplicata, Dav.
Syringothyris laminosa (M'Coy).
Ostracods.
Deltoptychius sp.
Psephodus magnus (M'Coy).
A new Crustacean.

(xx) Further to the east, near Waenbrodlas, the 'Aberdo' limestones are being worked by most extensive quarries, which are in many respects the most remarkable in the county of Flint. These limestones occur at the same horizon as those at Holloway, Gorsedd, and Trelogan, already described. The photograph (Pl. XXII) shows part of the face of the Waenbrodlas quarry, which presents physical features of some interest. A peculiar case of false bedding is here most clearly seen, where the edges of one set of thin limestones appear to have been almost planed off in a flat surface before the deposition of another bed of limestone of singularly uniform thickness and persistency. In the uppermost beds of the same quarry, and only partially represented on the right-hand side of Pl. XXII, a similar phenomenon may again be observed; in the latter instance the rate of cutting out of the lower set of limestones is 1 in 13. From the persistent parallelism of the upper and lower surfaces of the individual beds of limestone we infer that these two interruptions in the deposition of the strata were not of the nature of current-bedding, but really represent slight unconformities as a result of earth-movement at the time they were laid down, and though here they appear inconsiderable, it is possible that the movement at this period produced more striking results in other localities. In this connection we may remember that the 'Aberdo' variety of limestone (which is the kind worked in this quarry) is of very local distribution and of very erratic occurrence. The proportion of shale to limestone is extremely variable, increasing from Waenbrodlas to Trelogan, whilst further to the south and west the 'Aberdo' beds are absent altogether. Contemporaneous earth-movement is an easy explanation of this irregularity of deposition, and the section represented in Pl. XXII may offer some direct evidence in support of this view.

Waenbrodlas Quarry, Halkyn Mountain.

The actual top of the quarry, where the beds were much weathered, was characterised by the presence of corals of diagnostic importance, viz. :—

Cyathaxonia aff. *Rushiana*, Vaughan.
Lithostrotion irregulare (Phill.).
Lonsdaleia floriformis (Flem.).
L. rugosa, M'Coy.

Here again, in even greater numbers than at Gorsedd and Holloway, were *Producti* of the largest size. The full list from this quarry is as follows :—

Amplexi-zaphrentis, Vaughan MS.
Callophyllum θ, Vaughan.
Campophyllum cf. *Murchisoni*, E. & H.
Clisiophyllum aff. *Curkeenensis*, n.sp., Vaughan.
Cyathaxonia aff. *Rushiana*, Vaughan.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. Portlocki (Bronn).
Lonsdaleia floriformis, Lonsd.
L. rugosa, M'Coy.
Michelinia sp.
Archæocidaris sp.
Palæechinus sp.
Pentacrinus sp.
Glauconome sp.
Athyris expansa, Phill.
A. (*Actinoconchus*) *planosulcata*, Phill. (Wetton form.)
A. sp.
Camarophoria[1] cf. *crumena* (Mart.).
Chonetes cf. *Laguessiana*.
Martinia glabra (Mart.).
Orthotetes crenistria (Phill.).
Productus giganteus (Mart.). (Very abundant.)
P. giganteus, var. *Edelburgensis*.
P. latissimus, J. Sow.
P. longispinus, Sow. (Common.)
P. punctatus (Mart.).
P. scabriculo-costatus, Vaughan MS.
P. semireticulatus (Mart.).
P. sinuatus, De Kon.
P. Youngianus, Dav.
Reticularia lineata (Mart.).
Spirifer bisulcatus.
S. cf. *duplicicostatus*, Phill.
S. integricostatus, Phill.
S. cf. *pinguis*,[1] Sow.
S. planicostatus, M'Coy.
Aviculopecten dissimilis (Flem.).
Pseudamusium ellipticum (Phill.).
Bellerophon sp.
Serpulites membranacea, M'Coy.
Pacthodus sp.
Psammodus sp.
Psephodus magnus (M'Coy).

(xxi) The most important sections of Carboniferous Limestone in the district around Mold are confined to the hilly range extending from Hendre to near Llanferres. At the former place there are two quarries in the limestone at the same horizon. Since that on the north side of the road exhibits more of a sequence, its individual beds were more carefully worked. In the following section the particulars given by Mr. A. Strahan, F.R.S., in the Geological Memoir of Flint, Mold, and Ruthin, p. 39, are adopted :—

7.	Sandstone	27 feet.
6.	Shale	48 ,,
5.	Line of grit	,,
4.	Massive Coralline Limestone ...	12 ,,
3.	Thin-bedded Coralline Limestone ...	55 ,,
2.	Limestone and shale...	17 ,,
1.	Limestone	70 ,,

No. 1 (limestone) contains *Cyathophyllum regium*, Phill.

No. 2 (limestone and shale) contains—

Fistulipora aff. *incrustans*, N. & T. (Vaughan).
Athyris planosulcata, Phill.
Productus longispinus, Sow.
Rhipidomella Michelini (L'Eveillé).
Seminula ambigua (Sow.).
Spirifer cf. *duplicicostatus*, Phill.
Spiriferina biplicata, Dav.
Euomphalus sp.

[1] Upper *Dibunophyllum* zone forms.

No. 3 (thin-bedded Coralline Limestone) contains—

Cyathophyllum regium, Phill.
Dibunophyllum (probably) *Corwenense*, n.sp. (large).
Koninckophyllum magnificum, N. & T.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
Lonsdaleia floriformis (Flem.).
Schizophoria resupinata (Mart.).

No. 4 (massive Coralline Limestone) contains—

Chætetes sp.
Lithostrotion cf. *ensifer*, E. & H.
L. junceum (Flem.).
L. Portlocki (Bronn).
Amplexi-zaphrentis sp.
Phillipsastræa radiata, E. & H.
Schizophoria resupinata (Mart.).

No. 6 (shale) contains—

Campophyllum sp.
Cyathophyllum Murchisoni, E. & H.
Dibunophyllum θ–ψ, Vaughan.

At the smaller quarry at Hendre we collected from the limestone, corresponding to No. 1 of the preceding section:

Lithostrotion basaltiforme (Phill.).
Productus Cora, D'Orb.

And from the overlying limestone and shale—

Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
Crinoids.
Athyris planosulcata, Phill.
Camarotœchia pleurodon (Phill.).
Chonetes Laguessiana, De Kon.
Productus latissimus, J. Sow.
P. longispinus, Sow. (Common.)
P. punctatus (Mart.).
P. semireticulatus (Mart.).
Rhipidomella Michelini (L'Eveillé).
Schizophoria resupinata (Mart.). (Common.)
Seminula ambigua (Sow.).
Spirifer triangularis (Mart.).
Spiriferina cristata, Schloth.
Allorisma-like shell.

(xxii) The exposure at Gwernymyndd is an important one, and although it differs somewhat in its lithological character from those seen elsewhere, its palæontological features can easily be identified with those of other localities.

The following is the sequence of the upper strata at this place:—

6. Grit and sandstone.
5. Encrinital and arenaceous limestone.
4. Shale.
3. Chert band.
2. Quartz-grit and sandstone.
1. Encrinital limestone.

In the grit and sandstone at the top of the section, which was largely disintegrated, we found many fossils—the number of fish-teeth being extraordinary. The list obtained was—

Lithostrotion irregulare (Phill.).
Lonsdaleia rugosa, M'Coy.
Crinoids.
Orthotetes crenistria (Phill.).
Productus longispinus, Sow.
Spirifer sp.
Ctenoptychius lobatus (R. Eth., jun.).
Cochliodont tooth.
Pœcilodus sp.

The upper portion of the limestone (No. 5) below the grit was 'rubbly' in character, and contained *Productus giganteus* in fair abundance; in the lower portion we collected—

Amplexi-zaphrentis, Vaughan MS.
Dibunophyllum sp.
Fistulipora aff. *incrustans*, N. & T. (Vaughan).
Crinoids.
Athyris planosulcata, Phill.
Chonetes Laguessiana, De Kon.
Martinia glabra (Mart.).
Productus punctatus (Mart.).
P. pustulosus, Phill.
Spirifer bisulcatus, Sow. (Common.)

No. 4 (shale) was highly fossiliferous, and contained—

Athyris planosulcata, Phill.
Lingula mytiloides, Sow. (elongate sp.).
Martinia glabra (Mart.).
Productus cf. *semireticulatus* (Mart.).
Allorisma variabilis (?).
Aviculopecten dissimilis (Flem.).
Lithodomus lingualis (Phill.).
Nuculana attenuata (Flem.).
Parallelodon sp.
Posidoniella elongata (Phill.).
Solenomya sp.
Stroboceras bisulcata.
Straparollus sp.

No. 1 (encrinital limestone) yielded—

Amplexi-zaphrentis φ, Vaughan MS. (=*Z. Bowerbanki*, Thomp.).
Chonetes papilionacea, Phill.
Spirifer bisulcatus, Sow. (Common.)
S. grandicostatus.
S. integricostatus, Phill.
S. cf. *triangularis* (Mart.). (Common.)
S. trigonalis (Mart.), D'Orb. (Common.)

(xxiii) Further west, at a quarry in white limestone, which is worked in the wood near the summit of the hill east of the Loggerheads Inn, the following list was obtained:—

Dibunophyllum sp.
Syringopora cf. *distans*, Fischer. (Fairly common.)
Athyris expansa, Phill.
Dielasma hastata (Sow.).
Martinia glabra (Mart.).
Productus Cora, D'Orb.
P. giganteus (Mart.). (Not rare.)
P. hemisphericus. (Common.)

(xxiv) Crossing the River Alyn to the east, near Llanferres, we have a fine escarpment of the Carboniferous Limestone from the 700 feet contour-line to the 1,000 feet contour at Pant-du. Up this gorge the beds can be seen to have a regular dip south-east at 17°. At the bottom of the pass, near the river, the beds contain *Cyathophyllum Murchisoni*, E. & H., in abundance, and associated with it *Chonetes papilionacea*, Phill., which is a large, convex, fine-ribbed form, common at Cauldon Low, North Staffordshire. In addition we collected—

Alveolites septosa (Flem.).
Dibunophyllum sp.
Lithostrotion Martini, E. & H.
Syringopora cf. *distans*, Fischer.
Productus fimbriatus, Sow.
P. hemisphericus, J. Sow.
Spiriferina cristata, Schloth.

(xxv) Above Pot Holes the beds of limestone are thinner and often cherty; here we found—

Campophyllum sp.
Lithostrotion irregulare (Phill.). (Large variety, very common.)
L. junceum (Flem.).
L. Martini, E. & H.
L. Portlocki (Bronn).
Syringopora sp.
Productus giganteus (Mart.). (Abundant.)

And noted also beds of silicified *Productus giganteus* (Mart.) and crinoids similar to those occurring at Waenbrodlas.

(xxvi) Limestones higher in the series may be seen in the line of small quarries on the east side of the road, and parallel to it, at Gwyndy, where we obtained—

Amplexi-zaphrentis φ, Vaughan MS.
Productus longispinus, Sow.
P. punctatus (Mart.).
P. scabriculus (Mart.).
Spirifer bisulcatus, Sow.

(xxvii) In a disused quarry about 600 yards further north (lat. 53° 8′ 0″ N., long. 3° 10′ 52″ W.) the limestones and shales are remarkably fossiliferous, and yielded the following list:—

Amplexi-zaphrentis ϕ, Vaughan MS.
Campophyllum aff. *Murchisoni*, E. & H.
Cyathaxonia (?) sp.
Densiphyllum sp.
Dibunophyllum sp.
Cyclophyllum pachyendothecum, Thomp.
Athyris planosulcatus, Phill.
Chonetes Laguessiana, De Kon.
C. papilionacea, Phill.
Productus giganteus (Mart.).
P. longispinus, Sow.
P. pustulosus, Phill.
Schizophoria resupinata (Mart.).
Seminula ambigua (Sow.).
Spirifer bisulcatus, Sow. (Very abundant.)
S. cf. *triangularis* (Mart.). (Very abundant.)
S. trigonalis (Mart.), D'Orb. (Very abundant.)

(*To be continued in our next Number.*)

II.—The Chalk Bluff at Trimingham.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(With two Text-figures.)

Mr. R. M. BRYDONE'S account of the masses of chalk exposed on the Norfolk coast near Trimingham,[1] published in this Magazine during the first three months of the present year, is a valuable record of facts revealed by the encroachments of the sea, but it raises questions of a general nature, on which I should at once have commented, had I not preferred to wait until I could again examine the sections. This was done in company with the Rev. E. Hill during Easter week, when we found that even since the middle of last October (the date of Mr. Brydone's latest photograph) the destruction had been considerable.[2]

The isolation of the more notable bluff[3] is now complete. Though a memorial of defeat, it rises from the shore like a Roman arch of triumph (Fig. 2), one pier of which is formed of chalk, the other of boulder-clay (the so-called Cromer 'till'), while the outlines of the second and third masses[4] have been modified, as indicated in the sketch-plan (Fig. 1).

As I have not found Mr. Brydone's paper very easy to follow, owing to its being somewhat discursive and crowded with minute palæontological details, the time of readers may be saved by briefly enumerating the points to which I take exception. These palæontological details I abstain from discussing because I think that even

[1] I have followed the spelling of the Survey Memoir and my copy of the Ordnance Map.

[2] It may facilitate references to mention that in our paper we refer to the chalk masses as eastern and western (another instance of inattention to the minutiæ of the literature of the subject) where Mr. Brydone and some earlier writers use southern and northern. Herein we followed our notes; for the trend of the coast is more nearly in the former direction. From Weymouth to Sheringham it is nearly west and east. From the latter place it runs about E. 10° S., beginning at Cromer to point rather more to the south, and for some distance on either side of the 'bluff' its general direction is from 30° to 35° S. of E., not running quite S.E. even beyond Mundesley.

[3] That marked A in the illustration accompanying our paper (Plate XXII) in the September number of this Magazine, 1905.

[4] C and E of the same Plate.

if admitted they do not substantiate his conclusions. So I leave them and the nomenclature of zones to experts like Messrs. Jukes-Browne [1] and A. W. Rowe, and restrict myself to such as bear on the question discussed in our former paper, which dealt almost exclusively with the so-called northern block or blocks near Trimingham.[2] Mr. Brydone maintains the most noted one to be the remnant of a sea-stack or buried cliff, adopting a modification of the view put forward by Mr. Jukes-Browne.[3] This stack or cliff was formed at the margin of a chalk upland which, presumably in early Pliocene times, occupied the place of the present sea; the one

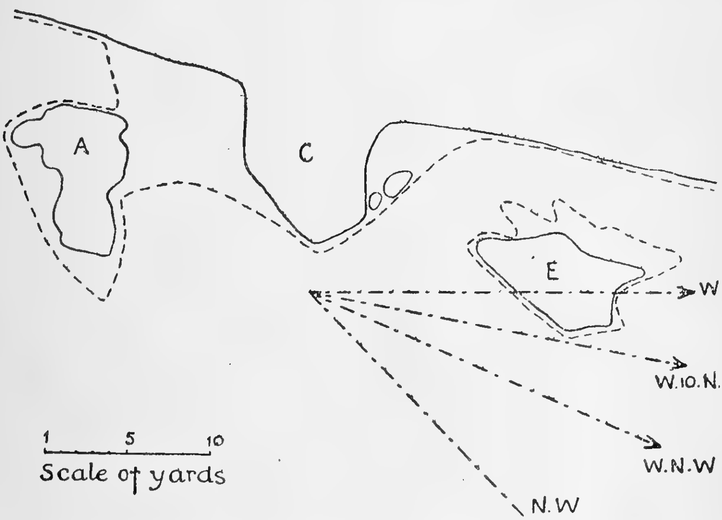


FIG. 1.—Sketch-plan (by Rev. E. Hill) of the "westerly chalk bluff" at Trimingham (see Plate XXII in the volume for last year).

The broken line indicates the boundary of chalk or clay in April, 1905; the continuous one that observed on almost the same day in the present year. A, E, C correspond with the masses bearing these letters on the above-named Plate, the first being the 'contorted' one, the condition of which at the latter date is shown in Fig. 2. The plan, Mr. Hill wishes me to say, does not pretend to minute accuracy.

which made it lying to the south-west and west. Mr. Brydone states that the uppermost part of the chalk (about two feet) visible at the headland differed from that below, lithologically in its grey colour, more crumbly condition, and apparently horizontal stratification, and palæontologically in several respects, notably the absence of *Ostrea lunata*; that this grey chalk formed an apparent connection with the chalk mass, then only recently disclosed (C), and, when

[1] This sentence was written in May; see GEOL. MAG., July, p. 335.

[2] The 'southern' chalk masses are mentioned only once in that paper, in a few lines at the end of p. 400 and beginning of p. 401. I shall again briefly refer to them in the present paper.

[3] Ann. Nat. Hist., sec. v, vol. vi, p. 305.

viewed from the more eastern side, seemed to be prolonged into a slab terminating in a kind of lobe.[1] The upper part of C and portions of its sloping more western face were also formed of the grey chalk, which Mr. Brydone found to be generally separated from the white chalk (in which *Ostrea lunata* is abundant) by a thin seam of 'fine grit' in which are scattered flint pebbles about the size of a potato, and which "sometimes swells out into a definite bed as much as two inches thick, containing small rolled pieces of Chalk."

This gravel Mr. Brydone assigns to Cretaceous times. He believes that late in that period earth-movements occurred which produced the flexures (attributed by Mr. Reid to the thrust of an ice-sheet), and that these were followed by denudation which removed part of the chalk and formed the gravelly seam, after which subsidence was renewed and the grey chalk deposited. The presence of water-worn flints in the chalk, as Mr. Brydone remarks, is practically unique, and if his view be correct it would throw "an important light on the time of consolidation of the flints, which must have taken place in this case almost simultaneously with the deposition of the Chalk in which they were formed" (p. 20). It does not, however, appear to occur to him that so unusual an occurrence requires exceptionally strong proof.[2]

The infilling of the 'arch' with clay and the apparent passage of the latter beneath the chalk in the masses C and E[3] receive from Mr. Brydone the following explanation (p. 77). At some date shortly before the formation of the glacial beds, the chalk must have been again raised and exposed to the erosive action of a sea lying to the south-west of the present coast, the waves of which formed caves in its cliffs, and these caves were filled by the first inflow of boulder-clay. The bottoms of them are probably well below the present beach-level,[4] so that we see only horizontal sections through the roofs and the upper surface of the infilling clay, which then, of course, seems as if it underlay the severed roof by natural deposition. The detached blocks of chalk visible in the cliff behind the 'bluff' "have clearly been carried up by a mass of clay from below, and represent parts of the roofs of these caves which were too weak to resist the upward pressure of the clay."

I now proceed to give a brief description of what we saw last April. The 'arch' (Fig. 2) was, more strictly speaking, a big window, the low 'sill' being formed of the usual boulder-clay, which exhibited a rather marked stratification as it approached the

[1] See Plate IX, No. 16, of Mr. Brydone's paper (p. 130). My sketch ended at the sudden rise of the clay, the left-hand one of the two (the oblong block of chalk beyond) being at that time hidden.

[2] The line of worn flints between the white chalk and the yellowish limestone of Maestricht to the south-west of that town is hardly a parallel.

[3] According to old diagrams the clay formerly underlay a corner of the chalk of which A is a remnant.

[4] If this view be correct, it is a little singular that the chalk should so often show up in this neighbourhood between tide-marks, still retaining in places a skin of boulder-clay.

chalk. The latter rock formed the seaward pier, and the curved bands of flints were distinctly visible on its more western and more eastern faces. On the former we saw, above the uppermost of these bands, a fairly distinct gritty streak (*f*), which was approximately on the level of the top of the 'arch' and was prolonged for some distance landwards. A mass of boulder-clay formed the landward pier, changing, in the right spandril of the arch, into a marly chalk. This was interrupted near the middle by a streak (*g*), averaging about two inches in thickness, which contained flint pebbles and looked like the 'washings' of boulder-clay. The eastern side of the 'arch' showed the masses of chalk and boulder-clay (the latter exhibiting stratification at a high angle), the rubbly grey chalk described by Mr. Brydone, and the two streaks just mentioned, the upper one

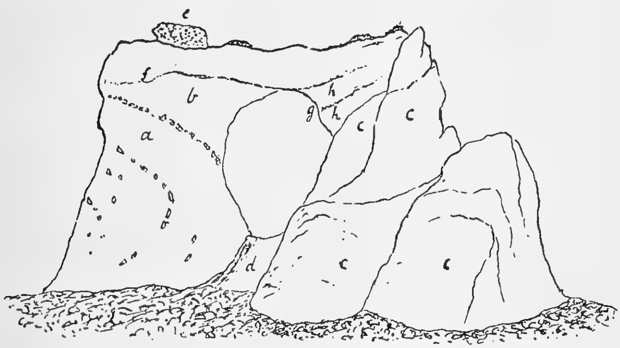


Fig. 2.—Remnant of Bluff near Trimingham, sketched from the Cromer side, April 18, 1906.

a. Chalk with flints.
b. Marly-looking chalk with some flints (probably remanié).
c. Boulder-clay.
d. Boulder-clay showing stratification.
e. Gravel, greatest thickness about 1 foot; little patches of it remain here and there to the right.
f. Gritty streak, generally distinct.
g. Streak, from 2 to 2½ inches thick, of clay with flint pebbles, looking like rearranged boulder-clay.
h. Marly chalk.

being apparently more marly at the seaward end and more gravelly at the other, and the lower one a gravel. Overlying the grey chalk (near the former end) was a patch of coarse gravel—perhaps a foot thick—remnants of which could be detected on the landward side. On the upper part of the sloping face of the second mass (C) we failed to discover any traces of the gritty or gravelly seam [1] between the grey and the white chalk (that containing *Ostrea lunata*), but a thin seam of fine gravel could be detected at the foot of the slope apparently overlain by the chalk (both grey and white) and overlying boulder-clay, a mass of which formed a kind of abutment,

[1] We attach no particular importance to its absence and do not dispute Mr. Brydone's observation.

rising to a height of a few inches from the shore-shingle and apparently supporting one or two outlying fragments of chalk. Boulder-clay, as shown in Mr. Mallet's photograph of 1905, underlay both the landward end of the mass C and the curved slab E.[1] That these two might be connected beneath the beach now seemed more probable than in 1905, but, if so, the mass must be strangely twisted, and the same would be true of the thin slab exposed in the cliff above.[2] In this case, however, the very great thickness of the well-bedded gravel underlying this slab on the more western side would be very difficult to explain, and we think it far more probable that the latter at any rate is a separate boulder.

In short, I cannot accept the principal points in Mr. Brydone's reading of this section—that any of these chalk masses are sea-stacks, or the gritty seam is a Cretaceous deposit, or the grey chalk is part of a mass *in sitû*. If it be, its position at the top and bottom of the sloping face of the mass C is a great and by no means the only difficulty. Much of this grey chalk has the appearance of remanié material.[3] That it has not been derived from rock quite identical with the white chalk below I fully believe, for I think that at this place two or three boulders have been dropped so as to be once or twice in actual contact, as has happened in at least one instance between the two Runton Gaps. I have often seen chalk fallen from a cliff which, were it frozen, transported, and then buried where clay or grit was accumulating, would present just the appearance of this grey chalk in the places we have described. We must also not forget the possibility of grey chalk from the higher part of a cliff falling on the top of white chalk from the lower part, when the two might be frozen together and transported as one block. In fact, I consider these boulders, like those near the Sidestrand Hotel, one or two of which are still visible, to be of "quite local origin" (p. 16). I differ also from Mr. Brydone in supposing that, while by a singular chance the present sea-line so nearly corresponds with that in pre-Glacial time, a chalk upland lay on the northern and the sea itself on the southern side. Neither can I understand how the Mundesley well section drives "a final nail into the coffin of the erratic theory" (p. 125), seeing that I have always looked in this direction for the chalk cliffs from which the erratics were derived.[4]

The two chalk masses nearer Mundesley—the south bluff of previous writers—were not so well exposed, either on this or on the previous occasion, as at some of Mr. Brydone's visits; the attenuated

[1] This seemed to have been reduced in thickness since our last visit.

[2] See Mr. Brydone's photograph, Pl. V, Fig. 11.

[3] Mr. Brydone says this chalk cannot be remanié because delicate fossils in it are unbroken. But, as we can still see in blocks of chalk fallen from the cliffs, the exterior breaks up into fragments, the interior only cracking, so that the former may get mixed with clay or gravel and yet not be ground up, and the latter be only fissured.

[4] The drift hills inland from east of Mundesley to west of Sheringham are quite high enough to conceal a buried line of pre-Glacial cliffs. One would be glad if it could be ascertained whether the chalk, worked in old pits and now exposed on the new railway cutting between Cromer Station and Overstrand village, is *in sitû* or only a very large erratic.

extension on the Mundesley side of the more eastern mass being only visible at one place, and thus like a separate boulder. We found no evidence (but that might have been due to unfavourable circumstances) in favour of the two forming part of a single mass, traversed by a fault, and thought them, as on previous occasions, more probably both separate and erratics.

In conclusion, Mr. Brydone's reference to our former paper (p. 127) as "dealing somewhat sketchily with the purely stratigraphical aspect of the Trimingham Chalk on apparently very incomplete data," calls for a few comments, because, like Mr. B. B. Woodward's criticism, with which we briefly dealt in the November number for last year, it involves a question in the method of writing papers which is of some importance. Notwithstanding Mr. Brydone's censure, I venture to remark that the study of fossil polyzoa may not be the best schooling for dealing with questions of physical and stratigraphical geology, and that at any rate we did not need to be informed, after committing ourselves to print, that the magnetic and the true north are some twenty degrees apart. We sought to disprove a particular hypothesis, i.e. that the chalk at Trimingham bluff showed, like a monument, how an ice-sheet could bend and pucker up the rock over which it advanced. After visiting the critical section, at intervals during twelve years, we found that the inroads of the sea had at last provided evidence which, in our opinion, was fatal to Mr. Reid's hypothesis and suggested that a group of erratics existed here as elsewhere on the coast. In stating this evidence, for that particular purpose, we considered (and remain of the same opinion) discussions both of minute palæontological details (interesting in their way) and of previous readings of the coast sections to be equally irrelevant. The new evidence was, in our opinion, unfavourable to the sea-stack hypothesis, so nothing was to be gained, except a waste of time and space, by discussing that. Certainly it was one against which we entertained no prejudice, for, could it have been established, it would have been, in our opinion, fatal to the ice-sheet Frankenstein. If a stack of by no means strong chalk could withstand the monster's ramming and rooting, what becomes of the fjords, lake-basins, and similar results of the "minor fury of ice-foam." That spectre, at any rate, would have been exorcised, melting into mists as it sought refuge in the place of its nativity.

We therefore maintain that as our evidence was new, and the scope of our paper limited, any *précis* of the literature of the subject was both needless and otiose. I will even venture to express a belief that this display of literary research threatens to be exalted into a geological fetish. Disinterring past errors, unless it be necessary to confute them, is a thankless process, and the hunting for mare's nests through dust-covered tomes consumes time that could be much better employed in the study of sections; for the contents of these nests but rarely provide a nutritious mental diet. When consciously indebted to others for a fact or an argument, we are bound to acknowledge it, but when the one is new or the other not yet accepted, little, I think, is gained by recounting ancient history. "Most votes" (unless intelligent) do not "carry the day" in science as they do in a Parliamentary election, so that even the opinions of the great men of old do not count for much in questions on which they could not be fully informed. Thus I maintain that while a chapter on the past literature is appropriate and even necessary to a complete memoir on any subject, it is useless padding, and even worse, in a paper which aims at either advancing or disproving one of certain views, the existence of which is a matter of common knowledge. Such a chapter is, I believe, rarely remunerative to the reader, and almost never to the writer. I am quite aware that the expression of such an heretical opinion may shock the sensibility of students more at home in the library than in the field, but am prepared to endure with equanimity even the sort of criticism which Mr. Brydone welcomes as effectual.

III.—Tarns on the Haystacks Mountain, Buttermere, Cumberland.

By R. H. Rastall, M.A., F.G.S., Fellow of Christ's College, Cambridge, and Bernard Smith, B.A., Sidney Sussex College, Cambridge.

(With five Text-figures.)

ALTHOUGH the lakes and larger tarns of the English Lake District have been the subject of much discussion and have given rise to a very voluminous literature, comparatively little has been written on the smaller tarns, and especially on those of the very smallest size, which are so abundant in many parts of the district. It seems to us, however, that the smaller ones are quite as deserving of consideration as the larger, since they present similar phenomena, and their interpretation gives rise to similar difficulties.

During an excursion in the autumn of 1903 we happened to come across a group of small tarns which seemed to be interesting in several respects, and we determined to investigate them fully.

These tarns are situated at considerable elevations, 1,600 or 1,700 feet, on the Haystacks, a mountain which separates the head of the Buttermere-Crummock-Water valley from Ennerdale, to the east of Scarth Gap, the usual pass between the two valleys (Ordnance Survey map, six inch, 69 N.E.). The highest part of the mountain very nearly attains the 2,000 feet contour-line near its western end. It consists of lavas and ashes of the Borrowdale series overlying Skiddaw slates : the lag-plane separating the two formations passes below the great crags on the northern side. The volcanic rocks dip with great uniformity to the south-east, striking transversely to the watershed, thus forming a good example of a plagioclinal ridge. The summits are very rugged, and the side towards Warnscale, the head of the Buttermere valley, shows some fine crags, several hundred feet high.

The upper surface of the mountain is extremely irregular, and consists of small peaks and pinnacles, enclosing numerous hollows, in some of which are small tarns and in others extensive peat-bogs.

This upper surface is well glaciated, and the *roches moutonnées* are exceptionally good. The ice has undoubtedly moved from the south-east, down the slopes of Brandreth and Grey Knotts, which form a continuation of the Haystacks ridge in this direction, and reach a considerably higher elevation.

Two of the tarns on this mountain are of considerable size, and there are also one or two much smaller pools which show some interesting features.

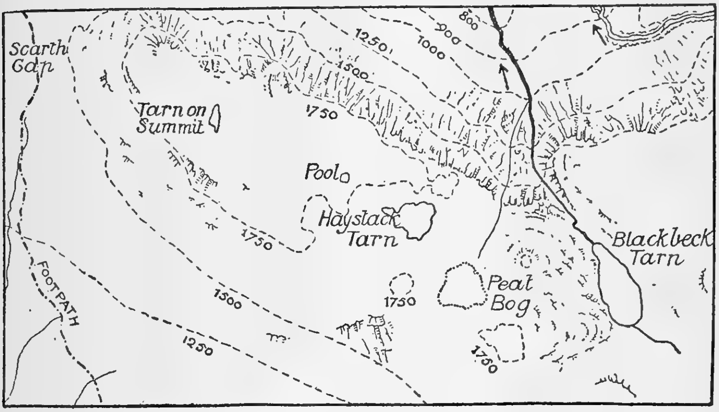


Fig. 1.—Contour Map of Haystacks Mountain, showing position of tarns and peat-bog. Scale 6 inches to 1 mile.

(1) Blackbeck Tarn.—This tarn is the only one which is dignified with a distinctive name on the six-inch Ordnance Map. It is a sheet of water some 250 yards long by 100 yards wide, and is situated towards the south-eastern end of the Haystacks, very near to the edge of the crags, and it drains over the lowest point of the crags into Warnscale.

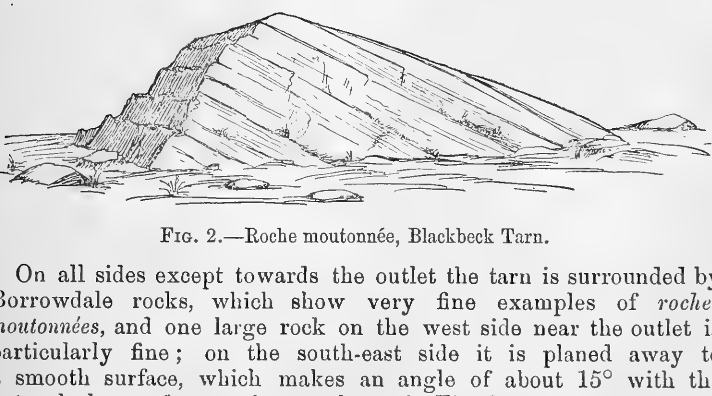


Fig. 2.—Roche moutonnée, Blackbeck Tarn.

On all sides except towards the outlet the tarn is surrounded by Borrowdale rocks, which show very fine examples of *roches moutonnées*, and one large rock on the west side near the outlet is particularly fine; on the south-east side it is planed away to a smooth surface, which makes an angle of about 15° with the natural planes of separation, as shown in Fig. 2.

At its upper end the tarn is being gradually filled up in the usual manner by stream deltas, but since the gathering-ground is so small this must naturally be a slow process. It seems to be much assisted by vegetation, which is more luxuriant than might be expected at such an elevation.

Turning now to a consideration of the outlet, we find several interesting features. No rock is found *in situ* at or near water-level; it is only at some distance down the stream that we first observed any unmistakable rock in place; this is at least seven or eight feet below the surface of the lake. The narrow outflow valley is filled with rounded mounds, which are very suggestive of moraines, although they contain a good many angular blocks.

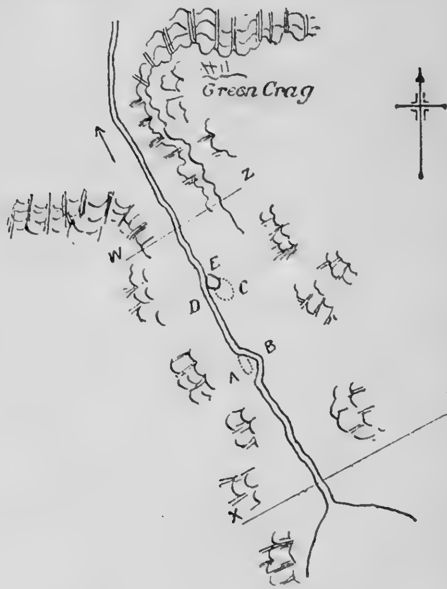


Fig. 3.—Outlet of Blackbeck Tarn.
A, C, old gorges; E, large boulder; B, D, present channel higher than at A, C respectively. Scale about 24 inches to 1 mile.

Many of the loose blocks lying on the surface are similar to the rock *in situ* on either side of the outlet. This suggests that the apparent moraine may in reality be scree, or a mixture of scree and rainwash. On the other hand, many of the boulders in the banks of the stream and in the stream itself are totally different from the rocks on either side, or *in situ* lower down the stream, and we were not able to match them in the immediate neighbourhood. The local rock is a fine-grained, cleaved, and slickensided ash, while most of the boulders proper, which are obviously ice- or water-worn, consist of coarse-grained banded ashes or tuffs, which may possibly have come from Green Gable.

The outflow valley, though narrow in comparison with the width of the tarn, is broad in proportion to the size of the stream; it is bounded by steep walls, and below this comes a nearly level surface, which in parts is slightly convex, suggesting the outline of a moraine; the stream runs at the bottom of a slightly meandering gorge, considerably below the level of this surface.

Further down the slope of the sides becomes much steeper, and the depth of the gorge increases greatly. At two points, A and C, are seen portions of former gorge-like channels at a much lower level than the present stream-bed alongside them (see Fig. 3). The lower of these contains an unusually large boulder of banded ash. It seems probable that these deeper gorges are parts of an old pre-Glacial channel, which was filled up by moraine. It is difficult to imagine that sufficient scree material could be derived from the low side-walls of this valley to make any appreciable difference in the level of the stream. The walls of these deeper gorges consist of rock *in sitû*, while in the present channel none is seen until we reach a point far below the level of the lake, where the stream cascades over the crags.

Fig. 4.—Cross-sections of the outlet of Blackbeck Tarn, along the lines X–Y and W–Z of Fig. 3.

After careful consideration of all the evidence it seems quite clear that this tarn is not a rock-basin, but is held up by some kind of loose material which blocks the outlet, and we incline to the belief that this material is of the nature of moraine rather than scree.

None of the facts above mentioned throw much light on the past history of the tarn, but it seems very probable that if the old partly buried channel could be cleared out the tarn would be completely drained. Unfortunately we have not, up to the present, been able to obtain any soundings, so that the real depth of the water is unknown: judging from the surrounding slopes, it is not likely to be great.

Although it is not possible, with the evidence at present at our disposal, to be quite certain, we think it highly probable that this tarn is entirely of post-Glacial date, and it is to be regarded as the direct consequence of the damming of a small pre-Glacial valley by morainic material.

(2) Haystack Tarn.—The second tarn on the Haystacks is a good deal smaller than Blackbeck Tarn, but still it is of considerable size, covering approximately one and a half acres. It is without a name on the six-inch Ordnance Map, so as a matter of convenience we have named it Haystack Tarn. This tarn is now evidently being rapidly filled up, as shown by the strong growth of rushes and peaty material. It contains several small islands of rock *in sitû*, showing the normal strike of the district, i.e. about E. 30° N. The tarn is

surrounded by very fine *roches moutonnées*, which have evidently been formed by ice advancing from the south, down the slope of Brandreth, from the great gathering-ground which seems to have existed on or near the ridge running eastwards from Great Gable.

The Haystack Tarn at present drains nearly due south, into Ennerdale, by means of a very shallow channel, which looks quite recent; rock may be seen *in sitû* in the channel at almost any point, and if there is any moraine or peat in the channel it cannot be more than one foot deep. This tarn, then, evidently drains over rock at the present time.

But closer examination shows that it is not a rock basin. In the north-east corner is a low opening, which seems to be blocked by loose material of some sort, either scree, or more probably moraine. Rock *in sitû* with the normal strike and nearly vertical dip can be traced close up to the shore at this point, but not by any means continuously, and there is plenty of room for a buried channel between some of the exposures. This old channel, if such it be, is some ten yards broad, and much resembles the upper part of the present outflow channel of Blackbeck Tarn. The ground rises for a few yards from the water's edge, and the highest level in the centre is some 3 or 4 feet above water-level. The cross-section is a smooth curve of the usual type.

This channel leads down without interruption to a low point in the crags on the northern or Warnscale side, exactly like the outflow of Blackbeck Tarn, and, in fact, in every respect completely resembles one of the numerous small valleys of erosion cut into the rugged surface of this mountain.

We have, therefore, no doubt whatever that this tarn owes its existence to the blocking of this channel by loose material of some sort, either scree or moraine, and it seems to be almost certain that this material is moraine; the sides of the channel are so low that it is almost impossible that they can have given rise to sufficient scree. This argument is even stronger here than in the case of Blackbeck Tarn.

Here, again, what appears at first sight to be a rock basin is shown to be nothing of the kind, but to owe its existence to moraine.

This tarn lies at an elevation of some 1,700 feet and about 100 feet above Blackbeck Tarn. On its south-eastern side, and about 10 feet above it, is a very small pool, which may be a true rock basin, but it is so small as to be unworthy of further notice.

(3) At a much higher level than either of the foregoing, in fact only about 15 feet below the highest point of the Haystacks, lies a small pool which presents some interesting features. It is very small, measuring only about 50 yards in length by 15 in width, and its elevation is nearly 2,000 feet. It seems to be quite deep in comparison with its size. This pool has no outlet at all, even in the exceptionally wet weather which prevailed when we were studying this region (August and September, 1903), and it appears to be surrounded on all sides by rock.

The above concludes our description of the tarns of this mountain, but there still remains an interesting feature to describe.

(4) On the southern side of the mountain and south-east of Haystack Tarn is to be seen a large pool of water of peculiar character, which suggests a possible way of formation of small lake-basins. The greater part of this hollow is at present filled by peat-hag of the usual type, and as usual at various levels in different parts, but the central part has been hollowed out by some means and now forms a fair-sized shallow pool; over a considerable area surrounding this is seen an expanse of bare peat only a few inches above the water-level. It is interesting to note that over this bare expanse are scattered a large number of branches or roots of trees, showing that the peat-hag must be of great antiquity.

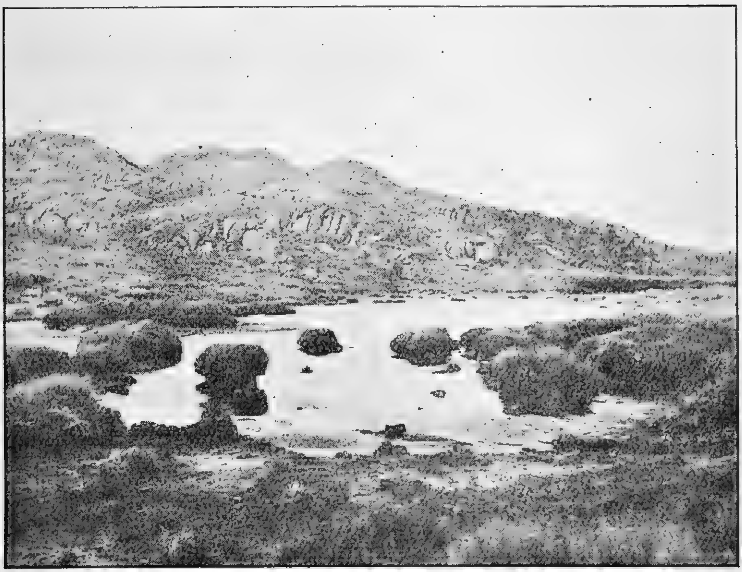


Fig. 5.—Tarn formed by wind-erosion of peat, Haystacks Mountain, Buttermere.

However, the most noticeable feature is the character of the small islands of peat which now project above the water in the pool. These islands are all remarkably undercut and overhanging, and in many cases are penetrated by actual tunnels; in fact, they mimic in a remarkable manner the natural features of a wave-beaten coast, such, for example, as the chalk cliffs of Antrim or Flamborough.

It seems almost certain that this peculiar form has been produced by wave-action, which indeed could be seen almost in active operation at the time of our visit, and it must have been especially potent in such a wet and stormy season as that of 1903. At this great elevation, over 1,800 feet, the wind is nearly always powerful, and this basin lies in a hollow very near the edge of an exceedingly steep slope into Ennerdale, where wind-action would be accentuated. The pool at present drains towards the north, over an outlet blocked to some extent by scree, instead of to the south, as would naturally be expected.

The life-history of this pool may have been as follows:—An old tarn of the ordinary type, due to moraine or scree, was gradually filled up by the growth of peat, as the present ones are now being filled. By some means, possibly owing to excessive rainfall, water began to accumulate on the surface, and this water under the influence of the wind was gradually able to erode a small basin, which is still much smaller than the original extent of the tarn. This excavation may also be assisted by desiccation and removal of matter as dust during dry periods; thoroughly dry peat is a very light material and easily blown away.

That something of the sort has occurred is quite evident, since the presence of wood on the surface clearly proves removal of peat; the chief difficulty is to account for the first formation of the pool of water on the surface. It is possible that an increase of scree material at the original outflow may have caused so great an accumulation of water that the peat could not soak it all up, and some collected on the surface.

In this case wind-action appears to be the primary cause of the present existence of this pool: whether there ever was a tarn here before is quite immaterial; all that the theory requires is a sufficiently level peat-bog, however formed. In any case some physical change seems necessary to cause a reversal of the usual process of accumulation of peat, but many reasons could be given for such a change, such as blocking of an outlet by landslips or scree, or capture of a larger drainage area by a feeder, and so on.

On the whole this idea seems worthy of consideration as a possible cause of the formation of lake-basins, at any rate, on a small scale; it seems especially likely to occur in cols and narrow passes, where the force of the wind is concentrated.

IV.—The Zones of the Lower Chalk.

By T. O. Bosworth, B.A., St. John's College, Cambridge.

THE object of this paper is to suggest some modification of the present zoning of the Lower Chalk.

I. Disadvantages of using *Holaster subglobosus*.

This fossil is at present supposed to characterise the Chalk between the zones of *Ammonites varians* and *Actinocamax plenus* (= *B. plena*), but its unsuitability is evident from the following summary of its occurrences:—

In Dorset and Devonshire *Holaster subglobosus* occurs in the zone of *Ammonites varians* and is absent from the Chalk above.

In Hampshire, Wiltshire, Isle of Wight, Sussex, and Kent it is nearly as common in the zone of *A. varians* as it is in the beds above. Except in the Isle of Wight, it is not recorded from the upper part of these beds.

In Berkshire, Oxfordshire, Suffolk, and Cambridgeshire, where the zone of *H. subglobosus* is typically developed, it is my experience that the zone fossil is absent from the upper half of the 80 feet of Chalk above the Burwell Rock. It is associated with *A. varians* in the Burwell Rock.

In Lincolnshire and Yorkshire *H. subglobosus* is abundant in the zone of *A. varians*, but so rare in the beds above that *Offaster sphericus* is used as the zone fossil in its stead.

In France *A. rotomagensis* is used as the zone fossil.

II. On the True Position of the Burwell Rock.

This bed appears to have been placed in the *H. subglobosus* zone for two reasons:—

(1) It contains occasional *H. subglobosus*.

(2) There is a lithological change on passing from the Chalk Marl into the Burwell Rock.

These arguments are neither of them sound. Regarding the first, we have seen that *H. subglobosus* is to be expected in the *A. varians* zone, and *A. varians* itself is common in the Burwell Rock. As regards the second, the change is often a very gradual one, and the practice of relying on lithology is only a relic of darker ages. There is quite as great a change on passing up out of the Burwell Rock into the Chalk above. Moreover, grey chalk rock beds of very similar nature are included in the upper part of the *A. varians* zone of Southern England. The fauna of the Burwell Rock is a large one, while those of the Chalk Marl beneath it, and the Chalk above it, are both small. But, of these two, that of the Chalk Marl is more nearly allied to the Burwell Rock fauna than is that of the Chalk above the Burwell Rock.

The fauna of the Chalk Marl of Cambridge and Suffolk, as recorded in the General Memoir,[1] 1903, together with *Nautilus elegans*, which I have found at Mill Road, consists of 4 Cephalopods, 2 Echinoids, 9 Brachiopods, 7 Lamellibranchs, 2 Annelids, and one fish. And of these 25 species, all save *Terebratulina triangularis* and *Serpula amnulata* occur in the overlying Burwell Rock, i.e. 92 per cent. of the species are common to both.

In the Chalk above the Burwell Rock the fauna as recorded in the General Memoir, together with several species not hitherto recorded (to which reference will be made), consists of—

6 Cephalopods,	of which	5	are recorded from the Burwell Rock;
7 Echinoids	,,	3	,, ,,
8 Brachiopods	,,	8	,, ,,
17 Lamellibranchs	,,	12	,, ,,
1 Annelid	,,	1	,, ,,
2 Polyzoa	,,	0	,, ,,
6 Fishes	,,	4	,, ,,
4 Reptiles	,,	0	,, ,,

i.e., of these 51 species only 33 are recorded from the Burwell Rock; i.e., 67·4 per cent. of the species are common to both.

[1] "General Memoir on the Cretaceous Rocks of Britain," vol. ii (1903).

The Echinoids which are not found in the Burwell Rock are *Cidaris Bowerbankii, C. hirudo, Echinocyphus difficilis*, and *Holaster trecensis*. The first and last of these are abundant. A large variety of *Discoidea cylindrica* is also common, and seems distinct from the smaller variety recorded from the beds below. The teeth of *Ptychodus decurrens* are common in the Chalk, but very rare in the Burwell Rock.

[The subjoined Diagram (Fig. 1) shows the comparative thickness of the zones under the suggested system. The localities chosen do not lie very far from a mean straight line. The distances between the columns roughly represent the distances between the points on the straight line which most nearly represent the positions of the towns named. Vertical scale is 1 cm. = 30 feet. (The Burwell Rock is indicated in black.)]

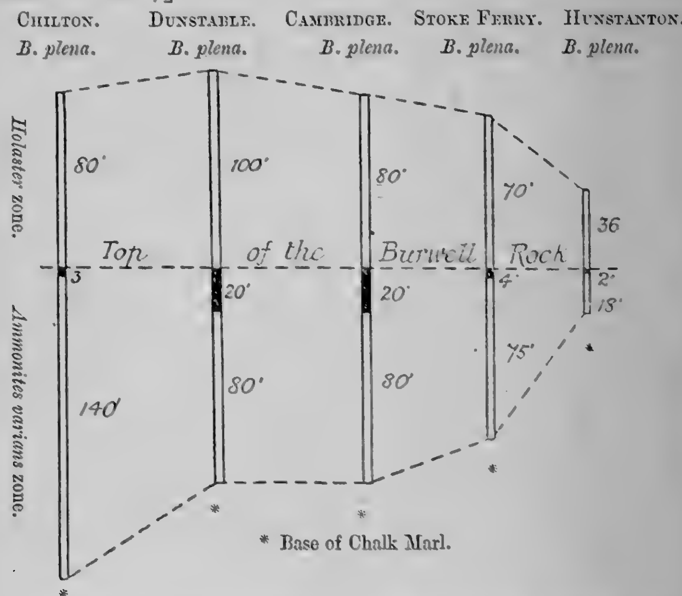


FIG. 1.—Comparative thickness of Zones of the Lower Chalk under suggested system.

Thus there seems to be a much more definite faunal change on passing up *out of* the Burwell Rock than on passing up *into* it. Now the zone of *A. varians* in Southern England contains a very rich fauna, but as we pass north of the Thames the fauna of the Chalk Marl becomes smaller and smaller, while the thickness of the Burwell Rock increases until in Cambridgeshire, where the Burwell Rock has its maximum thickness, the fauna of the Chalk Marl has dwindled down to 23 species. The explanation is that the Burwell Rock is really the most fossiliferous part of the *A. varians* zone, and by placing it in the *H. subglobosus* zone we endow that zone with an abnormally rich fauna and impoverish that of the *A. varians* zone. The fauna of the Burwell Rock is one typical of the zone of *A. varians*, and is practically identical with that of the shelly beds in the upper part of that zone in Kent.

Of the 16 Cephalopods (including *Baculites baculoides*, not recorded in the General Memoir, but which I find common at Fulbourn), 9 Echinoids, 10 Brachiopods, 11 Gasteropods, 25 Lamellibranchs, and 2 Corals, all occur in the zone of *A. varians* of Southern England, with the exception of *Nautilus reflectus* and 6 Lamellibranchs, of which I can find no record except occurrence at Burwell. *A. varians* itself is more plentiful in the Burwell Rock than in the underlying Chalk Marl.

This figure (Fig. 2) shows the comparative thickness of the zones under the present system :—

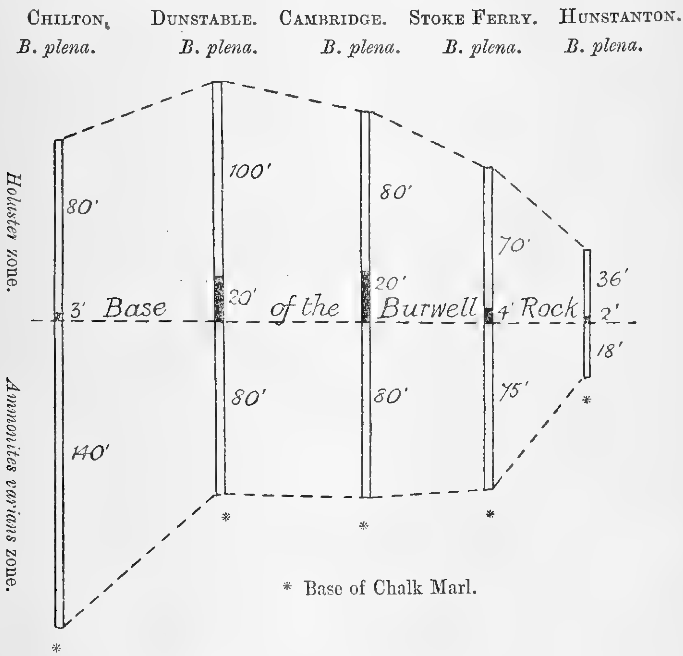


Fig. 2.—Comparative thickness of Zones under present system.

If, on the strength of these arguments, the Burwell Rock be relegated to the *A. varians* zone as a mere facies of Chalk Marl, the thinning of the Lower Chalk towards the north-east is somewhat simplified (see Figure), the thickness of the two zones decreasing more uniformly and simultaneously. The most convenient place to draw the line of separation is the well-marked band of *Rhynchonella Mantelliana*. This occurs a few feet above the Burwell Rock, and contains the *A. varians* zone fauna. The fossils are extremely numerous in this bed, consisting principally of large specimens of *R. Mantelliana, Serpula umbonata, Terebratulina nodulosa,* and *Cidaris dissimilis.*

III. On *Holaster trecensis.*

In Dorset and Devon this fossil is plentiful in the beds above the *A. varians* zone, *H. subglobosus* itself being absent. *H. trecensis* is almost confined to the zone and could well be used as the zone fossil.

In Hants, Sussex, Kent, and Isle of Wight, this fossil is common throughout the zone from base to summit, and is only occasionally found in the Chalk Marl.

In Yorkshire *H. trecensis* is not found.

In Lincolnshire *H. trecensis* is found above the Burwell Rock, and it is also recorded from the Chalk Marl, but I do not know whether it is common at that horizon.

In Cambridgeshire *H. trecensis* is not yet recorded except from Shelford, in the General Memoir (op. cit., 1903). But examination of the Lower Chalk of this county during the past three years has shown to me that this fossil is remarkably abundant, being much more common than *H. subglobosus.* In fact, there appear to be two very distinct zones in Cambridgeshire in this 80 feet of Chalk—the upper half (about 40 feet) abounding in *H. trecensis,* but with no *H. subglobosus*; the lower half with *H. subglobosus* and no *H. trecensis.*

I have found *H. trecensis* in the great pit at Cherry-Hinton in the upper part of the Lower Chalk, which has not been worked for many years, also at Shelford in abundance, and most plentifully in the pit on the Golf Links. In this latter locality the zone of *Actinocamax plenus* and the upper 35 feet of the so-called *H. subglobosus* zone are quarried. Fossils are on the whole very scarce, but I have found *H. trecensis in situ* from the bottom of the section up to within a foot of the *Actinocamax plenus* (= *B. plena*) zone. I have also had all the fossils from the workmen for the past two years.

The following is a list of the species, with the number of specimens obtained:—

Pisces.	
Otodus appendiculatus (tooth)	1
Ptychodus decurrens ,, ...	3
**Oxyrhina Mantelli* ,, ...	1
Vertebræ and scales	numerous
Crustacea.	
**Enoploclytia Imagei*	very numerous
Echinoidea.	
Holaster trecensis	77
**Discoidea cylindrica*	7
**Cidaris Bowerbankii* (spines)	6
Brachiopoda.	
Terebratula semiglobosa	4

LAMELLIBRANCHIATA.

**Dimydion Nilssoni* (=*Plicatula sigillina*) (attached to test of *Holaster*)	2
Ostrea vesicularis	very numerous
**Ostrea filata*	" "
Pecten Beaveri	7
Inoceramus sp.	3
Spondylus latus	1
**Teredo*, sp. nov. (?)	a group

POLYZOA.

**Proboscina*	1
**Stomatopora* (?)	numerous

ANNELIDA.

**Serpula umbonata*	1

NOTE.—Those marked with an asterisk (*) have not been previously recorded from the "Chalk above the Burwell Rock" of Cambridgeshire and Suffolk.

There are several points of interest about this fauna.

(1) The specimens of *Discoidea* are of very unusual size (base $2\frac{1}{4}$ inches in diameter). I can find no record of any so large as this.

(2) The tubes of *Teredo* are very fine and probably belong to a new species.

(3) The absence of *Rhynchonella*, although abundant in the zone of *B. plena* just above.

(4) No specimen of *Holaster subglobosus* has occurred.

(5) *H. trecensis* is unusually abundant, the test being thin, and taken with the rest of the fauna suggesting deeper water.

(6) *Ostrea filata* here includes two forms previously supposed distinct. The left valves are very abundant, occurring attached to specimens of *Holaster*. They have hitherto been erroneously ascribed to *Ostrea vesiculosa*. An excellent figure may be seen in Dr. S. P. Woodward's paper (GEOL. MAG., 1864, p. 114, Plate V). But they have little resemblance to the original *Ostrea vesiculosa* from the Upper Greensand of Warminster described and figured in Sowerby's Mineral Conchology (vol. iv, pl. 369) as *Gryphæa vesiculosa*, and afterwards found to be an *Ostrea*. The right valves have hitherto been referred to as *Avicula filata*, a species described by Etheridge. The type-specimen and three others, all from the Burwell Rock of Burwell, are in the Sedgwick Museum. I find it quite common in the Burwell Rock at Fulbourn.

In the monograph of the "Cretaceous Lamellibranchs of England" Mr. Henry Woods makes the following remark on this species (footnote, p. 61, vol. ii, part 2): "I am unable to accept the generic position assigned to this species by Etheridge; it may be an *Ostrea*."

Though the left valves (*Ostrea vesiculosa*) are so plentiful I have only found two right valves (the so-called *Avicula filata*). But one of these is in position attached to the left valve of the so-called *Ostrea vesiculosa*, which is itself along with several other left valves attached to a specimen of *Holaster trecensis*.

Mr. Woods has closely examined these specimens, and is satisfied that *Avicula filata* and the so-called *Ostrea vesiculosa* are right and left valves of the same shell.

This fossil therefore cannot be called either *Avicula filata* or *Ostrea vesiculosa*, for in the former the generic name is incorrect, and in the latter the specific name already belongs to an entirely different species from Warminster. The obvious course is to call it *Ostrea filata*.

IV. The 'Lower Holaster Zone.'

A brief comparison of the values of the two Holasters for zonal purposes may be made as follows:—

Holaster subglobosus.

(1) Does not often reach the top of its zone.
(2) In the type locality it only reaches half way.
(3) Is sometimes entirely absent from the zone.
(4) Is generally abundant in the zone below.

Holaster trecensis.

(1) Occurs up to the summit of the zone.
(2) Is rarely absent, but in Cambridgeshire does not occur in the lower half of the zone of *H. subglobosus*.
(3) Is very rarely found associated with *A. varians*.

Thus neither of these fossils is really fitted for zonal use, and of the two, *H. subglobosus* is the least suitable. But a fairly satisfactory zone might be defined as the 'Lower Holaster Zone' by using the two Holasters in partnership; for one or other of them is nearly always present in every part of the Chalk which occurs between the zone of *A. varians* and *B. plena* throughout Britain.

The following arrangement of the Chalk of Cambridgeshire is therefore recommended:—

Micraster zones ... ... *Holaster planus* zone ...	Upper Chalk and Chalk Rock and *Holaster planus* beds.
Terebratulina lata zone ... *R. Cuvieri* zone ... ... *Inoceramus labiatus* zone ... *B. plena* zone	Middle Chalk, Melbourn Rock, and Belemnite Marls.
Two Holasters Zone ...	Chalk with *H. trecensis*. Chalk with *H. subglobosus*.
A. varians zone	Burwell Rock. Chalk Marl.

NOTICES OF MEMOIRS, ETC.

I.—British Association for the Advancement of Science. Seventy-Sixth Annual General Meeting, held at York, August 1st to 8th, 1906.

President: Professor E. Ray Lankester, M.A., LL.D., D.Sc., F.R.S., F.L.S., Director of the Natural History Departments of the British Museum.

List of Papers Read in Section C, Geology.

Address by the President (G. W. Lamplugh, F.R.S.).

Professor P. F. Kendall.—On the Geology of the Country round York.

J. W. Stather.—Report of the Committee on Drift Deposits at Kirmington, etc.

W. G. Fearnsides.—On the Lower Palæozoic Series at Pomeroy.

H. Culpin & G. Grace.—Recent Exposures of Glacial Drift at Doncaster and Tickhill.

E. Greenly.—Report of the Committee on the Crystalline Rocks of Anglesey.

H. Brodrick.—On Faults as a predisposing cause for the existence of Pot-holes on Ingleborough.

C. G. Danford.—Notes on the Speeton Ammonites.

J. Parkinson.—The Post-Cretaceous Stratigraphy of Southern Nigeria.

Professor T. W. Edgeworth David, F.R.S.—Occurrence of the Diamond in the Matrix near Inverell, New South Wales.

Dr. F. H. Hatch.—On the 'Cullinan' Diamond.

T. H. Holland, F.R.S.—On a peculiar variety of Sodalite from Rajputana.

J. Lomas, Dr. A. Smith Woodward, F.R.S., H. C. Beasley.—Report of the Committee on the Fauna and Flora of the Trias.

A. Wilmore.—A contribution to our knowledge of the Limestone Knolls of Craven.

Professor E. J. Garwood.—On the Faunal Divisions of the Carboniferous Rocks of Westmoreland.

Dr. Wheelton Hind.—Report of the Committee on Life-Zones in the British Carboniferous Rocks.

Dr. A. Vaughan.—Report of the Committee on the Faunal Succession in the Carboniferous Limestone of the South-West of England.

Dr. Henry Woodward, F.R.S.—Arthropods from the Coal-measures.

A. C. Seward, F.R.S.—The Jurassic Flora of Yorkshire.

A. C. Seward, F.R.S.—Report of the Committee on the Fossil Flora of the Transvaal.

Professor G. A. J. Cole.—The Teaching of Geology to Agricultural Scholars.

Dr. F. A. Bather.—Notes on the "Index Animalium."

F. W. Harmer.—The Glacial Deposits of the East of England.

F. W. Harmer.—'Lake Oxford' and the Goring Gap.

M. B. Cotsworth.—On the Continuous Glacial Period.

Professor J. Milne, F.R.S.—Certain Earthquake-relationships.

Discussion on the Origin of the Trias, opened by Professor T. G. Bonney, F.R.S., and J. Lomas.

Professor T. W. Edgeworth David, F.R.S.—Notes on the Coal-measures of New South Wales.

Professor J. W. Gregory, F.R.S.—The Problems of the Palæozoic Glaciations of Australia and South Africa.

Professor E. Hull, F.R.S.—On an Artesian Boring for the Water-supply of the City of Lincoln from the New Red Sandstone.

Professor T. W. Edgeworth David, F.R.S.—Further Note on the Occurrence of Diamond in New South Wales.

Professor J. W. Gregory, F.R.S.—Report of the Committee on the Correlation and Age of South African Strata.

Professor W. W. Watts, F.R.S.—Report of the Committee on Geological Photographs.

Dr. H. Johnston-Lavis.—Recent Observations at Vesuvius.

R. D. Oldham.—A Criterion of the Glacial Erosion of Lake-basins.

Rev. W. Lower Carter.—Notes on the Glaciation of the Usk and Wye Valleys.

Professor S. H. Reynolds.—A Silurian Inlier in the Eastern Mendips.

Professor P. F. Kendall.—Report of the Committee on the Erratic Blocks of the British Isles.

T. Sheppard.—On a Section of a Post-Glacial Deposit at Hornsea.

W. H. Crofts & Professor P. F. Kendall.—The Plain of Marine Denudation beneath the Drift of Holderness.

Professor S. H. Reynolds.—Igneous Rocks of the district south-west of Dolgelly.

Professor S. H. Reynolds.—A Picrite from the Eastern Mendips.

J. Lomas.—On the form of Carbonate of Lime in Pearls and the Pearl Oyster.

Titles of Papers read in other Sections bearing upon Geology :—

Section A.—Mathematical and Physical Science.

Address by the President (Principal E. H. Griffiths, Sc.D., F.R.S.).

Reports of Committees.

Major E. H. Hills, C.M.G., & Professor J. Larmor, Sec. R.S.—The Irregular Motions of the Earth's Pole: a preliminary graphical Analysis of their causes.

The Hon. R. J. Strutt, F.R.S., opened a discussion on Radio-activity and the Internal Structure of the Earth.

Section B.—Chemistry.

G. Beilby.—The Crystallisation of Gold in the Solid State.

T. Jamieson, F.I.C.—Utilisation of Nitrogen in Air by Plants.

Section D.—Zoology.

Address by the President (J. J. Lister, M.A., F.R.I.).—The Life-history of the Foraminifera.

Professor Gary N. Calkins.—The Protozoan Life Cycle.

Report of the Committee on Naples Zoological Station.

Report of the Committee on "Index Animalium."

Report of the Committee on Development of Ophiuroids, etc., at the Marine Laboratory, Plymouth.

Professor E. A. Minchin.—Spicule-Formation.

Dr. C. W. Andrews, F.R.S.—The Milk Dentition of the Primitive Elephants.

Arnold T. Watson.—The Habits of Tube-building Worms.

J. E. S. Moore.—Halolimnic Faunas and the Tanganyika Problem.

A. D. Darbishire. — Preliminary note on a New Conception of Segregation.

Section E.—Geography.

Address by the President (the Right Hon. Sir G. T. Goldie, F.R.S.).—Geography and Geology.

Clement Reid, F.R.S.—Changes on the Coasts of the British Isles.

J. Stanley Gardiner.—Report of the Committee for Investigations in the Indian Ocean. The Chagos Islands, Indian Ocean.

J. Parkinson.—The Structure of Southern Nigeria.

John Thomson.—Geographical Photography.

R. N. Rudmose Brown.—The Geography of the South Orkneys and other parts of the Antarctic Region.

Professor A. B. Macallum, F.R.S.—Report of the Committee on the Quantity and Composition of Rainfall and of Lake and River Discharge.

Professor W. B. Bottomley.—The Limestone Caves of Western Australia.

SECTION H.—ANTHROPOLOGY.

Report of the Committee to Investigate the (Prehistoric) Lake-Village at Glastonbury.

J. R. Mortimer.—On the Relative Stature of the Men with Long Heads, Short Heads, and those with Intermediate Heads, in the Museum at Driffield.

Harold Brodrick & C. A. Hill.—On a recently discovered Skeleton in Scoska Cave, Littondale.

F. W. Rudler, I.S.O. — The 'Red Hills' of the East Coast Salt Marshes.

Miss Nina F. Layard.—A Winter's Work on the Ipswich Palæolithic Site.

Rev. R. Scott-Gatty.—Pygmy Flints from Yorkshire and Lincolnshire.

Report of the Committee to conduct Explorations with the object of ascertaining the Age of Stone Circles.

SECTION K.—BOTANY.

Address by the President (Professor F. W. Oliver, M.A., F.R.S.).—The Seed a Chapter in Evolution.

Reports of the Committees on Botanical Photographs, on Peat Moss Deposits, and on the Structure of Fossil Plants.

C. E. Moss, M.Sc.—Succession of Plant-Formations in Britain.

Dr. D. H. Scott.—Some Aspects of the Present Position of Palæozoic Botany.

Professor F. E. Weiss.—On the Occurrence, Distribution, and Mode of Formation of the Calcareous Nodules found in Coal-seams of the Lower Coal-measures.

Miss M. C. Stopes, D.Sc., Ph.D.—On the 'Coal-balls' found in Coal-seams.

Professor F. E. Weiss.—A *Stigmaria* of unusual type.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. MEETING AT YORK, AUGUST 1ST TO 8TH, 1906. PAPERS READ BEFORE SECTION C, GEOLOGY.

THE LOWER PALÆOZOIC ROCKS OF POMEROY. By WILLIAM G. FEARNSIDES, M.A., F.G.S.

The Pomeroy district was originally monographed by Portlock between 1838 and 1845, and has since been neglected. Its lower

Palæozoic succession includes both Ordovician and Silurian rocks, and rests unconformably upon a much older series of hornblendic and pyroxenic gneisses and schists, into which masses of granite were intruded in pre-Silurian time.

The succession may be tabulated as follows:—

C. Corrycroar Group: Tarannon (Gala Facies):—Variable green and grey flags and shales with purple and green grits and conglomerates. (*Undivided.*)

B. Little River Group: Llandovery (Birkhill Facies): Lime Hill Beds:—Black, blocky, micaceous mudstones, with light-coloured calcareous bands. Zone of *Monograptus Sedgwickii* with subzone of *Petalograpti.*—Mullaghnabuoyah Beds:—Variable grey shales and flaggy shales with pyritous spots and a few dark bands. Zone of *Monograptus triangulatus* (sp. ?).—Edenvale Beds:—Smooth, grey shales with black mudstone bands. Zone of *Monograptus tenuis.*—Upper Slate Quarry Beds:—Dark cuboidal mudstones, hard and calcareous. Zone of the *Dimorphograpti.*—Lower Slate Quarry Beds:—Soft, blue-grey, papery, micaceous flags. Zone of *Diplograptus modestus.*—Crocknagargan Beds:—Smooth, grey, pyritous shales. Zone of *Cephalograptus acuminatus.*

A. Desertcreate Group: Ashgillian Drummuck Facies: Upper Tirnaskea Beds:—Smooth, banded, green and dark mudstones. Zone of *Dicellograptus anceps.*—Lower Tirnaskea Beds:—Tough, blocky, calcareous grits. Zone of *Dicellograptus complanatus* and *Phacops mucronatus.*—Upper Killey Bridge Beds:—Soft, calcareous, grey mudstones, with *Remopleurides* and *Diplograptus truncatus.*—Lower Killey Bridge Beds:—Soft, ferruginous blue or yellow mudstones, with many *Trinucleus* and *Ampyx.*—Upper Bardahessiag Beds:—Hard and calcareous flags and grits with *Lichas, Phacops hibernicus, Staurocephalus,* etc., and *Strophomena.*—Lower Bardahessiag Beds:—Softer, uncompacted grits, sandstones, and conglomerates, with large *Strophomena* and occasional *Orthis.*

The Desertcreate Group finds its closest parallels in the Drummuck Beds of Girvan, while the Little River Group is most like the Birkhill shales of Moffat. The whole series is overlain unconformably by the Dingle Beds of the local Old Red Sandstone, and, with the formation, has been folded into a remarkable series of shallow isoclines trending a little south of east and north of west and having a general southerly pitch. The total thickness of Desertcreate and Little River Groups together does not exceed 500 feet.

REVIEWS.

I.—Elements of Mineralogy. By Frank Rutley, F.G.S. Fourteenth edition, revised and corrected. Demy 8vo; pp. 251, viii. (London: Thomas Murby & Co.)

This little book forms one of the series of textbooks issued by the publishers to meet the requirements of the Science and Art Department, and its popularity is sufficiently indicated by the fact that a fourteenth edition has been called for. It treats in concise and simple style of the properties and characters of minerals, and is suited to the needs of those who desire to acquire sufficient knowledge to enable them to identify any specimen that may come into their hands, and are not concerned with the more abstruse questions underlying the phenomena of crystallisation. In the present edition the discussion of the optical properties is based on the ideas put forward by Mr. L. Fletcher in his "Optical Indicatrix," and an excellent chapter on radio-active elements has been added by Mr. E. H. Adye. The author completed the revision of the proof-sheets only just before his lamented death in 1904.

II.—Annals of the South African Museum. Vol. IV, Part 4: The Trilobites of the Bokkeveld Beds. By Philip Lake, M.A., F.G.S. 8vo; pp. 201–220, with 5 plates and 1 text-figure. (West, Newman, & Co., London, 1904.)

As far back as 1856 J. W. Salter gave an account of the Trilobites of the Bokkeveld Beds as an appendix to Bain's paper "On the Geology of South Africa" (Trans. Geol. Soc., ser. II, vol. vii), since which time but little has been added to our knowledge of these South African forms. Dr. H. Woodward described (1873) a remarkable species from the Cock's-comb Mountains (Q.J.G.S., vol. xxix), and Dr. French (1897) figured a *Homalonotus* which he believed to be new (Lethæa Geognostica, Th. i, Bd. ii, Lief. 1).

The fine collection here described includes a number of new forms, of which by far the most remarkable is the gigantic *Homalonotus colossus*, sp. nov.

The author has fortified his views as to the affinities of the species he has described by examining the specimens in the British Museum and in the Museum of the Geological Society of London, which contain Salter's types.

The following species are recognized and described :—

Phacops pupillus, sp. nov.
Ph. arbuteus, sp. nov.
Ph. crista-galli (H. Woodw.).
Ph. Africanus, Salter.
Ph. ocellus, sp. nov.
Ph. impressus, sp. nov.
Ph. (*Cryphæus*) *caffer*, Salter.
Phacops (?) sp.
Dalmanites lunatus, sp. nov.
Dalmanites sp.
Proctus malacus, sp. nov.
Typhloniscus Baini, Salter.
Homalonotus Herscheli, Murch.
H. quernus, sp. nov.
H. colossus, sp. nov.
H. sp.

The presence of a true *Cryphæus* and of spiny forms of *Homalonotus* indicates that the beds may be referred with certainty to the Devonian, and probably to the lower division of that formation.

Few of the forms have any very near allies in Europe. The Phacopidæ are more closely allied to the forms described from Brazil by J. M. Clarke and from Bolivia by A. Ulrich than to any European ones. A. H. F.

III.—Cambrian Faunas of China. By Charles D. Walcott. From Proceedings United States National Museum, vol. xxx, pp. 563–595. 8vo. (Washington, 1906.)

THIS is the second preliminary paper on the Cambrian Faunas of China. In the first paper (Proc. U.S. Nat. Mus., xxix, Sept., 1905, pp. 1–106) a historical introduction was given along with a list of the species known at the time of publication.

During the summer of 1905 a collection made by Mr. Eliot Blackwelder was received, which came chiefly from the provinces of Shen-si and Shan-si. This collection has afforded a number of new species, but has not added otherwise to the knowledge of these faunas already acquired except as to the occurrence of the genus *Coscinocyathus.*

The full report is expected to be published before the close of the present year (1906).

The association of genera and species is given in the list below (all the species are new):—

Upper Cambrian (Ch'au-mi-tien formation) ....
- Brachiopoda:
  - *Discinopsis sulcatus.*
- Trilobita:
  - *Anomocare*, species undetermined.
  - *Anomocarella irma.*
  - *Ptychaspis bella.*

Middle Cambrian (Ku-shan formation) ....
- Trilobita:
  - *Blackwelderia cilix*, Walcott.
  - *Agraulos regularis.*

Middle Cambrian (Ch'ang-hia (Ki-chóu) formation)
- Anthozoa:
  - *Coscinocyathus elvira.*
- Brachiopoda:
  - *Obolus* (*Lingulepis*?), species undetermined.
  - *Yorkia*? *orientalis.*
  - *Orthis* (*Plectorthis*) *agreste*, *O.* (*P.*) *Kichouensis*, *O.* (*P.*) species undetermined.
- Gasteropoda:
  - *Scenella*? *dilatatus.*
  - *Platyceras Willisi.*
  - *Stenotheca*?? *simplex.*
- Trilobita:
  - *Dorypyge Richthofeni lævis.*
  - *Agraulos armatus*, *A. nitida*, *A. obscura*, *A. uta*, *A. vicina.*
  - *Agraulos* (?)[1] *capax*, *A.* (?) *melie.*
  - *Anomocare Bigsbyi*, *A. eriopia*, *A. flava.*
  - *Anomocarella contigua.*
  - *Ptychoparia comus*, *P. inflata*, *P. lilia*, *P. nereis*, *P. undata*, *P. vesta*, *P.* species undetermined.
  - *Ptychoparia* (?) *maia.*
  - *Ptychoparia* (*Liostracus*) *intermedia*, *P.* (*L.*) *subrugosa.*
  - *Solenopleura pauperata.*
  - *Dolichometopus hyrie.*

The fauna of the Ku-shan shale includes species of *Damesella*, *Dorypyge*, and genera that are typical of the Middle Cambrian fauna, while the fauna of the Ch'au-mi-tien limestone, above the Ku-shan

[1] Interrogation points within parentheses indicate undetermined subgenera.

shale, is more nearly related to that of the Upper Cambrian of North America and North-Western Europe. A. H. F.

[*Note.*—In connection with the Cambrian fauna of China we may refer our readers to two papers: (1) by Mr. G. C. Crick, "On some Straight-shelled Nautiloidea of Cambro-Silurian age from Shantung," Geol. Mag., 1903, pp. 481–485, Pl. XXII and Figs. 1–3; (2) by H. Woodward, "Trilobites from the Upper Cambrian of Shantung," Geol. Mag., 1905, pp. 211–215, and pp. 251–255, Pl. XIII, and Figs. 1, 2.—Edit. Geol. Mag.]

IV.—Geological Survey of India. General Reports (*a*) for the period April, 1903, to December, 1904; (*b*) for the year 1905. By T. H. Holland, F.R.S., Director. Records, vol. xxxii, parts 3, 4; vol. xxxiii, parts 1–3. 8vo. (Calcutta, 1905–6.)

THE Director's Reports show the very considerable amount of work carried on by the Survey under his supervision, and the efficient manner in which it is administered. Much is done in connection with the economic functions of geology as well as in its more strictly scientific sphere. We may refer in the former connection to inquiries relating to the occurrence of coal in beds of Tertiary age in the Jammu State (Rec. xxxii, 4), and to the solution of engineering problems, which depend on the nature of local geological formations; these include questions relating to tunnelling and landslips, the effects of railway cuttings on hill-slopes, and other kindred subjects. Much attention is also bestowed upon economic minerals and water-supply. In the scientific field of investigation additions are made from time to time to that magnificent series of scientific memoirs known as the *Palæontologia Indica*, in which the most skilled observers of whatever nationality take part. Palæontological contributions of less bulk and importance find a place in the "Records." Among these are the following: "Notes on the Anthracolithic Fauna from the Mouth of the Subansiri Gorge, Assam," and "The Triassic Fauna of the Tropites-Limestone of Byans, Central Himalayas of Kumaon," both by Professor C. Diener, of Vienna. The last-named paper will appear in an extended form in the *Palæontologia Indica*. Mr. G. E. Pilgrim contributes a paper "On the occurrence of *Elephas antiquus* (*Namadicus*) in the Godavari Alluvium." Both papers are contained in the "Records," xxxii, pt. 3.

In the General Report by the Director for 1905 we find first a description of the routine work of the museum and laboratory, and then a summary of publications in progress, and other matters coming within the scope of the Survey. Among palæontological papers is one by Mr. F. R. Cowper Reed on the fossils of Lower Palæozoic age from the Northern Shan States, with descriptions of the Cystideans by Dr. F. A. Bather, and of the Graptolites by Miss G. L. Elles, D.Sc. Professor C. Diener's services are again in request to describe the Triassic fossils collected by Mr. E. Vredenburg in shales occurring in the Pinshin district of Baluchistan. The fossils

(*Monotis* and *Halorites*) indicate the correlation of these beds with the *Monotis*-beds of Spiti and the Alaunic (Middle Noric) sub-stage of the Alpine Upper Trias.

An exhaustive memoir on the Foraminifera of the Indian Tertiary by Mr. Vredenburg is to appear in the *Palæontologia Indica*. The Nummulitic fauna is said to be a very rich one, nearly all the most important types being represented in it. Many interesting points relating to the zoological aspects of the group will also be brought to light.

Mr. Fermor's petrological studies of the Deccan Trap formation point to the important conclusion that the basalts and rhyolites of Pavagad Hill (Bombay) are genetically related to one another.

Under "Seismology" special reference is made to the destructive earthquake in the Kangra valley on the 4th April, 1905. A compilation of the results of inquiries relating to it that were set on foot by the Survey immediately after the event is published in vol. xxxii of the "Records." A. H. F.

OBITUARY.

PROFESSOR J. F. BLAKE, M.A., F.G.S.

Born April 3, 1839. Died July 7, 1906.

The Rev. John Frederick Blake, M.A., F.G.S., who died on July 7th, 1906, at his residence, 35, Harlesden Gardens, N.W., was born at Stoke-next-Guildford on the 3rd April, 1839; he was son of the Rev. Robert P. Blake, and married in 1866 the youngest daughter of the Rev. F. F. Haslewood, Rector of Smarden, Kent. J. F. Blake was educated at Christ's Hospital, London, gaining the first prize medal in Mathematics in 1852, and at Caius College, Cambridge, where he was Senior Scholar and Prizeman in various subjects, and a pupil from 1859–1862 of the illustrious Professor Sedgwick. In 1862 he took his B.A. degree as fifteenth Wrangler, and was first of that year in the Natural Science Tripos. In the same year he edited, in conjunction with the late Prebendary W. A. Whitworth and other representatives of Cambridge, Oxford, and Dublin Universities, a journal known as the *Messenger of Mathematics*, promoted to encourage original investigation, and to unite in style and selection of subjects the three schools, with the view of forming an undivided English School of Mathematics. Ordained at Lincoln Cathedral, Blake became Curate of Lenton, Nottingham, 1862–4, and subsequently held for a short period the curacy of St. Mary's, Bryanston Square, London. In 1865 he was appointed Mathematical Master and Assistant Chaplain at St. Peter's School, York, where he remained for nine years. Among his pupils who have since distinguished themselves may be mentioned: the Rev. P. Braithwaite, appointed Dean of Jersey 1888; H. Tomlinson, F.R.S.; A. T. Pollard, Head Master of the City of London School; G. H. Pickersgill, M.P.; W. Y. Fausset, Head Master of

Ripon School; and Dr. Alan Gray, the eminent musician and organist of Trinity College, Cambridge. In 1874 he gave up clerical work in order to devote himself specially to science, and left York for London. Soon afterwards, at the request of Professor Hughes, of Cambridge, he undertook the Science Lectures for a term at Aberystwith College. From 1876 to 1880 Blake was Lecturer on Comparative Anatomy at Charing Cross Hospital, and in 1878–9 he delivered the course of lectures on the same subject at King's College for the late Professor A. H. Garrod. He was an Examiner for the Civil Service Commission in Geology and Mathematics, and for many years Assistant Examiner in Physiography for the Science and Art Department. Until quite recently he was an Honorary Examiner in Geology to the City of London College, Moorfields. In 1877 Blake was awarded by the Council of the Geological Society the 'Murchison Fund,' in recognition of his original researches, chiefly in Palæontology and Stratigraphical Geology.

The Government Grant Committee recommended Professor Blake for several grants in aid of his work on the British Palæozoic Cephalopoda, and also in aid of stratigraphical researches on the Jurassic rocks of the Continent as compared with those of Britain.

In 1880 he was appointed Professor of Natural Science at University College, Nottingham, and Curator of the Museum, where he remained for eight years. Here he inaugurated and became first President of the Students' Association, and editor of the College "Record." In 1888 he again removed to London, and soon became actively engaged in bringing out the "Annals of British Geology," which ran into four volumes, 1890–1893. Owing to his acceptance of an appointment to equip and arrange the State Museum at Baroda, he was obliged to relinquish this work, and in the winter of 1895 he sailed for India. It was during his temporary absence from England that he met with the great calamity of his life in the loss of his wife, which occurred when they had been parted only two months.

In recognition of the valuable services rendered to Geology and Palæontology during a period of almost a quarter of a century, he was in 1895 awarded the Lyell Medal by the Council of the Geological Society. In 1891–2 he was President of the Geologists' Association, and at the time of his death a Vice-President. He was elected President of the Metropolitan Scientific Association, 1889, and of the London Amateur Scientific Society, 1890 and 1891. Professor Blake conducted many excursions of the Geologists' Association; and the enthusiasm and vigour which he displayed were remarkable. He served on the Council of the Geological Society, and was for some time Editor of the Proceedings of the Geologists' Association. As a member of the International Geological Congress, he attended the meetings held in Philadelphia, London, Switzerland, and Russia. At the London meeting of 1888 he conducted a party of the members through North Wales and over Snowdon. He seldom missed the meetings of the British Association, and read many papers in the Geological Section. Professor Blake was present at the Montreal meeting in 1884, and undertook by himself a difficult journey to the Rocky Mountains. His impressions of the district are embodied in a paper read at the meeting.

The more noteworthy of Professor Blake's contributions to geological science were those on the Kimmeridge Clay and Portland Beds, and that, prepared conjointly with Mr. Hudleston, on the Corallian rocks—papers that have become classic in the literature of British geology. It is much to be regretted that the monograph on the Fauna of the Cornbrash, on which he was engaged up to the time of his death, was not completed by the author.

Blake was not averse to geological battles, and he entered into sundry controverted matters with characteristic energy, but occasionally with more zeal than discretion. Thus he dealt with (what were at the time) the thorny subjects of the Pre-Cambrian rocks of St. David's, the North-West Highland problems, the Oligocene of the Isle of Wight, and the older rocks of North Wales.

With regard to Professor Blake's work in Anglesey, one who has had occasion to follow it in detail writes:—It seems hardly to have met with the recognition that it deserves. That he erred on certain points is true, but in regions such as Anglesey who has not? The "Monian System" did not, indeed, find general acceptance, but what Pre-Cambrian system has? On the other hand, his principal sub-divisions, as such, hold good for the most part. He discovered the Glaucophane Schist. He discovered the Variolite. These facts alone are enough to show how great an advance his work represents in our knowledge of the older rocks of Anglesey.

He leaves a family of three sons and one daughter to mourn his loss, the eldest of whom is Demonstrator of Chemistry in Queen's College, Belfast, and a Public Analyst in Ireland.

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"The Geological Results of Arctic Exploration." 12mo; London, 1878.

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GEORGE FREDERICK HARRIS, F.G.S.

Born September 13, 1862. Died July 16, 1906.

As supplementary to the short notice given in our last number (p. 384), we may mention that Mr. Harris was born at Anglesey in Hampshire, and educated at Netherhampton House School, Wilton, near Salisbury. He subsequently attended classes at King's College, London, and the Birkbeck Institution. At an early age he became interested in geology and archæology, and he enlarged his knowledge during extensive travels in Europe and during visits paid to North Africa and the United States.

To the Geological Magazine he contributed papers on "The Gelinden Beds," 1887, p. 108; on "The Geology of Gironde," 1890, p. 22; and "A Journey through Russia," 1898, pp. 9, 110.

In conjunction with Mr. H. W. Burrows, A.R.I.B.A., F.G.S., he published a valuable account of "The Eocene and Oligocene Beds of the Paris Basin," with geological map and sections, and numerous lists of species and localities, pp. 1–129, 8vo (read before the Geologists' Association, April 3, 1891, and published separately, E. Stanford, price 3*s*.).

He added an Appendix to Mr. R. B. Newton's Systematic List of British Oligocene and Eocene Mollusca in the British Museum (1891), and prepared a catalogue of the Tertiary Mollusca of Australia[1] in the Geological Department (1897), 8vo, pp. 26 and 408, with 8 plates, printed by order of the Trustees of the British Museum. In conjunction with Mr. Burrows he also named and arranged the Foreign Tertiary Mollusca in the Geological Department of the British Museum.

Mr. Harris was for more than 20 years a regular contributor to the *Builder*, and wrote a series of articles upon "Building Stones," which were afterwards published separately. His attention thus became directed to questions of practical geology. He issued in 1888 a work entitled "Granites and our Granite Industries," and wrote on London Water Supply (1892); he contributed for

[1] Intended to be one of a series.

many years to the *Clayworker*, and published in 1897 a work on "The Science of Brickmaking." While largely engaged on economic questions he carried on investigations into the structure of oolitic freestones (1895), and found time likewise to write occasional papers on Eocene and Oligocene Mollusca in conjunction with his friend Mr. R. Bullen Newton.

RICHARD GLASCOTT SYMES, M.A.

BORN MAY 8, 1840. DIED JULY 27, 1906.

SON of Glascott Symes, M.D., a leading physician of Kingstown, in the county of Dublin, R. G. Symes was born in that town, graduated as Master of Arts and Licentiate of Engineering in Trinity College, Dublin, qualifying for the Mechanical Section of his degree at the Inchicore works of the Great Southern and Western Railway.

Having become interested in geology, he joined the Geological Survey of Ireland as Assistant Geologist under Jukes in 1863. In the course of his work he entirely surveyed six of the one-inch maps and portions of seventeen in conjunction with other members of the staff. Though his earliest work was carried out over forty years ago, his lines as then drawn remain unaltered, though some of the districts he completed, such as that of Lough Conn in Sheet 64, were of a very complicated nature. His latest Irish work was in county Antrim, which he was detailed to examine on account of his practical knowledge of the coal and iron deposits. It is especially satisfactory to note that recent exploration of the Ballycastle Coal-field has entirely justified the indications of his map and six-inch section. In 1869 Symes was promoted to the rank of Geologist. In 1874 he was one of the Secretaries of Section C at the Meeting of the British Association in Belfast, and in 1878 one of the Secretaries of Section G (Mechanical Science) at the Meeting in Dublin. His descriptive memoirs of the Irish areas he surveyed were interesting and clear, and his mapping and draughtsmanship of more than ordinary merit.

Upon the completion of the one-inch Geological Map of Ireland in 1890 he was transferred to the Scottish branch of the Survey, where he surveyed considerable portions of Kintyre and the neighbourhood of Oban in the Argyll district.

He was an ardent sportsman and keen observer of the fauna of the districts in which he was successively engaged, and there were few better practical authorities upon the birds and fishes of Ireland.

Injuries sustained by a car accident whilst engaged some years ago in surveying the country near Campbelton, N.B., shattered a previously robust frame. He retired from the public service in 1900, and settled in Monkstown, near Dublin, where he died on the 27th of July, after a short illness. R. C.

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HORACE B. WOODWARD, F.R.S., &c.

OCTOBER, 1906.

CONTENTS.

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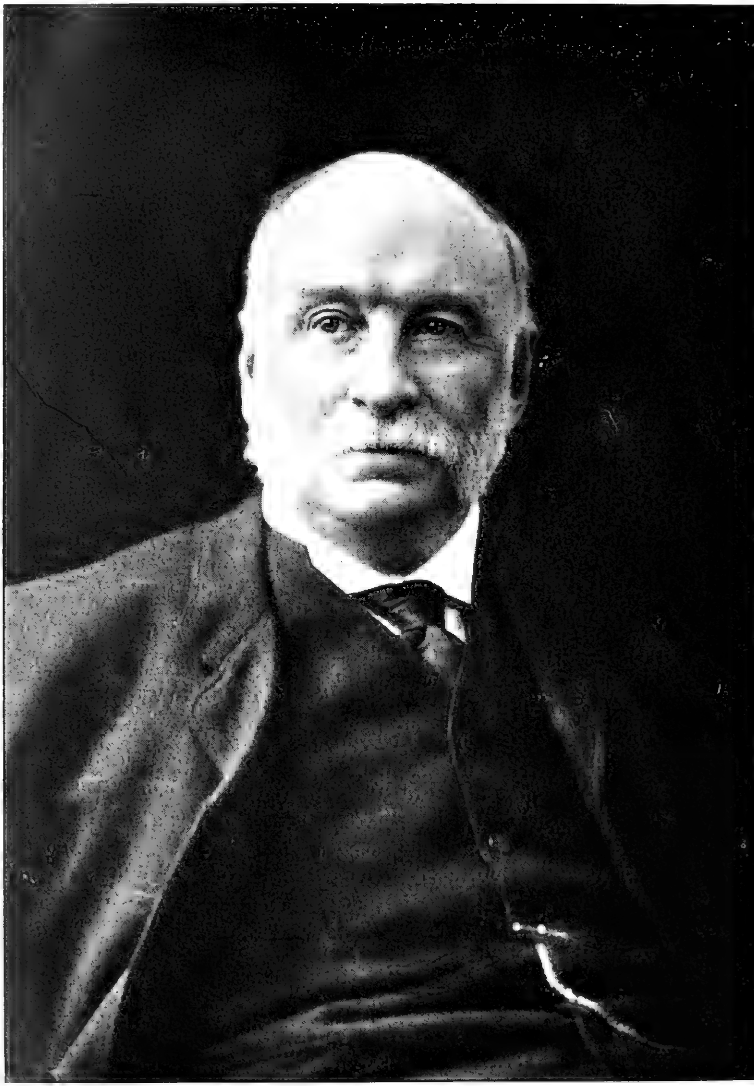
Erratum.—The number of the Plate (Plate XXI) used in the Geological Magazine for July, 1906, in illustration of Mr. Bernard Hobson's article, p. 312, was by an oversight *duplicated* in Dr. Wheelton Hind's and Mr. J. T. Stobbs' paper (Plate XXI), September Number, p. 394. Will readers have the kindness to mark that in the July Number as Plate XXIa, and that in the September Number as Plate XXIb: this will avoid the confusion which might otherwise arise. A reference to these duplicate numbers will of course be made in the list of plates in the December Number.—Edit. Geol. Mag.



Very truly yours,
J. F. Whiteaves.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. III.

No. X.—OCTOBER, 1906.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Joseph Frederick Whiteaves, LL.D., F.G.S., F.R.S. (Canada).

Palæontologist, Zoologist, and Assistant Director, Geological Survey of Canada; Hon. Memb. Ashmolean Soc. Oxford, Yorkshire Phil. Soc., Nat. Hist. Soc. Montreal, and Hist. and Scient. Soc. Manitoba.

(WITH A PORTRAIT, PLATE XXIII.)

We are glad to introduce to our readers a portrait and some account of the life-work of the distinguished Palæontologist to the Geological Survey of Canada, who has now held the office for thirty years.

Dr. Whiteaves was born at Oxford on the 26th of December, 1835, and resided in that city until 1861. In early life his attention was attracted to the pursuit of Natural History, and during the years 1855 and 1856 he collected and studied the land and fresh-water mollusca of the neighbourhood of his home, and communicated a paper thereon to the Proceedings of the Ashmolean Society. His energies were afterwards directed to geology, and during the years 1858 to 1860 he spent most of his time in collecting and studying the Jurassic fossils, and more particularly those of the Lower and Middle Oolites, of the country around Oxford. At this period the present Master of Pembroke (Bishop Mitchinson), the Rev. H. H. Wood, and Mr. James Parker were zealous collectors of fossils at Oxford. In 1861 Dr. Whiteaves published lists of the fossils thus obtained, and thereby added quite a large number of species to those previously known from the Great Oolite Series and the Corallian rocks. Many of the fossils upon which these lists were based were exhibited at the meeting of the British Association at Oxford in 1860, at which Sedgwick, Lyell, and Salter were present. Several of the species in these collections were then new to science. Four of them, from the Corallian, were described and figured by Dr. Whiteaves in the *Annals* for May, 1861. Fourteen others, from the Lower Oolites, were described and illustrated by the late Dr. John Lycett, in 1863, in his "Supplementary Monograph on the Mollusca of the Stonesfield Slate, Great Oolite, Forest Marble, and

Cornbrash," published by the Palæontographical Society. Professor John Phillips, who then occupied the Chair of Geology at Oxford, took a lively interest in these palæontological investigations, and subsequently referred to them in complimentary terms in his "Geology of Oxford and the Valley of the Thames." Dr. Lycett also called attention to the discovery by Dr. Whiteaves of Bradfordian species at Islip, while subsequent workers in the same field, Mr. E. A. Walford, Professor J. F. Blake, and the officers of the Geological Survey, have acknowledged the value of these original researches.

At intervals, during his residence at Oxford, Dr. Whiteaves collected at other famous localities for Oolitic fossils, such as Minchinhampton, and the neighbourhood of Stroud, Cheltenham, Dundry, and Bath. He also did a little amateur dredging on the coast of South Wales, near Swansea; at Lamlash Bay, Arran; and off St. Heliers, Jersey. He was elected an Honorary Member of the Ashmolean Society at Oxford in 1857, and a Fellow of the Geological Society of London in 1859.

In 1861 Dr. Whiteaves paid his first visit to Canada, landing in Quebec early in June. After spending a few months at and near that city and Montreal, he went with E. Billings (Palæontologist to the Geological Survey of Canada[1]) to examine some fossiliferous exposures on the Yamaska River, near St. Hyacinthe. In the middle of December the tidings of the recent death of his father reached him in Montreal, and he at once returned to England, landing in Liverpool early in January, 1862.

A few months later he recrossed the Atlantic, and visited New York, New Haven, Philadelphia, Burlington (New Jersey), and Cincinnati. At these cities he made the acquaintance of Thomas Bland, Benjamin Silliman, J. D. Dana, Isaac Lea, G. W. Tryon, and J. G. Anthony. He spent the remainder of the summer of 1862 in Ohio, collecting and studying the land and fresh-water shells, and especially the Unionidæ, of the State, at Waynesville, Franklin, and Columbus. He returned to Montreal *viâ* Lakes Erie and Ontario in the late autumn of 1862.

From 1863 to 1875 Dr. Whiteaves was Curator of the Museum and Recording Secretary of the Natural History Society of Montreal. During these twelve years he worked in its interests with Sir J. W. Dawson, Dr. T. Sterry Hunt, Dr. A. R. C. Selwyn, Elkanah Billings, Dr. P. P. Carpenter, George Barnston, Professor R. Bell, and others, and was a rather frequent contributor to its official organ, the *Canadian Naturalist and Geologist,* which had been founded in 1856 by E. Billings. His special objects of study while connected with this Society were, first, the land and fresh-water mollusca of Lower Canada, now known as the Province of Quebec; secondly, the fossils of the Trenton, Black River, Chazy, and Calciferous formations of the Island of Montreal and its immediate vicinity; and thirdly, the marine invertebrata of Eastern Canada. He carried on dredging

[1] Elkanah Billings, F.G.S., was born in the township of Gloucester, near Ottawa, in 1820. He was appointed Palæontologist to the Geological Survey of Canada in 1856, and died in 1876. See Obituary, Geol. Mag., 1877, pp. 43–45.

operations in the Gulf of St. Lawrence on behalf of the Montreal Society in 1867 and 1869, and under the direct auspices of the Department of Marine and Fisheries at Ottawa, which provided special facilities for this work, on Government vessels, during the years 1871, 1872, and 1873. In aid of this work Dr. J. Gwyn Jeffreys presented him in 1868 with a dredge of the most approved pattern. On an ordinary Gaspé fishing-boat it had been scarcely practicable to dredge at much greater depths than 50 or 60 fathoms, but on one or other of the fishery protection cruisers the greatest depths in the Gulf, from 200 and 250 to 313 fathoms, were for the first time successfully explored.

Sir J. W. Dawson has shown that the Pleistocene deposits of the St. Lawrence valley consist largely of a thin upper layer of sand, the 'Saxicava sand,' which is characterized by the abundance of a few common species of littoral marine shells and barnacles belonging to species still living; and of a lower and thicker deposit of clay, the 'Leda clay,' which holds the remains of a rich marine fauna of a distinctly deeper water type. The dredgings in the River and Gulf of St. Lawrence by Sir J. W. Dawson, Dr. Whiteaves, and others have so far shown that nearly all the species that have been found fossil in the Leda clay are still living in its waters, or in the North Atlantic. The principal exceptions seem to be the *Lepralia quadricornuta* of Dawson and the *Astarte Laurentiana* of Lyell, neither of which has yet been met with in a living state. *Tethea Logani,* Dawson (a tetractinellid sponge), was long supposed to be an extinct species, but Mr. L. M. Lambe thinks that it is the same as the recent *Craniella cranium* (Muller). The *Choristes elegans* of Carpenter, which was also once supposed to be an extinct species, has been dredged living by Verrill in deep water off the New England coast. The so-called *Leda* of the 'Leda clay,' now called *Portlandia glacialis* (Wood), has not yet been found living in the River or Gulf of St. Lawrence, though Mr. A. P. Low dredged a few fine living specimens of it at Richmond Gulf, on the east side of Hudson Bay, in from fifteen to twenty-five fathoms, in 1899. In this connection it may be mentioned that Dr. Whiteaves materially assisted in the preparation of the lists of Pleistocene fossils in the "Geology of Canada," published by the Geological Survey in 1863, and in the "Canadian Ice Age," published by Sir J. W. Dawson in 1893.

In 1875 Dr. Whiteaves joined the palæontological branch of the Geological Survey of Canada at the request of E. Billings, who was then in failing health. He was appointed Palæontologist to that institution in the autumn of 1876, shortly after the decease of Mr. Billings in June of that year, and was made one of the original Assistant Directors in 1877, and Zoologist in 1883.[1] During the

[1] The Assistant Directors were originally four in number, viz., Dr. Robert Bell, now Chief Geologist also; Dr. G. M. Dawson, who died in 1901; Dr. B. J. Harrington, who resigned in 1881; and Dr. Whiteaves. Drs. Bell and Dawson represented Field Geology; Dr. Harrington, Mineralogy and Chemistry; and Dr. Whiteaves, Palæontology. Dr. G. C. Hoffmann and Professor Macoun were since appointed assistant directors, the former in 1883, the latter in 1887.

thirty years of his official connection with the Survey he has published three descriptive and illustrated volumes on Canadian Palæontology or rather Palæozoology, which were issued in parts at varying intervals; a "Catalogue of the Marine Invertebrata of Eastern Canada"; and rather more than 100 papers on Canadian Palæontology or Zoology. His palæontological publications are based chiefly upon specimens brought in by the field geologists or acquired from local collectors, but on various occasions he has personally gathered fossils at many localities in the provinces of Quebec, Ontario, and Manitoba. With Drs. A. R. C. Selwyn, Robert Bell, G. M. Dawson, G. C. Hoffmann, Professor Macoun, and other members of the Staff, he has sedulously and persistently striven to add to and improve the collections of the Survey, in the hope of forming as large a nucleus as possible of a Canadian National Museum, such as that which was contemplated by Sir W. E. Logan in 1853.

For the first twenty-five years of its existence, the Geological Survey of Canada was only a Survey of the two provinces now known as Ontario and Quebec. During those years its collections were almost exclusively confined to the illustration of the geology, geological economics, mineralogy, and palæontology of these two provinces. Since the confederation of all the Canadian provinces, which was commenced in 1867 and completed in 1873, the Survey has become a Geological Survey of the whole Dominion. It was definitely constituted a Natural History Survey, also, in 1877, and a distinct department of the Civil Service of Canada in 1890. Its Museum now contains large and important collections illustrative of the botany, zoology, ethnology, and archæology of the Dominion, as well as of its geology and palæontology. These collections, and the memoirs and papers that have been based thereon, represent the labours of two generations of specialists. In palæontology the Museum of the Survey contains the types of nearly all the species of fossils that have been described in its publications.

The premises in Montreal in which its collections were housed from 1852 to 1881 ultimately proved to be quite inadequate for their proper accommodation. The much larger and more commodious buildings at Ottawa, into which the Survey moved in 1881, are also now found to be far too small for its present and future requirements, and the foundation of a new building for the suitable housing of its present staff and collections was laid at Ottawa in 1905.

Dr. Whiteaves is one of the original Fellows of the Royal Society of Canada, and has contributed twenty-two papers to its Transactions. This Society was founded in 1881 by the Duke of Argyll, who was then Marquis of Lorne and Governor General of Canada. From 1882 to 1899 Dr. Whiteaves was an active member of the American Association for the Advancement of Science, and was elected a Fellow thereof in 1887. At its meeting in Montreal in 1882 he exhibited and read a paper on some remarkable fossil fishes that had recently been collected from the Upper Devonian rocks at Scaumenac Bay in the province of Quebec, and from the Lower

Devonian rocks at Campbellton, New Brunswick; and at its meeting at Columbus, Ohio, in 1899, he was the presiding officer in the Section of Geology and Geography.

With the exception of short visits to England and the Continent in the summer seasons of 1865, 1866, and 1868, Dr. Whiteaves has lived in Montreal from 1863 to 1881, and at Ottawa from 1881 up to the present time. In 1900 he received the honorary degree of LL.D. from McGill University, Montreal.

His name has been associated with one genus of Ordovician Pelecypoda, with two species of fossil fishes, with sixteen species of fossil invertebrata, and with six species of recent marine invertebrata. His "Catalogue of the Marine Invertebrata of Eastern Canada," issued by the Geological Survey of Canada in 1901, summarizes the information gathered, largely by himself, but also by Sir J. W. Dawson and various Canadian and United States workers. This volume is of considerable interest in its geological bearings—the distribution of the fauna as compared with that of Western Europe. The identical, the slightly divergent or representative species, and the distinct species furnish endless subjects of study.

The record of work accomplished by Dr. Whiteaves in almost every branch of zoology and palæozoology, and his untiring industry, are apparent from the full list of papers herewith appended.

LIST OF PAPERS AND OFFICIAL PUBLICATIONS BY J. F. WHITEAVES.

(The titles of volumes that were issued in parts are printed in small capitals.)

1857. "On the Land and Fresh-water Mollusca inhabiting the Neighbourhood of Oxford": Proc. Ashmolean Soc., Oxford, vol. iii, p. 110.

1861. "On the Invertebrate Fauna of the Lower Oolites of Oxfordshire": Rep. Brit. Assoc., 1860, Trans. Sect., p. 104.

"On the Palæontology of the Coralline Oolites of the Neighbourhood of Oxford": Ann. Mag. Nat. Hist., London, ser. III, vol. viii, p. 142.

"On the Oolitic Echinodermata of the Neighbourhood of Oxford": Geologist, vol. iv, p. 174.

1863. "On the Land and Fresh-water Mollusca of Lower Canada," parts i and ii: Canadian Naturalist and Geologist, ser. I, vol. viii, pp. 50 and 98.

Transatlantic Sketches.—I. "On the Little Miami River, Waynesville, Warren County, Ohio": Zoologist, London, vol. xxi, p. 8419.

1865. "On the Fossils of the Trenton Limestone of the Island of Montreal": Canad. Nat. and Geol., ser. II, vol. ii, p. 312.

1869. "On the Marine Mollusca of Eastern Canada": ibid., ser. II, vol. iv, p. 48.

"On some Results obtained by Dredging in Gaspé and off Murray Bay": idem, ser. II, vol. iv, p. 270.

1870. "Notes on some Canadian Birds": ibid., ser. II, vol. v, pp. 103 and 230.

1871. "Report on a Deep-sea Dredging Expedition to the Gulf of St. Lawrence": Rep. Dept. of Marine and Fisheries, Ottawa.

1872. "Report on a Second Deep-sea Dredging Expedition to the Gulf of St. Lawrence, with some Remarks on the Marine Fisheries of the Province of Quebec": idem, Ottawa, 1872.

"Deep-sea Dredging in the Gulf of St. Lawrence": Canad. Nat. and Geol., ser. II, vol. vi, p. 351.

"Notes on a Deep-sea Dredging Expedition round the Island of Anticosti, in the Gulf of St. Lawrence": Ann. Mag. Nat. Hist., ser. IV, vol. x, p. 341. Reprinted, with some alterations and additions, in the Canad. Nat., etc., ser. II, vol. vii, p. 86.

1873. "Report on Deep-sea Dredging Operations in the Gulf of St. Lawrence, with Notes on the Present Condition of the Marine Fisheries and Oyster-beds of part of that region": Rep. Dept. of Marine and Fisheries, Ottawa.

1874. "On Recent Deep-sea Dredging Operations in the Gulf of St. Lawrence": Amer. Journ. Sci., ser. III, vol. vii, p. 210.

"Notes on the Cretaceous Fossils collected by Mr. James Richardson at Vancouver and the adjacent Islands": Rep. Progr. Geol. Surv. Canada for 1873–4, p. 260.

1875. "On a Collection of Himalayan Birds recently presented to the Natural History Society by Major G. E. Bulger": Canad. Nat., etc., ser. II, vol. vii, p. 394.

"Notes on the Marine Fisheries, and particularly on the Oyster-beds, of the Gulf of St. Lawrence": idem, p. 336.

1876. GEOLOGICAL SURVEY OF CANADA. MESOZOIC FOSSILS, Vol. I, Part 1.—(1) "On some Invertebrata from the Coal-bearing Rocks of the Queen Charlotte Islands, collected by Mr. James Richardson in 1872": Montreal, pp. 1–92, with ten plates and nine text-figures.

1877. "Critical Notes on Fossils collected by A. R. C. Selwyn and Prof. Macoun in the Valleys of the Peace, Athabasca, and Clearwater Rivers": Rep. Progr. Geol. Surv. Canada for 1875–6, pp. 96–106.

"On the Fossils of the Missinaibi and Moose Rivers collected by Dr. R. Bell in 1875": ibid., pp. 316–329.

Obituary Notice of Elkanah Billings, F.G.S., Palæontologist to the Geological Survey of Canada: Canad. Nat., etc., ser. II, vol. viii, p. 251.

1878. "Preliminary Report on some supposed Jurassic Fossils collected by Dr. G. M. Dawson in the Coast Range of British Columbia": Rep. Progr. Geol. Surv. Canada for 1876–7, pp. 150–159.

"On some Marine Invertebrata from the West Coast of America."—Being a critical list of about 125 species from the Strait of Georgia, Burrard Inlet, etc., with descriptions of a new Alcyonarian by Prof. A. E. Verrill, and of a supposed new lamellibranchiate bivalve by the writer: Canad. Nat., etc., ser. II, vol. viii, p. 464.

"On some Primordial Fossils from South-Eastern Newfoundland, with description of one new species": Amer. Journ. Sci., ser. III, vol. xvi, p. 224.

1879. GEOLOGICAL SURVEY OF CANADA. MESOZOIC FOSSILS, Vol. I, Part 2.—(2) "On the Fossils of the Cretaceous Rocks of Vancouver and adjacent Islands in the Strait of Georgia": Montreal, pp. 93–190, and ten plates.

"Provisional List of the Fossils collected by Dr. R. Bell in 1877 between the Long Portage of the Missinaibi River and York Factory": Rep. Progr. Geol. Surv. Canada for 1877–8, p. 50.

1880. "On some Marine Invertebrata from the Queen Charlotte Islands."—Contains a list of 160 species, with descriptions of three new starfishes by Prof. A. E. Verrill, and of two new species of mollusca by the author: idem, 1878–9, p. 190B.

"On a New Species of *Pterichthys*, allied to *Bothriolepis ornata*, Eichwald, from the Devonian Rocks of the North Side of the Baie des Chaleurs": Amer. Journ. Sci., ser. III, vol. xx, p. 132.

1881. "On some remarkable Fossil Fishes from the Upper Devonian Rocks at Scaumenac Bay, P.Q.": idem, ser. III, vol. xxi, p. 494.

"On some remarkable Fossil Fishes from the Devonian Rocks of Scaumenac Bay, with descriptions of a new genus and three new species": Canad. Nat., etc., ser. II, vol. x, p. 27.

"Description of a New Species of *Psammodus* from the Carboniferous Rocks of the Island of Cape Breton": idem, p. 36.

"On some Fossil Fishes, Crustacea, and Mollusca from the Devonian Rocks of Campbellton, N.B., with descriptions of five new species": ibid., p. 93.

"List of Fossils collected by Dr. R. Bell in Manitoba during the Season of 1880": Rep. Progr. Geol. Surv. Canada for 1879–80, p. 57C.

1882. "Note on the occurrence of *Siphonotreta Scotica*, Davidson, in the Utica Formation near Ottawa": Amer. Journ. Sci., ser. III, vol. xxiv, p. 278.

1882. "On a Recent Species of *Heteropora* from the Strait of Juan de Fuca": idem, p. 279.

1883. "On the Lower Cretaceous Rocks of British Columbia": Trans. Royal Soc. Can., vol. i, sect. iv, p. 81, with three text-figures.

"On some supposed Annelid Tracks from the Gaspé Sandstones": idem, p. 109, with two plates.

"Recent Discoveries of Fossil Fishes in the Devonian Rocks of Canada": American Naturalist, vol. xvii, p. 158.

1884. GEOLOGICAL SURVEY OF CANADA. PALÆOZOIC FOSSILS, Vol. III, Part 1.—(1) "On some new, imperfectly characterised, or previously unrecorded species of fossils from the Guelph Formation of Ontario": Montreal, pp. 1–43, with eight plates and four text-figures.

GEOLOGICAL SURVEY OF CANADA. MESOZOIC FOSSILS, Vol. I, Part 3.—(3) "On the Fossils of the Coal-bearing Deposits of the Queen Charlotte Islands, collected by Dr. G. M. Dawson in 1878": idem, pp. 191–262, with twelve plates.

1885. "Note on a Decapod Crustacean from the Upper Cretaceous of Highwood River, Alberta": Trans. Royal Soc. Can., vol. ii, sect. iv, p. 237.

"Description of a New Species of Ammonite from the Cretaceous Rocks of Fort St. John, on the Peace River": idem, p. 239.

"Note on the Possible Age of some of the Mesozoic Rocks of the Queen Charlotte Islands and British Columbia": Amer. Journ. Sci., ser. III, vol. xxix, p. 444.

"List of Marine Invertebrates from Hudson Strait, collected by Dr. R. Bell in 1884": Rep. Progr. Geol. Surv. Canada for 1882–3–4, Montreal, pp. 58–60.

GEOLOGICAL SURVEY OF CANADA. CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY, Vol. I, Part 1.—(1) "Report on the Invertebrata of the Laramie and Cretaceous Rocks of the vicinity of the Bow and Belly Rivers and adjacent localities in the North-West Territory": Montreal, pp. 1–90, and eleven plates.

1886. "Colonial and Indian Exhibition. Catalogue of Canadian Pinnipedia, Cetacea, Fishes, and Marine Invertebrata exhibited by the Department of Fisheries of the Dominion Government": Ottawa, pp. 1–42.

1887. "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," part 1: Trans. Royal Soc. Can., vol. iv, sect. iv, pp. 101–110, with five plates.

"On some Marine Invertebrata, dredged or otherwise collected by Dr. G. M. Dawson in 1885 on the Coast of British Columbia, with a supplementary list of a few land and fresh-water shells, fishes, birds, etc., from the same region": idem, pp. 111–137, with four woodcuts.

"Notes on some Mesozoic Fossils from various localities on the Coast of British Columbia, for the most part collected by Dr. G. M. Dawson in the Summer of 1885": Annual Report, Geol. Surv. Canada, New Series, vol. ii, pt. B, pp. 108–114.

"On some Fossils from the Cretaceous and Laramie Rocks of the Saskatchewan and its Tributaries, collected by Mr. J. B. Tyrrell in 1885 and 1886": idem, pt. E, pp. 153–166.

1889. "Illustrations of the Fossil Fishes of the Devonian Rocks of Canada," part 2: Trans. Royal Soc. Can., vol. vi, sect. iv, pp. 77–96, with six plates.

GEOLOGICAL SURVEY OF CANADA. CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY, Vol. I, Part 2.—(2) "On some Fossils from the Hamilton Formation of Ontario, with a list of the species at present known from that formation and province"; (3) "The Fossils of the Triassic Rocks of British Columbia"; (4) "On some Cretaceous Fossils from British Columbia, the North-West Territories, and Manitoba": Montreal, pp. 91–196, with fifteen plates.

1890. "Descriptions of eight New Species of Fossils from the Cambro-Silurian Rocks of Manitoba": Trans. Royal Soc. Can., vol. vii, sect. iv, pp. 75–83, and six plates.

1891. "Descriptions of some new or previously unrecorded Species of Fossils from the Devonian Rocks of Manitoba": idem, vol. viii, sect. iv, pp. 93–110, with seven plates.

GEOLOGICAL SURVEY OF CANADA. CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY, Vol. I, Part 3.—(5) "The Fossils of the Devonian Rocks of the Mackenzie River Basin": Montreal, pp. 197–253, with six plates.

"Descriptions of four New Species of Fossils from the Silurian Rocks of the South-Eastern portion of the District of Saskatchewan": Canad. Rec. Sci., vol. iv, p. 293, with one plate.

"Description of a New Species of Panenka from the Corniferous Limestone of Ontario": idem, p. 401, with one plate.

"Note on the occurrence of Paucispiral Opercula of Gasteropoda in the Guelph Formation of Ontario": idem, p. 404.

1892. "The Orthoceratidæ of the Trenton Limestone of Manitoba": Trans. Royal Soc. Can., vol. ix, sect. iv, pp. 77–90, with seven plates.

"Description of a New Genus and Species of Phyllocarid Crustacea from the Middle Cambrian of Mount Stephen, B.C.": Canad. Rec. Sci., vol. v, p. 205.

GEOLOGICAL SURVEY OF CANADA. CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY, Vol. I, Part 4.—(6) "The Fossils of the Devonian Rocks of the Islands, Shores, or immediate vicinity of Lakes Manitoba and Winnipegosis": Ottawa, pp. 255–359, with fifteen plates.

1893. "Notes on the Ammonites of the Cretaceous Rocks of the District of Athabasca, with descriptions of four new species": Trans. Royal Soc. Can., vol. x, sect. iv, pp. 111–121, with four plates.

"Notes on the Gasteropoda of the Trenton Limestone of Manitoba," with a description of one new species: Canad. Rec. Sci., vol. v, p. 317, with two text-figures.

"Descriptions of two New Species of Ammonites from the Cretaceous Rocks of the Queen Charlotte Islands": idem, vol. vi, p. 441, with one plate.

1894. "Notes on some Marine Invertebrata from the Coast of British Columbia": Ottawa Naturalist, vol. vii, p. 133, with one plate.

"The Cretaceous System in Canada" (Presidential Address in Section IV): Trans. Royal Soc. Can., vol. xi, sect. iv, pp. 3–16.

"The Recent Discovery of large Unio-like Shells in the Coal-measures at the South Joggins, N.S.": idem, pp. 21–24, with one plate.

1895. "Notes on Recent Canadian Unionidæ": Canad. Rec. Sci., vol. vi, p. 250.

"Additional Notes on Recent Canadian Unionidæ": idem, p. 365.

"Notes on some Fossils from the Cretaceous Rocks of British Columbia, with descriptions of two species that appear to be new": ibid., p. 313.

"Descriptions of eight New Species of Fossils from the (Galena) Trenton Limestones of Lake Winnipeg and the Red River Valley": ibid., p. 387.

GEOLOGICAL SURVEY OF CANADA. PALÆOZOIC FOSSILS, Vol. III, Part 2.—(2) "Revision of the Fauna of the Guelph Formation of Ontario, with description of a few new species"; (3) "Systematic List, with references, of the Fossils of the Hudson River or Cincinnati Formation at Stony Mountain, Manitoba": Ottawa, pp. 45–128, with seven plates.

1896. "Notes on some of the Cretaceous Fossils collected during Captain Palliser's Explorations in British North America in 1857–60": Trans. Royal Soc. Can., ser. II, vol. i, sect. iv, p. 101.

"On some Fossils from the Nanaimo Group of the Vancouver Cretaceous": idem, p. 119.

"Note on the occurrence of *Primnoa reseda* on the Coast of British Columbia": ibid., p. 135.

"Canadian Stromatoporoids": Canad. Rec. Sci., vol. vii, p. 129.

1897. GEOLOGICAL SURVEY OF CANADA. PALÆOZOIC FOSSILS, Vol. III, Part 3.—(4) "The Fossils of the Galena-Trenton and Black River Formations of Lake Winnipeg and its vicinity": Ottawa, pp. 129–242, with seven plates and thirteen text-figures.

"Description of a New Genus and Species of Cystideans from the Trenton Limestone at Ottawa": Canad. Rec. Sci., vol. vii, p. 287.

1898. "Postscript to a 'Description of a New Genus and Species of Cystideans from the Trenton Limestone at Ottawa'": idem, p. 395.

"On some Remains of a Sepia-like Cuttle-fish from the Cretaceous Rocks of the South Saskatchewan": ibid., p. 459.

"Note on a Fish Tooth from the Upper Arisaig Series of Nova Scotia": ibid., p. 461.

"On some Fossil Cephalopoda in the Museum of the Geological Survey of Canada, with descriptions of eight species that appear to be new": Ottawa Nat., vol. xii, p. 116.

Geological Survey of Canada. Contributions to Canadian Palæontology, Vol. I, Part 5, and last.—(7) "On some additional or imperfectly understood Fossils from the Hamilton Formation of Ontario, with a revised list of the species therefrom." (8) Appendix: Revision of the nomenclature of some of the species described or enumerated in previous parts of this volume, and additional notes on others, necessitated by the progress of palæontological research. Ottawa, pp. 361–436, with three plates and five text-figures; also with general title-page, letter of transmittal, and index.

1899. "Recent Discovery of Rocks of the Age of the Trenton Formation at Akpatok Island, Ungava Bay, Ungava": Amer. Journ. Sci., ser. iv, vol. vii, p. 433.

"The Devonian System in Canada."—Address of the Vice-President and Chairman of Section E (Geology and Geography) of the American Association for the Advancement of Science, at its forty-eighth annual meeting, held at Columbus, Ohio, in 1899, and published in its Proceedings for that year.

1900. Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 4. —(4) "On some additional or imperfectly understood Fossils from the Cretaceous Rocks of the Queen Charlotte Islands, with a revised list of the species from these rocks": Ottawa, pp. 263–307, with two text-figures and seven plates.

1901. "Description of a New Species of *Unio* from the Cretaceous Rocks of the Nanaimo Coal Field, V.I.": Ottawa Nat., vol. xiv, p. 177.

"Notes on some Land and Fresh-water Mollusca from Fort Chimo, Ungava Bay, Ungava": idem, p. 221.

"Note on a supposed New Species of *Lytoceras* from the Cretaceous Rocks at Denman Island, in the Strait of Georgia": idem, vol. xv, p. 31.

Geological Survey of Canada. "Catalogue of the Marine Invertebrata of Eastern Canada": Ottawa, pp. 1–272, with two figures in text.

1902. "Bibliography of Canadian Zoology for 1900": Trans. Royal Soc. Can., ser. ii, vol. vii, sect. iv, p. 87.

"The Golden Eagle (*Aquila chrysaetos*) in Ontario": Ottawa Nat., vol. xv, p. 249.

"On the genus *Panenka*, Barrande," with a description of a second species of that genus from the Devonian rocks of Ontario: idem, p. 263.

"Note on the Nesting of the Northern Raven (*Corvus corax principalis*) in Canada": ibid., vol. xvi, p. 86.

"Notes on some Fresh-water and Land Shells from Keewatin, Northern Ontario, and British Columbia": ibid., p. 91.

"Additions to the Geological Survey's Collection of Eggs in June, 1902": ibid., p. 96.

"On the Genus *Trimerella*," with descriptions of two supposed new species of that genus from the Silurian rocks of Keewatin: ibid., p. 139.

"A Canadian Two-headed Snake": ibid., p. 148.

"The Acadian Sharp-tailed Sparrow (*Ammodramus caudacutus subvirgatus*)": ibid., p. 162.

1903. "Description of a Fossil Cyrena from Alberta": ibid., p. 231.

"Crania of Extinct Bisons from the Klondike Creek Gravels": ibid., p. 240.

"Description of a New Species of *Matheria* from the Trenton Limestone at Ottawa": ibid., vol. xvii, p. 32.

"Bibliography of Canadian Zoology for 1900, exclusive of Entomology."—Supplement: Trans. Royal Soc. Can., ser. ii, vol. viii, sect. iv, p. 149.

1903. "Bibliography of Canadian Zoology for 1901, exclusive of Entomology": ibid., p. 151.

"Description of a Species of *Cardioceras* from the Crows Nest Coal Fields": Ottawa Nat., vol. xvii, p. 65.

Geological Survey of Canada. Mesozoic Fossils, Vol. I, Part 5, and last.—(5) "On some additional Fossils from the Vancouver Cretaceous, with a revised list of the species therefrom": Ottawa, pp. 309–415, with fourteen text-figures and twelve plates; also with index and general title-page.

"Notes on some Canadian specimens of *Lituites undatus*": Ottawa Nat., vol. xvii, p. 117.

"Additional Notes on some Canadian Specimens of *Lituites undatus*": idem, p. 161.

1904. "Bibliography of Canadian Zoology for 1902, exclusive of Entomology": Trans. Royal Soc. Can., ser. ii, vol. ix, sect. iv, p. 163.

"*Helicigona arbustorum* in Newfoundland": Ottawa Nat., vol. xvii, p. 192.

"The Canadian Species of *Trocholites*": idem, vol. xviii, p. 13.

"A White Pelican at Manotick": ibid., p. 71.

"The Brown Pelican on Cape Breton Island": ibid., p. 108.

"Description of a New Genus and Species of Rugose Corals from the Silurian Rocks of Manitoba": ibid., p. 113.

"*Uintacrinus* and *Hemiaster* in the Vancouver Cretaceous": Amer. Journ. Sci., ser. iv, vol. xviii, p. 287.

"Preliminary List of Fossils from the Silurian (Upper Silurian) Rocks of the Ekwan River and Sutton Mill Lakes, Keewatin, collected by D. B. Dowling in 1901, with descriptions of such species as appear to be new."—Appendix I to Mr. Dowling's Report: Geol. Surv. Can., Ann. Rep., vol. xiv, part F, pp. 38–39.

1905. "Notes on the Apical End of the Siphuncle in some Canadian Endoceratidæ, with descriptions of two supposed new species of *Nanno*": American Geologist, vol. xxxv, p. 23.

"Bibliography of Canadian Zoology for 1903, exclusive of Entomology": Trans. Royal Soc. Can., ser. ii, vol. x, sect. iv, pp. 161–166.

"Notes on some Fresh-water Shells from the Yukon Territory": The Nautilus, vol. xix, p. 1; and Ottawa Nat., vol. xix, p. 63.

"Lists of a few Species of Land and Fresh-water Shells from the immediate vicinity of James Bay, Hudson Bay": The Nautilus, vol. xix, p. 4; and Ottawa Nat., vol. xix, p. 66.

"The Banded Pocket-Mouse (*Perognathus fasciatus*)": Ottawa Nat., vol. xix, p. 69.

"List of Land and Fresh-water Shells from the District of Keewatin, collected by W. McInnes in 1904": Geol. Surv. Can., Summary Rep. 1904, p. 160.

"Description of a New Species of *Goniobasis* from British Columbia": The Nautilus, vol. xix, p. 61.

"Some New Localities for Canadian Land and Fresh-water Shells": Ottawa Nat., vol. xix, p. 169.

1906. "Some New Canadian Records for Gyrfalcons": idem, p. 208.

"Bibliography of Canadian Zoology for 1904, exclusive of Entomology": Trans. Royal Soc. Can., ser. ii, vol. xi, sect. iv, p. 65. But, separates were issued in 1905.

Geological Survey of Canada. Palæozoic Fossils, Vol. III, Part 4, and last.—(5) "The Fossils of the Silurian (Upper Silurian) Rocks of Keewatin, Manitoba, the North-Eastern Shore of Lake Winnipegosis, and the lower Saskatchewan River"; (6) "The Canadian Species of *Plectoceras* and *Barrandeoceras*"; (7) "Illustrations of seven species of Fossils from the Cambrian, Cambro-Silurian, and Devonian Rocks of Canada"; (8) "Revised List of the Fossils of the Guelph Formation of Ontario." With Appendix, consisting of a list of errata and an index to the volume. Ottawa, pp. 243–352, with twenty plates and eight text-figures.

II.—On two Specimens of *Ichthyosaurus* showing contained Embryos.

By A. Smith Woodward, LL.D., F.R.S.

(PLATE XXIV.)

FOR many years it has been known that *Ichthyosaurus* was a viviparous reptile,[1] but until quite recently the British Museum has not possessed a specimen with contained embryos. This deficiency has now been supplied by the acquisition of two fine skeletons, which are worthy of special notice.

The first of these newly acquired specimens (Pl. XXIV, Fig. 1) is of much historic interest, because it was discovered and described so long ago as 1846 by the late Dr. J. Chaning Pearce, a well-known pioneer in Palæontology.[2] It was obtained from the Lower Lias of Somersetshire, and appears to belong to the species *I. communis*. The skeleton is nearly complete, and is exposed from the right side, though partly from below. The ribs and paddles of the right side are displaced upwards; and the tail is dislocated, though clearly exhibiting the downward flexure of its terminal portion. The single embryo, as described by Chaning Pearce, lies between the two sides of the pelvis, crushed on the three hindmost ribs. Its head points backwards, but is flattened by crushing, and does not show any structural details. The vertebral centra are small biconcave discs of spongy bone, not arranged in continuous series but somewhat scattered. The head of the embryo, so far as preserved, measures 0·04 m. in length, while the remains of the trunk extend for another length of 0·105 m. The total length of the parent is about 2·25 m., that of the head being 0·5 m. Although its precise dimensions cannot be determined, the embryo in this individual is therefore relatively smaller than in the other known specimens.

The second Ichthyosaur with embryos received by the British Museum (Pl. XXIV, Fig. 2) was obtained from the Upper Lias of Holzmaden, Würtemberg, and is referable to *I. quadriscissus*, which has been provisionally identified by Mr. Lydekker with *I. acutirostris*.[3] This is the species to which all the best specimens displaying embryos belong. The skeleton, which measures about 2·4 m. in length, is well preserved and exposed from the right side, the right ribs only being displaced upwards. The black contents of the stomach are clearly shown in the lower part of the abdominal region. There are remains of at least six embryos within the ribs, but some of them have been displaced forwards, either by *post-mortem* crushing or by escape into the body-cavity during life (as happens occasionally in

[1] H. G. Seeley, "Report on the Mode of Reproduction of certain species of *Ichthyosaurus* from the Lias of England and Würtemberg": Rep. Brit. Assoc., 1880 (1881), pp. 68–76, pl. i. E. Fraas, "Die Ichthyosaurier der süddeutschen Trias- und Jura-Ablagerungen" (Tübingen, 1891), p. 34, pl. iv, fig. 2.

[2] J. Chaning Pearce, "Notice of what appears to be the Embryo of an *Ichthyosaurus* in the Pelvic Cavity of *Ichthyosaurus* (*communis* ?)": Ann. & Mag. Nat. Hist., vol. xvii (1846), pp. 44–46.

[3] R. Lydekker; "Catal. Foss. Rept. B.M.," pt. ii (1889), p. 73.

viviparous lizards [1]). All the embryos are of the same size, relatively large, and with the proportions of the skull similar to those of the parent's skull. The snout in every case points forwards. The embryonic skull is best displayed in an individual far forwards within the ribs above the vertebral column, where it is shown in direct side-view. The rostrum here is crushed on the heads of the ribs, and bears the impress of the latter, indicating the soft nature of its bone-tissue. Behind the skull is part of the vertebral column in position, with some of the ribs, and apparently the ossified portions of the coracoids. A second good embryonic skull occurs slightly further back just below the vertebræ of the parent, and is interesting as displaying the teeth in the form of thin, hollow cones. At the hinder end of its mandible is seen the ossified shaft of a humerus. Below and in front of this second specimen are three more imperfect embryonic skulls, only partially exposed, the lowest somewhat obscured by the black stomach-contents. Behind the middle specimen there occurs part of the vertebral column with ribs; and some of the small vertebral centra appear to exhibit the facettes for neural arches. The sixth embryo is indicated only by short chains of biconcave vertebral centra scattered in the region of the pelvis. The limbs are not shown in any embryo within the body, but there is an embryonic fore-paddle 0·036 m. in length near the displaced ribs above the head. The bones in this paddle are not completely ossified, but so far as preserved are in their natural position. The radius is half as long as the ossified part of the humerus, whereas in the adult paddle the same bone measures only one-third the length of the humerus. The length of the best embryonic skull is about 0·19 m., while that of the skull of the parent is not more than 0·5 m.

The largest number of embryos hitherto observed in one individual of *Ichthyosaurus acutirostris* (*quadriscissus*) is seven [2]; and it is interesting to note that in each recorded case of more than one contained embryo, the young are always directed with the snout forwards. A single embryo in the middle of one specimen in the Stuttgart Museum is also turned forwards; but in each known instance in which the single embryo is so far back as the pelvis, the snout is directed backwards.[3] The specimens recently acquired by the British Museum conform to this rule.

EXPLANATION OF PLATE XXIV.

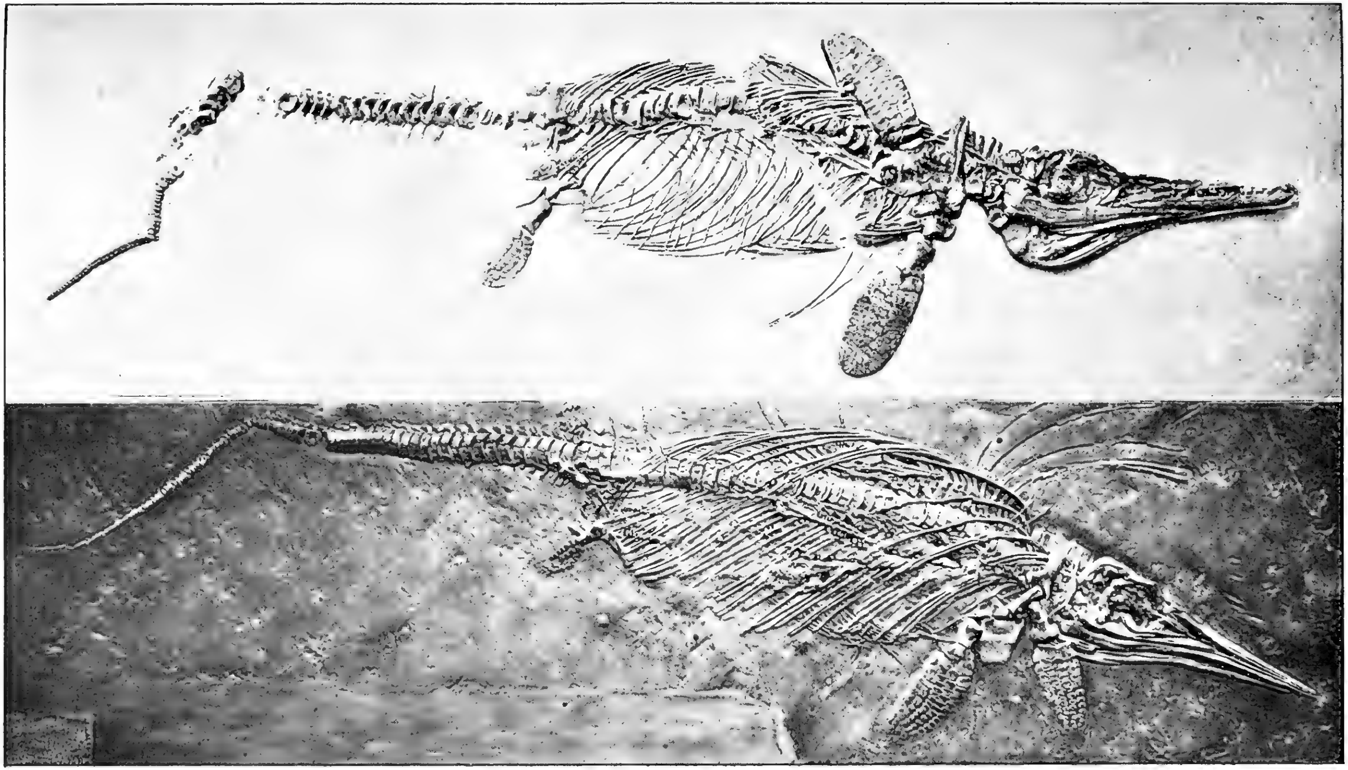
Fig. 1.—*Ichthyosaurus communis*, Conybeare; skeleton showing very small embryo in the pelvic region. About one-fourteenth nat. size. Lower Lias: Somersetshire. [Chaning Pearce Collection, British Museum, No. R. 3372.]

Fig. 2.—*Ichthyosaurus acutirostris*, Owen (*quadriscissus*, Quenstedt); skeleton showing remains of six large embryos within the ribs. About one-fourteenth nat. size. Upper Lias: Holzmaden, Würtemberg. [British Museum, No. R. 3300.]

[1] F. E. Beddard, "Note on an apparently Abnormal Position of the 'Brephos' within the Body of a Skink (*Chalcides lineatus*)": Proc. Zool. Soc., 1904, vol. ii, pp. 145–147, text-fig. 25.

[2] E. Fraas, op. cit. H. F. Osborn, "Ichthyosaurs": Century Magazine, vol. lxix (1905), pp. 414–422, text-figs. 1–6.

[3] See Seeley and Fraas; also A. Gaudry, "Les Enchaînements du Monde Animal—Fossiles Secondaires" (1890), p. 185, fig. 275.



1.

2.

Two specimens of *Ichthyosaurus* showing contained Embryos:

1. *Ichthyosaurus communis*, Conybeare; Lower Lias, Somersetshire.
2. *Ichthyosaurus acutirostris*, Owen: Upper Lias, Würtemberg.

III.—The Carboniferous Succession below the Coal-Measures in North Shropshire, Denbighshire, and Flintshire.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

(*Continued from the September Number, p.* 400.)

(xxviii) The road from Llanarmon to Graianryd practically traverses the whole limestone sequence. The following fossils were obtained from the quarry about half a mile north of Llanarmon, by the roadside, where some 20–30 feet of limestone was exposed:—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Syringopora sp.
Athyris expansa, Phill.
Chonetes aff. *comoides* (J. Sow.). (Like the mutation in D_1 of the Bristol area.)
Martinia glabra (Mart.).
Productus Cora, D'Orb.
P. hemisphericus, J. Sow.
P. punctatus (Mart.).

In the quarry opposite the Stag Inn, east of Llanarmon, limestone beds with *Productus giganteus* (Mart.) are well exposed.

A few hundred yards further east there is a quarry in a farmyard with thin rubbly and bedded limestones. Here *Productus giganteus* (Mart.) occurs in several bands, with *Cyathophyllum* and *Amplexizaphrentis*. A little further up the wood occur dark thin-bedded limestones, with bands of *Productus hemisphericus* (J. Sow.), *P. giganteus* (Mart.), and *Lithostrotion irregulare*, Phill., on which lie yellow calcareous shales with *Productus giganteus* (Mart.).

(xxix) The next section is at Graianryd, which shows soft yellow sandstone, with occasional quartz pebbles and pebbly grit. The sandstone is very fossiliferous, and contains—

Camarotœchia trilatera (De Kon.).
Productus longispinus, Sow.
Spirifer bisulcatus, Sow.
Fragment of a large Nautiloid.
Fish-teeth (fragments ? *Psephodus*).

This bed, evidently, is the equivalent of the coarse pebbly grit and soft sandstone with fish-teeth seen at Gwernymynydd (*ante*, p. 398).

(xxx) Half a mile south-east of Graianryd, at Pant-y-terwyn, on the west of the road, is a fine quarry in cherts, which evidently succeed conformably the calcareous pebble grit, and we there get the following sequence:—

Cherts (of Pant-y-terwyn).
Calcareous pebbly grit (of Graianryd).
Carboniferous Limestone, with *Productus giganteus* (Mart.) near the Stag Inn.

Some of the latter series, however, are not exposed. This sequence agrees well with that at Gwernymynydd, and shows the transition from the Cherty Limestone near Pentre Halkyn (p. 396), through the calcareous grits of Hendre and Gwernymynydd, to the pebble grit of Graianryd. It is this part of the series that is represented by the lower part of the Cefn-y-Fedw Series of G. H. Morton.[1]

(xxxi) The neighbourhood of Minera affords sections of practically the whole of the Carboniferous System up to the horizon of

[1] G. H. Morton: "The Carboniferous Limestone and Cefn-y-Fedw Sandstone of the Country between Llanymynech and Minera," 1879.

the Gwespyr Sandstone, whose representative is exposed in a quarry near Berwig Station. The beds here resemble closely, both in colour and in petrological character, the sandstones and grits of Gwespyr, and contain many fragments of plants and woody débris. At the top of the hill at Pen-y-Bwlch are a series of strong cherts, which crop out behind the houses in the village. Morton mentions[1] that the sandy limestones and white sandstones with quartz pebbles, about 170 feet thick, are to be seen at Craig Mawr and Craig Fechan. At Minera the limestones rest directly on the Bala Beds, with a thin, patchy basement conglomerate, and the junction can be seen and traced for some distance in the bed of the stream which runs from Ty hir through the quarries called the Clywedog. The lower beds of limestone are crammed full of *Daviesiella Llangollensis* (Dav.), a very easily recognised species, even in section, on account of the large comparative thickness of the pedicle valve. This species we consider to have a time value in North Wales, a fact which Morton seems to have recognised, for it always occurs in his lists of fossils from the Lower Brown Limestone. In the case of Minera, however, Morton did not recognise the existence of the Lower Brown Limestone, but refers the lower beds (160 feet) to his Upper White Limestone division. From a colour point of view he is certainly correct, since there is no *brown* limestone in this locality, but the presence of large numbers of *D. Llangollensis*—evidently the maximum of this fossil—seems to us to be conclusive evidence of the contemporaneity of these beds with others containing the same fossil. Beds immediately above the *Daviesiella* beds contain abundance of *Seminula* aff. *ficoides*, giving a similar palæontological succession to that at Llandulas.

Morton estimates the whole limestone series at Minera as 436 feet thick, and *D. Llangollensis* is confined to the lowest few feet of the series. Fossils were very rare indeed in the succeeding 350 feet of limestone. Quarrymen said that specimens occurred only occasionally, and we were not able to find any in the loose blocks about the quarry.

On the other hand, the upper beds of limestone east of the large quarries, exposed successively in abandoned quarries and outcrops on the hill, contain the typical fossils of that zone, viz.:—

Cyathophyllum cf. *regium*, Phill.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia rugosa, M'Coy.
Productus giganteus (Mart.).
And many beds of crinoids.

In this series the limestones become cherty, and the beds assume the lithological character of the upper limestones on Halkyn Mountain.

Morton gives a much longer list of fossils from the Upper Grey Limestone of Minera than we collected—a list which we are prepared to accept, with three exceptions, because we know the species enumerated occur universally at this horizon in the counties of Flint and Denbigh. The exceptions are—(1) *Athyris Royssii*, which should probably stand for *A. planosulcata*, Phill.; (2) *Aviculopecten*

[1] Op. sup. cit., p. 71.

micropterus, which is probably *A. dissimilis* (Flem.); and (3) *Zaphrentis cylindrica*, which is either *Campophyllum* or *Amplexi-zaphrentis*.

The *Productus giganteus* beds are succeeded by yellowish sandy limestones and a pebbly grit, and at the top of the hill are the strong cherts of Pen-y-Bwlch. Morton estimates the Carboniferous Limestone of the Eglwyseg ridge at 1,200 feet, which he subdivided as under :—

	feet.
Upper Grey Limestone	300
Upper White Limestone...	300
Lower White Limestone	120
Lower Brown Limestone	480
	1200

These beds are all exposed either in the fine escarpment of the Eglwyseg ridge or the Trevor and Bronheulog quarries, and rest in places on a basement of red conglomerate, which is to be seen near Dibren Uchaf and at the foot of Craig-yr-ogof. The brown limestones at the base of the limestone series contain plant-remains in a fragmentary state. The most abundant and characteristic fossil is *Daviesiella Llangollensis*. The number of fossil species is not large, but individuals are fairly numerous, and we collected the following :—

Alveolites septosa (Flem.).
Syringopora sp.
Athyris planosulcata, Phill.
Daviesiella Llangollensis (Dar. sp.).
Productus Cora, D'Orb.
Fragments of a giganteid *Productus*.
Reticularia lineata (Mart.).
Bellerophon sp.
A Nautiloid shell. (Fragmentary.)
Euomphalus Dionysii, Goldfuss.
Murchisonia Kendalensis, M'Coy (Donald).
Pleurotomaria. (Large globular species.)

A list which is almost identical with that of G. H. Morton.

The fossils all seem to come from the lower part of the series. They are not very common in the whiter beds above the Brown Limestone, but we obtained the following :—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Lithostrotion Martini, E. & H.
Syringopora sp.
Athyris expansa, Phill.
Chonetes papilionacea, Phill. (Flattened form.)
Productus Cora, D'Orb.
P. giganteus (Mart.).
Edmondia sulcata (Phill.).
Sanguinolites striatolamellosus, De Kon.

Morton states that he found *Lonsdaleia duplicata* (Mart.) and *L. rugosa*, M'Coy, *Lithostrotion irregulare* (Phill.), *L. junceum* (Flem.), and *L. Portlocki* (Bronn) at this horizon. In the appendix to his larger work, "The Geology of the Country round Liverpool," p. 318, he says: "Of the 37 species in the Upper Grey Limestone of Flintshire there is only one which seems peculiar to it, and that is *Lonsdaleia rugosa*, but it occurs in the Middle White Limestone of Llangollen." We find that the range of this fossil includes a portion of the Middle White Limestone of Morton.

Mistakes might easily occur at the Eglwyseg ridge unless the specimen were actually taken from the rocks *in sitû*, for slopes of talus extend largely from the top to the base of the hill, and fossils from the upper beds are brought down in this way and mingle with those from the lower beds.

Still higher in the series, Morton's 'Upper White Limestone' has practically the same fauna as the beds immediately below, and hence no palæontological line can be drawn between them.

The 'Upper Grey Limestone' of Morton is much richer in species than the beds below, and is characterised by the abundance of giganteid *Producti* and *Spirifer bisulcatus*, Sow. Morton's list is a large one, containing 98 species of Brachiopods, Lamellibranchs, Corals, Echinoderms, Polyzoa, and fishes.[1] The Lamellibranchs passed through the hands of one of the writers, and were determined by him as—

Conocardium aliforme, Sow.
Edmondia sulcata (Phill.).
Leiopteria sp.
Lithodomus lingualis (Phill.).
Pinna flabelliformis, Mart.
Protoschizodus impressus, De Kon.
Sanguinolites clavatus, R. Eth., jun.

With regard to the rest of the fauna, it has a distinctly Viséan facies, and indicates the upper part of the Carboniferous Limestone. We collected the following Corals *in sitû* from a bed nearly at the top of the Ty-nant ravine below the yellow calcareous shales. Corals are present in great abundance:—

Cyathophyllum cf. *regium*, Phill.
Dibunophyllum sp.
Lithostrotion ensifer, E. & H.
L. irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia floriformis, Lonsd.
L. rugosa, M'Coy.
Phillipsastræa radiata, E. & H.
Syringopora sp.

Morton also quotes, amongst others, *Aulophyllum*, *Axophyllum*, several species of *Clisiophyllum*, *Cyclophyllum fungites*, *Koninckophyllum*, *Zaphrentis Bowerbanki*, *Z. cylindrica*, and *Z. Enniskilleni*—all of which, with the exception of *Zaphrentis cylindrica* (= *Caninia*), we should expect to occur at this horizon.

The horizon of this coral band all over North Wales is definite, and marks out a time-zone of great importance, not only locally, but one which can be perfectly correlated with the D_2 zone of the Bristol and Mendip areas, so ably worked out by Dr. A. Vaughan.[2]

In the Eglwyseg ridge the coral zone is succeeded by yellowish calcareous shales, which in turn are overlain by a whitish limestone with giganteid *Producti* and crinoids. This bed, we suppose, is the top of Morton's Carboniferous Limestone Series, but it may possibly belong to the lowest beds of his Cefn-y-Fedw Sandstone, which he terms 'the sandy limestone.' Above this limestone Morton describes "a bed of dark grey limestone, 11 feet thick . . . . It contains numerous encrinite stems with *Productus giganteus*, *P. semireticulatus*, and *P. Cora*, and is succeeded by yellow flaggy sandstones containing annelid tracks." The fact that *P. giganteus* occurs here militates against any subdivision at this horizon. If one feature comes out strongly all over the British Isles and Belgium it is that *P. giganteus* characterises the upper beds of the Carboniferous Limestone Series, and that the faunal change only comes on when this shell disappears, whilst from the stratigraphical

[1] G. H. Morton: "Carboniferous Limestone of Anglesey," pp. 52, 64.
[2] A. Vaughan: Q.J.G.S., vol. lxi, pp. 181–307.

point of view this *P. giganteus* bed is succeeded by the pebbly conglomerate—a bed which can be traced in the sequence from Gwernymynydd to Llangollen. It is interesting to note that the upper beds of limestone at Castleton, Derbyshire, contain occasional quartz pebbles.

(xxxii) The outlier of Carboniferous Limestone at Corwen was also visited by one of us. The quarry exposes the upper beds of the limestone, and is altogether in the zone of *Lonsdaleia*, the upper *Dibunophyllum* zone, but it is impossible to ascertain the thickness of the beds below those that are quarried. At the top there are thick, well-bedded limestones, beneath which are shales with nodules in layers and thin limestones. The beds worked in the quarries are estimated by Morton at 80 feet. The upper limestones contain—

Lithostrotion Portlocki (Bronn).
Syringopora sp.
Rhynchonella pleurodon (Phill.).
Martinia glabra (Mart.).
Productus giganteus (Mart.).
P. punctatus (Mart.).

The 10 feet of black shaly beds below the limestone are full of corals, and contain—

Alveolites septosa (Flem.).
Cyathophyllum cf. *regium*, Phill.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
L. Portlocki (Bronn).
Lonsdaleia rugosa, M'Coy. (Very abundant.)
Phillipsastræa radiata, E. & H. (Common.)
Seminula ambigua (Sow.).

(xxxiii) South of the Dee the limestone outcrops almost continuously for 12 miles from Fron-y-cysyllte to Llanymynech, the outcrop varying from a half to one mile in width. It is of interest that at Fron, according to Morton, only the upper moiety of the series, as exposed in the Eglwyseg ridge, is present, demonstrating the fact that the Wenlock beds in this position were not submerged till later on in Carboniferous time. This also seems to be borne out by the various sections of limestone at Bron-y-garth, Craignant, Llawnt, Porth-y-waen, and Llanymynech. At the latter place Morton estimated the whole limestone series to be 450 feet thick, as against 1,200 feet at Ty-nant, near Llangollen.

Morton[1] shows the following variation in thickness in a distance of 4 miles from west to east:—

Ty-nant.	Tan-y-castell.	Trevor Rocks.	Bronheulog.	Fron.
1,200 feet.	1,025 feet.	607 feet.	295 feet.	115 feet.

And as the upper part of the series is similar in each locality, it follows that the floor on which the limestone was deposited was very uneven, and a considerable overlap of the upper beds occurs locally and in a definite manner from south to north.

(xxxiv) A traverse from Sweeney Mountain, through Treflach Wood Quarries, gives a fairly complete view of the sequence in this area. The old tramway which afforded the section of Cefn-y-Fedw Sandstone published by D. C. Davies[2] and by G. H. Morton[3] has now unfortunately largely disappeared, but many of the beds can

[1] G. H. Morton: op. sup. cit., p. 39.
[2] Geol. Mag., Vol. XII (1870), p. 69.
[3] G. H. Morton: op. sup. cit., p. 93, pl. vi.

still be seen. Morton estimated the thickness of these beds at about 500 feet. Several quarries still exist close to the tramway, showing sandstones of various shades of colour. The highest bed, called by Morton the Sweeney Mountain Sandstone, is a very white and soft rock, in which are traces of fossils, fragments of Brachiopoda, and an obscure coral. Below this bed are other sandstones, pink and red in colour, containing marine fossils—

Actinoceras giganteum, Sow. (*Fide* Morton.)
Productus sp.
Schizophoria resupinata (Mart.).

Still lower comes a hard white sandstone estimated at 70 feet, resting on 150 feet of soft red sandstone, which is fossiliferous in places.

The following section is to be seen at the Treflach Wood Quarries :—

5. Pebbly grit, 1 foot.
4. Soft red sandstone, 6–8 feet.
 Gap, hollow ground, grassed over.
3. Thin beds of limestone, 20 feet.
2. Limestone and shale, 10–15 feet (the limestones varying from 6 in. to 1 ft. thick).
1. Dark limestones, well bedded.

Thin limestones (2) contain—

Campophyllum aff. *Murchisoni*, E. & H.
Cyathophyllum cf. *regium*, Phill.
Productus giganteus (Mart.).

Thin beds of limestone (3) contain—

Alveolites septosa (Flem.).
Campophyllum aff. *Murchisoni*, E. & H.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
Lonsdaleia floriformis (Flem.).
Productus giganteus (Mart.).

The same series with a similar fauna occur at Dolgoch, a little more than a mile S.S.W. of the last section.

(xxxv) The sandstones of the Cefn-y-Fedw Series at Selattyn, Oswestry Racecourse, and Sweeney Mountain are fossiliferous, and the following species were obtained, many of which have been mentioned by Davies and Morton :—

Rhynchonella pleurodon (Phill.).
Orthotetes crenistria (Phill.).
Productus Cora, D'Orb.
P. costatus, J. Sow.
P. punctatus (Mart.).
Schizophoria resupinata (Mart.).
Spirifer sp.
Edmondia Goldfussi, De Kon.
E. sulcata (Phill.).
Parallelodon Geinitzi, De Kon.
P. semicostatus (?).
Pinna flabelliformis, Mart.
Protoschizodus aequilateralis (M'Coy).
Tellinomorpha cuneiformis, Hind.
Pleurotomaria sp.

(*b*) *Pendleside Series.*

The best exposure showing the conformable relation of the Pendleside Series to the underlying cherts is seen at the Grange Quarry, Holloway (lat. 53° 16′ 35″ N., long. 3° 14′ 25″ W.), about a mile north of Holywell. At the entrance to this quarry the black shales and thin platy black limestones are deposited directly on the cherts, which at this locality are about 25 feet thick and dip eastwards at 20°. The cherts in turn rest on the uppermost beds of limestone, so that the succession here is uninterrupted, and presents no complications. In the Pendleside limestones, which are rarely more than 2 inches in thickness, the following fossils were found :—

Posidonomya membranacea, M'Coy. (Abundant.)
Acrolepis Hopkinsi (M'Coy). (Not rare.)

A small portion of the same horizon, consisting of black shales and thin black limestones, has escaped denudation, and may be observed resting conformably on about 70 feet of black cherts (the full section of which was not exposed) near the foot of the hill at Pentre, near Gronant (see *supra*, p. 393) (lat. 53° 20′ 20″ N., long. 3° 21′ 30″ W.). At the east side of the entrance to this quarry we have the following section :—

3. Thin, platy black limestones.
2. Soft, laminated black shales, 1 ft. 6 in.
1. Black cherts in beds from 1 in. to 3 in. in thickness.

The black limestones at the top of the section have the characteristic 'sawn edges' referred to later (p. 452). The black shales yielded the following list :—

Posidonomya Becheri, Bronn. (Rare.)	Plant-remains. (Indeterminable.)
Cladodus. (Teeth.)	*Acrolepis Hopkinsi*.

Beds identical with these are exposed on the west side of the road at and below the well near Gronant Mine (lat. 53° 20′ 7″ N., long. 3° 21′ W.), where they are found to dip north at 13°.

Succeeding these beds in order of deposition is the following section of a large quarry in the wood facing to the south the Nant Hall Hotel, near Prestatyn (lat. 53° 19′ 50″ N., long. 3° 23′ 10″ W.) :—

LADY MCLAREN'S QUARRY.

		ft.	in.	
16.	Shales and limestone	12	0	
15.	Shale	1	0	*Pterinopecten papyraceus* (Sow.). (Abundant.)
14.	Fissile limestone	2	0	*Pterinopecten papyraceus* (Sow.).
13.	Paper shales	0	4	
12.	Platy black limestones and shales	1	0	*Productus hemisphericus*, J. Sow.; Crinoids.
11.	Shale	0	3	
10.	Black limestone	0	3	
9.	Shell bed (limestone)	1	6	
8.	Limestone and shales	2	6	
7.	Shales	0	5	
6.	Limestone...	1	4	
5.	Shales	0	4	
4.	Thin platy limestones	1	6	*Pterinopecten papyraceus*, *Orbiculoidea nitida*.
3.	Fissile black shales	1	2	*Glyphioceras* sp., *Amusium* sp., plant-remains.
2.	Black limestone	1	10	*Phillipsia Polleni*, *Cyathaxonia*.
1.	Shale	2	0 +	*Amplexi-zaphrentis*, *Acrolepis*, *Wilsonia*, *Elonichthys* (scale), large plates.

In addition to the fossils given in the above section, No. 9 (shell bed) contains *Amplexi-zaphrentis* sp., *Productus giganteus* (Mart.), *P. Cora*, D'Orb., *P. hemisphericus*, J. Sow., and *Spirifer bisulcatus*, Sow. No. 13 (paper shales) contains *Pterinopecten papyraceus* (Sow.) (in abundance), Goniatites, and plant-remains. No. 16 (shales and limestones) contains *Posidonomya Becheri*, Bronn (common), *Orthoceras* sp., and *Dithyrocaris* sp.

In the same wood, not many yards from the last section and resting immediately above it, is an excellent exposure of the thinly bedded black limestones, whose upper and lower surfaces are remarkably planar. When struck by a hammer they produce a sonorous metallic 'chink.' Their vertical joints, as they are seen passing through all the platy limestones in contact, have the appearance of the sawn edges of a pile of boards. These black limestones of this horizon we will refer to as 'Teilia Beds,' from the fact of their occurrence at a farm called Teilia, near Gwaen-ys-gor. At the quarry already mentioned near Nant Hall Hotel the beds dip to the west at 5°, and the following list was obtained:—

Posidonomya Becheri, Bronn. (Common.)
Goniatites.
Orthoceras sp.
Dithyrocaris sp.
Plant-remains.

The same beds are to be found in a quarry under the road leading from Prestatyn to Gwaen-ys-gor (lat. 53° 19′ 40″ N., long. 3° 23′ 20″ W.), where they are faulted to the east against beds of Carboniferous Limestone (see p. 392). The fault can be traced close to the road, and its downthrow to the east is estimated to be at least 80 feet. In this quarry the following fossils were fairly common:—

Productus plicatilis, Sow.
Posidonomya Becheri, Bronn.
Orthoceras sp.
Plants.

Lower down the hillside and cropping out midway between the first and second bends in the road from Prestatyn (lat. 53° 19′ 45″ N., long. 3° 23′ 25″ W.), the underlying limestone shales were observed dipping S.S.E. at 15° and containing the following fauna:—

Posidoniella lævis (Brown), or young form of *Posidonomya Becheri*, Bronn.
Posidonomya Becheri, Bronn. (Abundant.)
Pterinopecten papyraceus (Sow.).
Glyphioceras. (Large reticulate form.)
? *Prolecanites compressus*.

The section at Teilia (lat. 53° 19′ 15″ N., long. 3° 22′ 55″ W.) has been frequently described, and the plants collected there form the subject of a paper by Mr. R. Kidston,[1] F.R.S., who in it says (p. 427): "Little or no assistance is given in deciding this point [i.e. the horizon] by the molluscan remains, as some of them extend from the base to the top of the Carboniferous formation." The following list of the fauna collected at this locality enables the correlation of this horizon to be made with certainty and exactness, not only with those sections above described, but with others in widely separated areas:—

[1] Trans. Roy. Soc. Edinburgh, vol. xxxv (1888), pp. 419–428.

Posidoniella lævis (Brown).
Posidonomya Becheri (Bronn). (Common.)
Pterinopecten cf. *carbonarius*, Hind.
Rhynchonella sp.
Glyphioceras reticulatum (Phill.).
Orthoceras sp.
Spirorbis sp.
Ostracods.
Fish-remains.

Mr. Kidston's paper may be referred to for an account of the plants from this locality: it is interesting to note, however, that this flora occurs in the Pendleside Series of Poolvash, Isle of Man, Pendle Hill, and North Staffordshire, associated as at Teilia with a typical Pendleside fauna.

We are indebted to Mr. T. W. D. Gregory for the following analyses of samples of this limestone which were collected from the quarries at Teilia and near Prestatyn:—

	Teilia.	Near Prestatyn.
Moisture	0·104	0·53
Analysis of Dried Sample.		
Carbon dioxide ($C O_2$)	38·68	26·76
Ferric oxide ($F_2 O_3$)	0·73	0·71
Aluminium oxide ($Al_2 O_3$)	1·27	0·69
Calcium oxide ($Ca O$)	43·60	32·57
Magnesium oxide ($Mg O$)	0·61	0·51
Soluble silica ($Si O_2$)	0·11	0·32
Phosphorus pentoxide ($P_2 O_5$)	trace	—
*Insoluble residue	14·91	38·31
**Analysis of insoluble residue.*		
Or anic matter + combined water	2·92	0·95
Silica ($Si O_2$)	10·26	34·55
Aluminium oxide ($Al_2 O_3$)	1·70	2·48
Ferric oxide ($Fe_2 O_3$)	trace	trace

Some strata, possibly a little higher in the series, were examined in a quarry on the high side of the road leading from Holywell to Brynford (lat. 53° 16′ 10″ N., long. 3° 13′ 10″ W.). We found similarly thin-bedded black limestones overlying finely laminated black shales, and all dipping off the flanks of the mass of Carboniferous Limestone of Halkyn Mountain. In the black limestones we found—

Posidonomya Becheri, Bronn. (Rather rare.)
Plant-remains. (Indeterminate, but not rare.)

In stratigraphical sequence the next horizon is exposed near the entrance to Nant-figillt at Hendre, where a brickworks is established for the manufacture of bricks, etc., from the soft laminated black shales which are quarried there (lat. 53° 12′ N., long. 3° 11′ 10″ W.). Near the floor of the quarry is a band of thin black limestone which is very fossiliferous, and has yielded the following:—

Lingula mytiloides, Sow. (In adjacent shales also.)
Posidoniella lævis (Brown).
P. minor (Brown).
Pterinopecten papyraceus (Sow.). (In shales also.)
Dimorphoceras Gilbertsoni (Phill.).
Glyphioceras cf. *Phillipsi*, Foord & Crick.
G. reticulatum (Phill.).

Higher again in the series a section consisting of laminated dark shales is seen on the eastern side of the Baggilt Old Road, near the bottom of the valley about ⅜ mile from Holywell (lat. 53° 16′ 12″ N., long. 3° 12′ 35″ W.). The following fauna was collected:—

Posidoniella lævis (Brown). (Very abundant.)
Pterinopecten carbonarius, Hind.
P. papyraceus (Sow.).

Near the summit of the sharp rise from the bottom of the valley, 200 yards further on the same road from Holywell, there is an exposure of soft black shales, which are rather barren of fossil remains.

The cutting on the north side of the Glyn Abbot Road (lat. 53° 16′ 22″ N., long. 3° 12′ 20″ W.) presents a fairly thick series of soft, pyritous, black shales, which are the highest beds of the Pendleside Series examined *in situ* by us in this district. A few feet above the level of the road is a band of black limestone about 3 inches thick, which in one layer is crowded with a peculiar *Productus*, which is also found about this horizon at Congleton Edge, Cheshire, and according to Dr. A. Vaughan occurs in stage ϵ of the Bristol area. Concerning *Productus* ϵ, Dr. Vaughan reports that it shows effects of convergence with *Productus* aff. *Cora* and *P.* aff. *hemisphericus* and homœomorphy with *P. semireticulatus*. It is a very complex type, and is identical with the most abundant form which is found in the Upper *Dibunophyllum* zone and stage ϵ near Wick, East Bristol area. In the above section the shales overlying the thin limestone yielded—

Lingula mytiloides, Sow.
Leiopteria longirostris, Hind.
Posidoniella lævis (Brown). (Very common.)
P. minor (Brown).
Pterinopecten carbonarius, Hind.
P. papyraceus (Sow.).
Actinopteria persulcata, M'Coy, sp.
Glyphioceras diadema, Berg.
G. Phillipsi, Crick.
Orthoceras Steinhaueri, Sow.
Reed-like plant-remains.

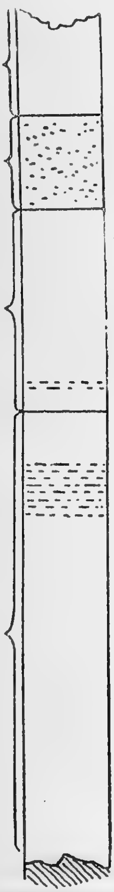
(*c*) *The Millstone Grit.*

This member of the Carboniferous system is represented in North Flint by the massive grit so extensively quarried in the neighbourhood of Gwespyr and Talacre, where its thickness is at least 300 feet; it is usually referred to as the Gwespyr Sandstone. There is a small exposure in the road leading from Kelston Farm to the bridge near the head of Talacre Dingle, whose stream, also, has cut through the same thick sandstone, where it forms steep bank-sides, and gives rise to the dantesque scenery for which the dingle is well known. At the top end of the smaller lake which the stream of the Dingle enters, there is a small exposure of 'crowstones.' At the village of Gwespyr the bedding-planes of the large blocks of grit obtained from the quarries are marked by abundant débris of leaves and stems of plants; *Stigmaria ficoides* (Sternb.) was collected from one of these layers.

Reference has been made (*ante*, p. 446) to the representative of the Gwespyr Sandstone near Berwig station, the most southerly point at which any representative of the Millstone Grit appears in force.

4. The actual Sequence as now established.

The chief result of our examination of this area of development of Carboniferous rocks is the discovery that the sequence is normal, in every respect, to that observed throughout the North Midlands. The structure of the country is fairly indicated by its topographical features, and the succession of the chief divisions of the Carboniferous system is not obscured or complicated by the various faults that traverse the district. Both the palæontological and lithological sequence agree most remarkably with that already established for the area of the southern portion of the Pennine Chain, as will be seen from the following diagram (Fig. 2) of the succession in North Wales :—



General Nomenclature.	Local Nomenclature.	Mining Classification.	Abundant and Characteristic Fossils, etc.
d. Coal-measures.	Coal-measures.	Coal-measures.	Coal-seams.
c. Millstone Grit.	Gwespyr Sandstone.		*Calamites, Stigmaria*, etc.
b. Pendleside Series.	Holywell Shales.	Watertight barrier.	*Posidoniella lævis* / Fossiliferous bullions / *Posidonomya Becheri* / *P. membranacea* — *Pterinopecten papyraceus.*
	Teilia Beds, or Chert in places.		
D₂	Cherts and Calcareous Grits in places.	Lead-measures.	*Productus longispinus.* / *P. giganteus.* / *Lonsdaleia floriformis.* (*Cyathaxonia* beds.)
	Aberdo Limestone.		*Lithostrotion irregulare* / *L. junceum* / *L. Portlocki* / *Spirifer triangularis.* (Abundant.) / *S. trigonalis.* ,, — *Amplexi-zaphrentis*
a. Carboniferous Limestone.	Grey Limestone.		
D₁	White Limestone.		*Lithostrotion Martini.* *Productus Cora.* (Abundant.)
S₂	Brown Limestone.		*Chonetes papilionacea.* (Abundant.) *Cyathophyllum Murchisoni.*
Pre-Carboniferous.			*Seminula ficoides.* *Daviesiella Llangollensis.*

Note.—This diagram, Fig. 2, is not to scale.

The above general succession was made out from field-work and from analysis of the fossils collected during that work, but our conclusions received confirmation from an unexpected source which it is desirable to mention here. A few years ago a water-level was driven from Baggilt to the East Halkyn Mine, which passed through the whole series from the Coal-measures to the Carboniferous Limestone. We are much indebted to Mr. J. Powell Jones, of Holywell, for calling our attention to this, and for showing us the section of the tunnel. Mr. Jones also took the trouble of pointing out to us the débris from the excavation of the tunnel in the order in which it was drawn (so far as he could certify this), it having been tipped *seriatim* over a great area of ground. We saw several typical large Pendleside bullions, and from the shales we collected—

Posidoniella lævis (Brown).
Pterinopecten papyraceus (Sow.).
Goniatites.
Nautiloid form.
Acrolepis Hopkinsi (?).
Listracanthus sp.

We also observed a grit which Mr. Jones informed us was met with near the top of the cherts, and which was crowded with detached fish-remains (teeth, spines, etc.), representing undoubtedly the great bed at the top of the section at Gwernymynydd (p. 398). The full thickness of the Holywell shales was about 1,000 feet, as proved by this adit-level.

With respect to the correlation of the numerous exposures of Carboniferous Limestone there is more difficulty; we may, however, as a preliminary, make some observations on the range and distribution of the most important and most abundant fossils (chiefly Corals and Brachiopods) which occur throughout this district.

Seminula ficoides, Vaughan. This form characterises the lowest beds of the series, which may be seen at Llandulas and south of Dyserth. Its vertical range is rather limited, and for that reason it is of great value for stratigraphical purposes. At Llandulas and Minera it is associated with *Daviesiella Llangollensis* (Dav.), which also appears to have a limited range and yet possess a wide distribution. Both forms were very numerous; the latter occurs at Llandulas, Minera, and Eglwyseg ridge.

Cyathophyllum Murchisoni, E. & H. The range of this coral is very considerable, and its zone is mainly above that of *Seminula ficoides*, although they possibly overlap to a slight extent. In the lower portion of the zone, it is very abundant at Bwlch-y-gwynt, near Dyserth, near Llanferres, Llanarmon, Eglwyseg ridge, and near Sweeney Mountain, and at nearly all these localities it is associated with *Chonetes papilionacea*, Phill., which is also abundant. The highest beds in which it occurs are seen near Axton Mine, at Hendre, and at Treflach Wood Quarries, where it occurs near the base of *Productus giganteus* zone, and is associated with *Campophyllum Murchisoni*, E. & H.

Cyathophyllum cf. *regium*, Phill. This coral was found in beds just below the highest of the series at Hendre, Minera, Corwen, Eglwyseg ridge, and Treflach Wood Quarries, and was always associated with *Lithostrotion irregulare* (Phill.), *L. junceum* (Flem.), *L. Portlocki* (Bronn), and frequently with *Lonsdaleia rugosa*, M'Coy, and *Phillipsastræa radiata*, E. & H. It differs somewhat from the typical *C. regium* from the Bristol area.

Dibunophyllum. Corals belonging to this genus are distributed through the whole series of the Carboniferous Limestone of North Wales, with the possible exception of the lowest of these or the *Seminula ficoides* zone.

Lithostrotion Martini, E. & H. This coral appears to characterise those limestones that occupy an intermediate position, and it has therefore a moderate range, extending from the base of *Cyathophyllum Murchisoni* zone, as seen at Bwlch-y-gwynt and near Llanferres, to beds 300 feet higher in the series at Pot Holes, in the White Limestone on Holywell Common above the Grange Quarry (see section, Fig. 1, p. 394), at Gwaenysgor, and in the White Limestone overlying the Brown Limestone of the Eglwyseg ridge.

Lithostrotion irregulare (Phill.), *L. Portlocki* (Bronn), *L. junceum* (Flem.). These species are found most abundantly in beds which form the uppermost 100 feet of the Carboniferous Limestone of this district, as exposed at Hendre, Gwernymynydd, Pot Holes, Minera, Ty-nant ravine, Corwen, and Treflach Wood Quarries; they are thus seen to be widely distributed.

Calophyllum θ, Campophyllum Murchisoni, Clisiophyllum Curkeenensis. These three corals are not very abundant, and have only been found in the upper beds of limestone occurring at Waenbrodlas, near Gwyndy, and at Treflach Wood Quarries.

Spirifer triangularis (Mart.), *S. trigonalis* (Mart.), d'Orb. These Brachiopods practically make up whole beds in quarries at Gwernymynydd and north of Gwyndy, at an estimated distance of 100 feet from the top of the limestone.

Productus longispinus, Sow. This is abundant in the uppermost beds only of the limestone, such as the Aberdo Limestone horizon, and it extends into the cherts at Gronant.

Amplexi-zaphrentis. This genus is fairly abundant in the upper portion of the limestone, and has a wide distribution.

Clisiophyllum aff. *Curkeenensis*, Vaughan, *Calophyllum θ*, Vaughan. These two species of Corals have only been found near the top of the limestone, and are more restricted than *Productus longispinus*, Sow.

Productus giganteus (Mart.). These large Brachiopods are very abundant in the top beds of the limestone; after a distance of 100 feet from the top they are of sparing occurrence, and are not met with in those beds where *P. Cora*, d'Orb., and *P. hemisphericus* are so abundant near the base of *Cyathophyllum Murchisoni* zone.

By analysis of the fossil lists, then, we are enabled to correlate, with varying degrees of precision, the different exposures of the Carboniferous Limestone in this part of North Wales. In ascending order, the localities affording sections in the same horizons may thus be summarised:—

1. The lowest limestones at Llandulas; Pentre-bach, near Dyserth; and Eglwyseg ridge, near Dibrun Uchaf. Characteristic fossils: *Seminula ficoides, Daviesiella Llangollensis.*

2. The beds east of Bwlch-y-gwynt, at the foot of the hill near Llanferres, and near Llanarmon. Characteristic fossils: *Cyathophyllum Murchisoni, Chonetes papilionacea, Productus Cora, P. hemisphericus.*

3. Intermediate strata, whose position relative to one another cannot as yet be definitely assigned, appear at the surface at Meliden, Gwaenysgor, Axton Mine, Garreg, and Cat Hole, east of the Loggerheads Inn. Characteristic fossils: *Productus Cora* (few), *P. hemisphericus* (common), *P. giganteus* (not rare). The quarry at Holywell Common, above the Grange Farm, is probably at the upper limit of this horizon (see Fig. 1, p. 394).

4. The next stage is exposed at Hendre, Gwernymynydd, north of Gwyndy, Pot Holes (the last-named quarry can be definitely correlated with the "No. 1 Encrinital Limestone" at Gwernymynydd; see p. 398), Minera, Ty-nant ravine, Corwen, and Treflach Wood

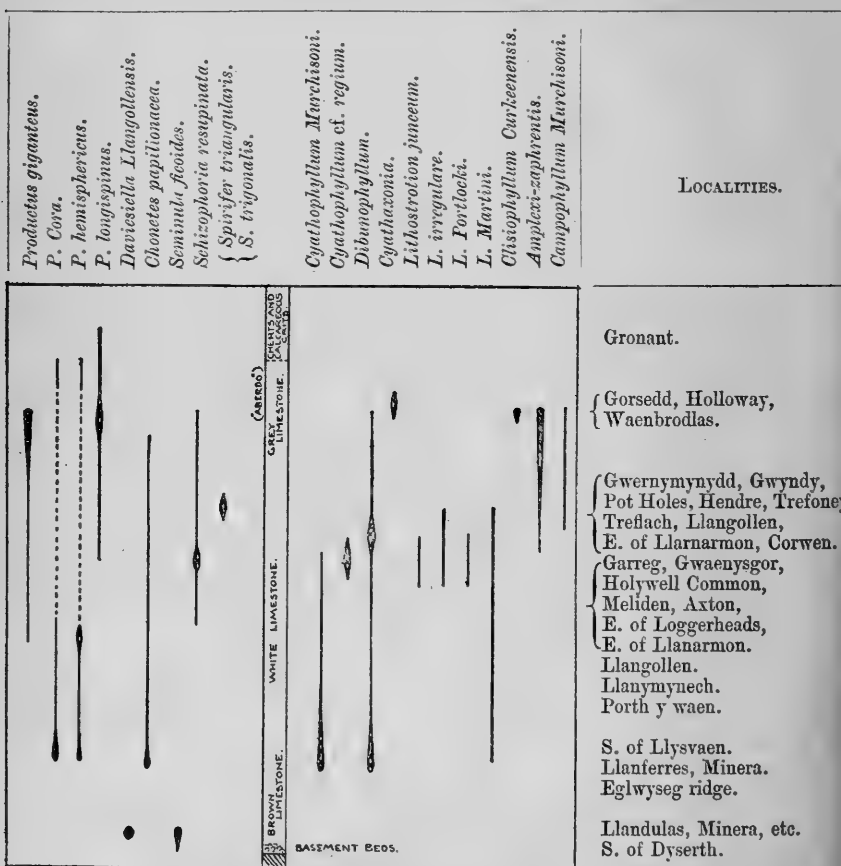


Fig. 3.—Diagram showing the stratigraphical distribution of the most important fossils.

Quarries. Characteristic fossils: *Amplexi-zaphrentis, Lithostrotion irregulare, L. junceum, L. Portlocki, Spirifer bisulcatus, S. triangularis, S. trigonalis.*

5. The uppermost beds, which in all probability were not deposited over the whole of this Carboniferous area (p. 394), are seen at Trelogan, Gorsedd, Holloway, Waenbrodlas, Eglwyseg ridge, and Treflach Wood Quarries. Characteristic fossils:—

Cyathaxonia Rushiana.	*Lonsdaleia floriformis.*
Clisiophyllum Curkeenensis.	*Productus giganteus.*
Callophyllum θ.	*P. longispinus.*
Campophyllum Murchisoni.	

6. The very highest member of the Carboniferous Limestone Series are the cherty beds and their equivalent calcareous grits or Cefn-y-Fedw Sandstone, as exposed near Pentre Halkyn, Holloway, Gronant, Gorsedd, Trelogan, Prestatyn, and Graianryd. The grits are characterised by the presence of abundant fish-remains in a more or less fragmentary state.

(*To be concluded in our next number.*)

IV.—The Somabula Diamond Field of Rhodesia.

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

The last few years have inaugurated a new era in the history of the South African diamond deposits, inasmuch as rich bodies of diamantiferous ground have been located at great distances from localities which have previously been worked successfully. The group of which the Premier Mine is the best known member is the most striking example of this extension of area, but the centre of gravity of the diamond-mining industry seems to be gradually shifting northward, and the opening up of the interesting deposit of the Somabula Forest, so far north of any other known occurrence, foreshadows the development of an important branch of the industry in the Cinderella of the South African provinces, as Rhodesia has been not inaptly termed.

No detailed or authentic description of the Somabula field has so far appeared. The writer briefly referred to the occurrence of a remarkable gravelly deposit west of Gwelo in his "Geology of Southern Rhodesia," and ascribed its formation to the Tertiary period, a course which appears fully justified by more recent and detailed investigation. He had already seen diamonds and other gems from the locality, but had not been made aware of their source. Last year he made an examination of the ground on behalf of the South African Options Syndicate, who hold a large area on the field and who have just erected plant for producing diamonds on a large scale. The reports of their preliminary operations will have shown that a rich deposit of good quality stones has been opened up. A large quantity were disposed of at a price which works out at £3 17*s.* per carat, and a smaller parcel sold more recently fetched £6 per carat. The following notes, for permission to publish which I am indebted to the Syndicate, are intended to afford some idea of the geological and mineralogical features of the field, of which I hope to give a much more detailed account at an early date.

The diamond area may be described as a tongue of the Somabula Forest stretching along the central plateau of Rhodesia from the Uvungu River for about seven miles in the direction of Gwelo. The beds of which it consists are undoubtedly younger than the Forest Sandstones, as shown by their numerous pebbles of agates derived from the lavas interbedded with those rocks, but they are probably very different in age, and may perhaps be regarded as the uppermost portion of the Forest Sandstone series. They directly overlie the granite of the watershed, on to the apex of which they extend, but further down the Uvungu River the ordinary Forest Sandstones are met with. The general sequence appears to be—

	5.	Surface rainwash, etc., chiefly redistributed gravel and sand (often absent)	say 10 feet
Somabula Beds.	4.	Red and white sands	say 40 feet
	3.	Gravel, with partings of clay, etc.	say 40 feet
	2.	White micaceous sand	30 feet
		resting unconformably upon	
	1.	Granite.	

The top of the upper sandy beds is not seen, but the thickness given is probably well within the mark. The levels of the granite bed-rock also vary considerably, and the beds themselves tend to assume a lenticular shape, so that it is impossible to give more than a rough idea of their proportionate development.

The upper sands, which have been entirely removed by denudation from some of the ridges and from all the lower ground, are sometimes clayey and stained red by iron oxides and sometimes fine and white. In a shaft at one spot on the slope of a ridge, an actual thickness of 16 feet was passed through before reaching the underlying gravel. It may be stated, however, that so heavy an overburden is met with on few parts of the diamantiferous area.

The gravel itself is composed of beautifully rounded pebbles in a matrix of sandy clay, sometimes ferruginous. There are some concretionary masses of iron-cemented sandstone, and the gravel is converted in places into a hard conglomerate by infiltrated iron oxides, or more rarely by silica. The pebbles are mostly of quartz, frequently rock crystal, but they also include jaspery banded ironstone, chert, agate, hard sandstone or quartzite, and occasional large and small pieces of silicified wood, as well as fragments of granite and chloritic schist. Large boulders are comparatively rare. The silicified wood, though distributed about in all sorts of positions, may possibly have been *in sitû*; the granite and schist last mentioned are the only other constituents of the deposit that are not well rounded. The presence of the agate, as already mentioned, shows the deposit to be newer than the lavas of the Forest Sandstone series. In one shaft 25 feet of gravel had been passed through at the time of my visit without any indications of approaching the base, and more recent work has shown that my estimate of 40 feet is probably a moderate one for the maximum thickness.

The lower sandy beds have obviously derived most of their materials from the underlying granite. They are micaceous throughout, the upper and lower parts south of the railway being clayey with a bed of clean sand in between. The base shows fragments of decomposed granite, and it is difficult to fix the point where the bed-rock really begins.

It is clear that in these sands and gravels we are not dealing with the insignificant accumulations of the present-day river system. This is no less evident from the character and distribution of the deposits than from their position on the crest of what is now the main watershed of the country. Their extent is quite in keeping with a lacustrine origin; on the other hand, they correspond closely with the alluvial deposits of rivers which have eroded their valleys practically to the lowest possible level, and have for long been chiefly occupied in widening them and spreading the materials furnished by the process evenly over their flood plains. The Somabula beds may therefore be set down provisionally as due to the action of an important Tertiary river or river system, probably a feeder of the great lake which must once have filled the adjacent portion of the Zambesi basin, and draining an area chiefly occupied by granite and the Archæan banded ironstone.

The gravels of the Somabula are interesting from their unique lithological character as far as Rhodesia is concerned, but their chief interest naturally arises from their being the source of various gem stones, particularly the diamond. The diamonds themselves are peculiar as almost invariably of a green shade in the rough; this is, however, entirely lost in cutting. They occur in very good crystals, principally octahedra, spinel twins of two octahedra, twinned tetrahedra, twinned hexatetrahedra, dodecahedra, etc. Etched triangles are characteristic of the tetrahedral faces. Worn stones are almost entirely absent. The mineralogical associates of the precious stones are not precisely similar to those of the Kimberley diggings or of the more recent Transvaal discoveries, but they nevertheless present a general resemblance to those of the localities named. Garnets are often common, but are not of the blood-red Kimberley variety. Ilmenite too is uncommon. Both magnetite and hæmatite, of which grains are numerous, are evidently derived from the banded ironstone, while the source of the zircon and of the mica (muscovite) is equally clearly the granite; these minerals have no necessary connection with the original matrix of the diamond. This too is probably the case with the beryls which also occur. The typical minerals of the deposits are (besides the diamond) enstatite, chrysoberyl, kyanite, and sapphire. Enstatite is the commonest of the minerals popularly grouped together under the name of olivine at Kimberley, but is here a remarkably hard brownish variety. It is an abundant constituent of the sorted material from the puddling machines. Some of the grains are fairly clear, and might almost be taken for garnets on account of their red-brown colour. Chrysoberyl is quite abundant for so rare a stone. The prevailing variety is yellow, but the opalescent (precious) 'catseye' and the form known as 'alexandrite,' which is green by day- and red by candle-light, also occur. This mineral would seem to be usually a product of contact-metamorphism; at the same time, although it is not strictly analogous in a chemical sense, its similarity of composition and isomorphism with olivine are to be noted. As a gem the ordinary variety is actually called 'chrysolite,' one of the names properly applied to olivine. Kyanite and sapphire are unequivocal contact minerals, so are rutile and tourmaline, whose occurrence may also be noted. The presence of the first-named is interesting owing to its softness, which makes its survival rather remarkable. Of the sapphires both the blue and colourless varieties occur, while true rubies and Oriental amethysts are also found, though they are distinctly rare even for such scarce stones. Another stone whose occurrence may be noted is the so-called 'Somabula blue.' This is harder and heavier than common beryl, and is possibly a variety of topaz; when cut it is one of the most beautiful gems imaginable.

With regard to the origin of the gems, the mere richness of the deposit is sufficient to indicate a near source for the diamond, although many of the constituents of the gravel itself have obviously travelled far. Despite theories to the contrary, it seems certain from the evidence obtained in New South Wales as well as in this country that what is commonly called 'blue ground' is in all cases the original source of the diamond, and the great abundance of enstatite, as well as the presence of garnets, points to the same origin in the case of the Somabula field. I am aware that Professor Gregory after a hurried inspection of the ground has pronounced the opinion that the diamond comes from pegmatite veins, but such an idea is so completely at variance with the local conditions and with all that we know of diamond occurrences that it scarcely merits discussion. I have little doubt that it will not be long before the pipe which produced the diamonds is discovered, and that it will present, apart from slight local peculiarities, all the usual features of the South African mines already known.

V.—A Key to the Published Figures of the Cretaceous Forms of the Polyzoan genus *Entalophora*.

By W. D. Lang, M.A., F.Z.S., F.G.S., of the British Museum (Natural History).

In view of the vigour with which the investigation of the English Chalk is at present being carried out by amateurs, resulting in the accumulation of large numbers of fossil specimens which give rise to difficulties of nomenclature, the publication of a key to aid collectors in determining the specific position of members of one of the largest Cretaceous genera of the phylum Polyzoa does not seem inappropriate.

The most inclusive work on Cretaceous Polyzoa is the British Museum Catalogue. While this gives descriptions of such species as the British Museum possesses, with figures of many, and references to all the literature on the group, it does not present any tabular arrangement of forms nor easy means whereby the different species of a genus may be compared for identification by a collector.

Fourteen species of *Entalophora* are described in the Catalogue as being represented in the Museum collection, and references with a few words of description are given of thirty-three more described forms. Without access to the works mentioned the task of identification becomes impossible, and the collector can hardly be blamed if he leaves alone the Cretaceous forms of *Entalophora.*

It is hoped that, prefaced with a few explanatory remarks, the key here given will be found intelligible.

First, all references and descriptions without figures have been ignored, because in the case of such small differences of detail as occur between the 'species' in this genus, descriptions unaccompanied by figures are useless unless (and in no case is this so) they are such as to compare with the whole series of described forms.

Next, the question of synonymy has been left alone. All the figures which can be referred to this genus are mentioned, and references given as in the British Museum Catalogue. In many cases several figures fall under one heading; and it will be generally found that they are grouped as one species in the British Museum Catalogue. But by no means does it follow that the converse is true; for forms widely separated on the table may be different topomorphs[1] of one species. This only demonstrates the artificiality of the grouping in the key. For this artificiality no apology is tendered; for the 'genus' itself is probably as artificial as other Polyzoan genera; and the key is only meant to help the identification of figured forms, and not to show genetic relationships. It is to be hoped that further investigation of forms, especially with regard to the horizons at which they occur, will throw light on these. Meanwhile the accurate recognition of described forms is the first step towards their further elucidation.

The terms used in the key are for the most part self-explanatory. The size and arrangement of the apertures are the characters chiefly used. The distances between the apertures are described in terms of the diameter of the aperture—the vertical distance being that in a proximal-distal direction—along the branch, and the transverse distance at right angles to this.

The term *emergent* is used of zoœcia whose upper surface is arched well above the general level of the zoarium, which therefore has a surface with a crenulate outline. On the other hand a zoarium is composed of *immersed* zoœcia whose surface is flat, though the outlines of the zoœcia may be apparent thereon. The terms are comparative, that is, degrees of emergence and immersion are exhibited.

The measurements and statements in the table are approximate, for allowance has to be made for some zoœcial variation within even small pieces of a zoarium.

[1] A topomorph is a term, applicable to Polyzoa and colonial Madreporaria, denoting an individual or group of individuals differing in form from those surrounding it. See Geol. Mag., 1906, pp. 66–68.

A. *Branches cylindrical.*

I. Apertures distant (i.e. vertical distance between the apertures more than about four times the diameter of the aperture).

a. Apertures very distant and zoaria thin.

α. Apertures two or three in the breadth of a branch.

1. Zoœcia immersed.

a. Zoarium smooth.

α. Zoarium exceedingly thin and delicate ... 1

β. Zoarium not so thin and delicate ... 2

b. Zoarium with transverse striæ.

α. Transverse striæ faint and close ... 3

β. Transverse striæ coarser and farther apart ... 4

c. Zoarium with outlines of zoœcia marked, though the zoœcia are not emergent.

α. Apertures arranged in pairs ... 5

β. Apertures irregularly arranged.

1. Apertures very distant (6–8 diameters), zoœcia strictly cylindrical.

a. Apertures 1–2 in the breadth of a branch.

α. Zoarium exceedingly thin and delicate ... 6

β. Zoarium not so thin nor delicate ... 7

b. Apertures 2–4 in breadth of a branch ... 8

2. Apertures not so distant (4–6 diameters), zoœcia fusiform ... 9

2. Zoœcia emergent.

a. Zoœcia only somewhat emergent ... 10

b. Zoœcia very emergent ... 11

β. Apertures four to six in the breadth of a branch.

1. Apertures arranged in twos and threes (zoœcia are shorter than in *geminata* and zoœcial boundaries less marked) ... 12

2. Apertures irregularly arranged.

a. Zoœcia very emergent ... 13

b. Zoœcia somewhat emergent, zoœcial boundaries very clearly marked 14

c. Zoœcia immersed, though zoœcial boundaries are shown ... 15

b. Apertures comparatively close, and zoaria stout compared with diameter of apertures. Peristomes very high.

α. Apertures of smaller diameter (·04–·06 mm.) ... 16

β. Apertures of larger diameter (·08–·12 mm.) ... 17

II. Apertures close (i.e. vertical distance between the apertures less than about four times the diameter of the aperture).

a. Apertures two or three in the diameter of a branch.

α. Zoœcia emergent ... 18

β. Zoœcia immersed ... 19

b. Apertures four to eight or more in the diameter of a branch.

α. Zoœcia emergent.

1. Apertures in whorls ... 20

2. Apertures in spirals.

a. Zoœcia cylindrical ... 21

b. Zoœcia fusiform ... 22

β. Zoœcia immersed.

1. Apertures comparatively distant (2–4 diameters apart).

a. Apertures regularly arranged in whorls ... 23

b. Apertures regularly arranged in spirals.

α. Apertures about four or five in the breadth of a branch ... 24

β. Apertures about eight in the breadth of a branch.

1. A transverse ridge across each zoarium just beneath the aperture ... 25

2. No transverse ridges across the zoœcia ... 26

c. Apertures irregularly arranged ... 27

2. Apertures close (1–2 diameters apart vertically).

a. Diameter of apertures ·35 to ·4 mm.

α. Branches short and stumpy ... 28

β. Branches normal though stout ... 29

b. Diameter of apertures ·1 to ·2 mm.
  α. Transverse distance between apertures about the diameter of one aperture 30
  β. Transverse distance between apertures $\frac{1}{2}$ to $\frac{3}{4}$ diameters of aperture 31
c. Diameter of aperture ·04 to ·1 mm.
  α. Peristomes moderately high 32
  β. Peristomes very high 33

III. Apertures close, but bare patches on the zoarium 34

B. *Branches compressed.*

I. Apertures transversely elongate 35

II. Apertures circular.
a. Zoœcia emergent.
  1. Apertures very distant (four to six diameters apart vertically)... ... 40
  2. Apertures distant (three to four diameters apart vertically) 36
  3. Apertures close (two and a half diameters apart vertically) 37
b. Zoœcia immersed.
  1. Zoarium transversely striate 38
  2. Zoarium smooth.
    α. Vertical distance between apertures 3 to 6 times their diameter.
      a. Boundaries of zoœcia not apparent... 39
      b. Boundaries of zoœcia clearly marked 40
    β. Vertical distance between apertures 1 to 3 times their diameter.
      a. Lateral distance between apertures 2 to 3 times their diameter ... 41
      b. Lateral distance between apertures $\frac{1}{2}$ to $1\frac{1}{2}$ times their diameter.
        1. Lateral distance $\frac{1}{2}$ a diameter. Diameter of aperture about ·3 mm. 42
        2. Lateral distance $1-1\frac{1}{2}$ diameters. ? Diameter of aperture about ·1 mm. 43

C. *Branches triangular in cross-section* 44

D. *Zoarium cylindrical with a cup-shaped top* 45

E. *Zoarium clavate.*

I. Apertures close (vertical distance between the apertures about 3 diameters of an aperture and lateral distance about $1\frac{1}{2}$). Apertures tending to an arrangement in whorls 23

II. Apertures distant (vertical distance between the apertures 3–5 diameters of an aperture). Apertures irregularly arranged.
a. Zoœcia thoroughly emergent 46
b. Zoœcia somewhat emergent... 47
c. Zoœcia immersed 48

1. *Entalophora Pergensi*, Gregory, 1899: Brit. Mus. Cat. Cret. Bry., vol. i, pl. x, figs. 5, 7 ... ... *E. Pergensi.*
2. *Pustulipora virgula*, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 3 ... ... *E. virgula.*
   Entalophora virgula, var. *alternata*, Gregory: loc. cit., pl. x, fig. 3. ,,
   E. virgula, var. *subgracilis*, Gregory: loc. cit., pl. x, fig. 4. ,,
   E. virgula, var. *raripora*, Gregory: loc. cit., pl. xi, fig. 2. ,,
   ? *E. virgula*, Gregory: loc. cit., pl. xi, fig. 16. ,,
   Pustulipora rustica, von Hagenow, 1851: loc. cit., pl. i, fig. 5. ,,
   P. nana, von Hagenow, 1851: loc. cit., pl. i, fig. 4. ,,
   Entalophora raripora, Beissel, 1865, Bry. Aach. kr.: Nat. Verh. holl. Maatsch. Wet., ser. II, vol. xxii, pl. x, fig. 123. ,,
   E. iconensis, d'Orbigny, 1851: Bry. Crét., pl. 616, figs. 12–14. ,,
   E. subgracilis, d'Orbigny, 1851: loc. cit., pl. 621, figs. 4–6. ,,
   E. alternata, d'Orbigny, 1851: loc. cit., pl. 621, fig. 7. ,,
   ? *E. santonensis*, d'Orbigny, 1851: loc. cit., pl. 623, figs. 15–17. ,,
   ? *E. variegata*, d'Orbigny, 1851: loc. cit., pl. 622, figs. 18–21. ,,

3.	*Entalophora proboscidea*, Pocta, 1892, Mech. Koryc. Hory.: Ceska Ak. Fr. Jos. Pratze, sect. ii, pl. ii, figs. 23, 24	*E. virgula.*
	E. virgula, var. *raripora*, Gregory, 1899: loc. cit., pl. x, fig. 1.	"
	E. virgula, Gregory, 1899: loc. cit., pl. x, fig. 2; pl. xi, fig. 18.	"
4.	*E. raripora*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 1–3.	"
	E. raripora, Novak, 1877, Bry. böhm. kr.: Denk. Ak. Wiss. Wien., vol. xxxiii, pl. x, figs. 1, 2.	"
5.	*Pustulipora geminata*, von Hagenow, 1851: loc. cit., pl. i, fig. 11.	*E. geminata.*
	Entalophora geminata, Gregory, 1899: pl. x, fig. 8.	"
6.	*E. Pergensi*, Gregory, 1899: pl. x, fig. 6	*E. Pergensi.*
7.	*E. raripora*, Beissel, 1865: loc. cit., pl. x, fig. 120	*E. virgula.*
8.	*E. raripora*, Novak, 1877: loc. cit., pl. viii, figs. 1–5.	"
	E. echinata, Gregory, 1899: pl. xi, fig. 17	*E. echinata.*
9.	*E. vassiacensis*, d'Orbigny, 1853: loc. cit., pl. 753, figs. 13–15.	*E. vassiacensis.*
10.	*E. raripora*, Fric, 1883, Iserch: Arch. naturw. Landesf. Böhm, vol. v, No. 2, p. 125, fig. 107	*E. virgula.*
11.	*E. virgula*, von Reuss, 1872, Bry. unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, figs. 1, 2.	"
	E. raripora, Vine, 1885, Notes Cambr. Gr.: Proc. Yorks. Geol. Soc., new ser., vol. ix, pl. i, figs. 1, 2.	"
	E. proboscidea, Pergens, 1892, Nouv. Cycl. Crét.: Bull. Soc. Belge Géol., vol. iv (1890), Mém., pl. xi, fig. 6.	"
	E. carantina, d'Orbigny, 1853: loc. cit., pl. 753, figs. 16–18 ...	*E. geminata.*
12.	*E. conjugata*, von Reuss, 1872–3: loc. cit., pl. xxix, fig. 8 ...	*E. conjugata.*
13.	*E. fecunda*, Pocta, 1892: loc. cit., pl. ii, figs. 17, 18; pl. iii, figs. 14, 15	*E. fecunda.*
	Pustulipora tubulosa, von Hagenow, 1851: loc. cit., pl. i, fig. 2.	*E. tubulosa.*
14.	*Entalophora fecunda*, Novak, 1877: loc. cit., pl. vi, figs. 22–27 ...	*E. fecunda.*
	E. echinata, Gregory, 1899: loc. cit., pl. x, fig. 13	*E. echinata.*
15.	*E. soror*, Pocta, 1892: loc. cit., pl. iii, figs. 9–13	*E. soror.*
16.	*E. horrida*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 13–15 ...	*E. horrida.*
	E. horrida, Gregory, 1899: loc. cit., pl. x, fig. 9.	"
17.	*Pustulopora echinata*, Roemer, 1840: Verst. nordd. kr., pl. v, fig. 23.	*E. echinata.*
	P. echinata, von Reuss, 1846: Verst. böhm. kr., pl. xiv, fig. 4.	"
	Entalophora echinata, d'Orbigny, 1851: loc. cit., pl. 622, figs. 15–17.	"
	E. gracilis, d'Orbigny, 1851: loc. cit., pl. 617, figs. 1–4.	"
	E. tenuis, d'Orbigny, 1851: loc. cit., pl. 619, figs. 10–12 (peristomes worn).	"
	E. linearis, d'Orbigny, 1851: loc. cit., pl. 622, figs. 5–7.	"
	? *E. pulchella*, von Reuss, 1872–3, Bry. unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, fig. 3.	"
	E. echinata, Gregory, 1899: loc. cit., pl. x, figs. 10–12; pl. xi, fig. 1.	"
	? *Entalophora* sp., Gregory, 1899: loc. cit., pl. xi, fig. 3	*E.* sp.
18.	*E. Conradi*, Gabb & Horn, 1862, Mon. Poly. N. Amer.: Journ. Acad. Sci. Nat. Phil., ser. II, vol. v, pl. xxi, fig. 59... ...	*E. Conradi.*
19.	*Vincularia cretacea*, d'Orbigny, 1851: loc. cit., pl. 600, figs. 17–19.	*E. cretacea.*
	? *Entalophora filiformis*, d'Orbigny, 1851: loc. cit., pl. 622, figs. 1–4.	*E. echinata.*
	? *E. cretacea*, Gregory, 1899: loc. cit., pl. xi, fig. 12	*E. cretacea.*
	? *E. madreporacea*, var. *inconstans*, Gregory, 1899: loc. cit., pl. xi, fig. 13	*E. madreporacea.*
20.	*Laterotubigera varapensis*, de Loriol, 1863: Invert. Néoc. Int. Salève, pl. xvi, fig. 1	*E. varapensis.*
21.	*Entalophora sarthacensis*, d'Orbigny, 1851: loc. cit., pl. 619, figs. 6–9	*E. vendinnensis.*
	Pustulopora echinata, Michelin, 1845: Icon. Zooph., pl. liii, fig. 5	"
22.	*Entalophora neocomiensis*, de Loriol & Gillièron, 1869: Ung. Land. Mém. Soc. Helvét. Sci. Nat., vol. xxiii, pl. ii, fig. 19.	*E. neocomiensis* (1).
23.	*E. heros*, Pocta, 1892: loc. cit., pl. ii, figs. 25–30...	*E. heros.*

24. *Ceriopora madreporacea*, Goldfuss, 1827: Petref. Germ., pl. x, figs. 12*a*, *b* ... ...*E. madreporacea.*
Pustulopora madreporacea, Bronn, 1838: Leth. Geog., 2nd ed., pl. xxix, fig. 6. ,,
P. madreporacea, von Reuss, 1846: Verst. böhm. kr., pl. xiv, fig. 5. ,,
Ceriopora madreporacea, von Hagenow, 1846: in Geinitz, Grund. Verst., pl. xxiii*b*, fig. 14. ,,
Pustulopora } *madreporacea*, de Blainville, 1834: Man. Act.,
Pustulipora } pl. lxx, fig. 5. ,,
Pustulipora madreporacea, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 8. ,,
Entalophora madreporacea, d'Orbigny, 1861: Bry. Crét., pl. 623, figs. 1–3. ,,
E. madreporacea, var. *inconstans*, Gregory, 1899: loc. cit., pl. x, fig. 14. ,,
E. madreporacea, var. *Benedeni*, Gregory, 1899: loc. cit., pl. x, fig. 15. ,,
E. subregularis, d'Orbigny, 1851: loc. cit., pl. 621, figs. 16–18. ,,
Pustulipora Benedeni, von Hagenow, 1851: Bry. Maastr. kr., pl. i, fig. 6. ,,
? *Eschara Ehrenbergi*, von Hagenow, 1840, Mon. Rüg., pt. ii: N. Jahrb., 1840, pl. ix, fig. 2. ,,
Entalophora inconstans, d'Orbigny, 1853: loc. cit., pl. 754, figs. 15–17. ,,
E. kolinensis, Novak, 1877: loc. cit., pl. vii, figs. 11–13. ,,

25. *E. rugosa*, d'Orbigny, 1853: loc. cit., pl. 754, figs. 18–20 ... *E. rugosa.*
26. *E. pustulosa*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 1–3 ... *E. symmetrica.*
27. *E. neocomiensis*, d'Orbigny, 1851: loc. cit., pl. 616, figs. 15–18 ... ... *E. neocomiensis* (1).
28. *E. brevissima*, d'Orbigny, 1851: loc. cit., pl. 625, figs. 5–10 ... *E. brevissima*
29. *E. salevensis*, de Loriol, 1863: Invert. Int. Salève, pt. ii, pl. xvi, figs. 4*a*–*d*. De Loriol & Gillièron, 1869: loc. cit., pl. ii, fig. 20. *E. salevensis.*
30. *E. symmetrica*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 4–6. *E. symmetrica.*
31. *E. ramosissima*, d'Orbigny, 1851: loc. cit., pl. 618, figs. 1–5. *E. ramosissima.*
32. *E. vendinnensis*, d'Orbigny, 1851: loc. cit., pl. 617, figs. 15–17. Von Reuss, 1872–3, Bry. Unt. Quad.: Palæontogr., vol. xx, pt. 1, pl. xxix, figs. 4–5 ... ... *E. vendinnensis.*
33. *E. horrida*, d'Orbigny: see No. 16.
34. *E. Gamblei*, Gregory, 1899: loc. cit., p. 248, figs. 26, 27. ... *E. Gamblei.*
35. *Bidiastopora regularis*, d'Orbigny, 1853: loc. cit., pl. 756, figs. 4–6... ... ... *E. regularis.*
36. *B. elegans*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 5–8 ... *E. elegans.*
Entalophora compressa, d'Orbigny, 1851: loc. cit., pl. 619, figs. 1–5. *E. compressa.*
Bidiastopora gracilis, d'Orbigny, 1853: loc. cit., pl. 755, figs. 10–12. ,,
B. Mariæ, d'Orbigny, 1853: loc. cit., pl. 755, figs. 13–15. ,,

37. *B. crassa*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 13–16 ... *E. crassa.*
38. *B. rustica*, d'Orbigny, 1851: loc. cit., pl. 628, figs. 1–4... ... *E. virgula.*
39. *B. cultrata*, d'Orbigny, 1851: loc. cit., pl. 627, figs. 9–12 ... *E. cultrata.*
40. *B. inornata*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 7–9 ... *E. inornata.*
41. *B. neocomiensis*, d'Orbigny, 1853: loc. cit., pl. 784, figs. 9–11 ... ... *E. neocomiensis* (2).
42. *Entalophora gigantopora*, Vine, 1885: loc. cit., pl. i, fig. 3. Gregory, 1899: loc. cit., pl. xi, fig. 4 ... ... *E. gigantopora.*
43. *Bidiastopora subacuta*, Peron, 1888, Craie S.E. Bassin, Anglo-Par.: Bull. Soc. Sci. nat. Yonne, vol. xli, pl. iii, figs. 27–29. *E. subacuta.*
44. *B. triangularis*, d'Orbigny, 1853: loc. cit., pl. 755, figs. 16–18. *E. triangularis.*
45. *Entalophora anomalissima*, Novak, 1877: loc. cit., pl. vii, figs. 14–16. Pocta, 1892: loc. cit., pl. ii, figs. 19–22. *E. anomalissima.*
46. *E. clavata*, d'Orbigny, 1851: loc. cit., pl. 621, figs. 8–12 ... *E. echinata.*
47. *E. juvenis*, Pocta, 1892: loc. cit., pl. iv, figs. 19, 20 ... ... *E. juvenis.*
48. *Clavisparsa turbinata*, Marsson, 1887, Bry. Rüg.: Pal. Abh., vol. iv, pl. i, fig. 7 ... ... *E. turbinata.*

NOTICES OF MEMOIRS, ETC.

British Association for the Advancement of Science, York, 1906. — Abstracts of Papers read before Section C (Geology).

I.—The Glacial Deposits of the East of England. By F. W. Harmer, F.G.S.

THE eastern part of Norfolk forms a low-lying area which, could the glacial beds be removed, would seldom rise above the 100 foot contour. This region, therefore, with the Fenland, was the first part of East Anglia to be overrun by the North Sea ice. None of the resulting moraine (similar, for example, to the Contorted Drift of Cromer) is now found in the Fenland, as it has been destroyed by the subsequent advance of the inland ice-stream to which the Chalky Boulder-clay was due; its former presence is evidenced by the occasional occurrence there of igneous erratics like those found on the Norfolk coast.

At this period, moreover, the North Sea ice must also have advanced over Holderness and the East Lincolnshire plain. A portion of the glacial deposits of those regions may therefore be of equivalent age to the Contorted Drift of Cromer. As, however, the movement of the Scandinavian glacier from north to south must have been gradual, the Contorted Drift may be somewhat newer than the earliest of the glacial beds of North Britain.

Before the deposition of the Chalky Boulder-clay in East Anglia, the North Sea ice had withdrawn from a great part of that region, and it did not reappear. During its retreat, however, it heaped up a well-marked terminal moraine in the form of a hummocky ridge of drift, in places reaching 300 feet above O.D., extending 20 miles in a S.S.W. direction from Mundesley and Cromer.

The Chalky Boulder-clay of Suffolk is blue and intensely Kimeridgian; that of Norfolk is whitish, with a chalky matrix, the boundary between the two being clearly defined. Jurassic Boulder-clay, moreover, may be traced across the Fenland from Suffolk into the Lincolnshire plain, while the chalky drift of Norfolk is represented by the chalky clay which is piled against the western slopes of the southern part of the Lincolnshire Wolds to a height of 300 and 400 feet. The behaviour of the last-named drift is instructive. Due to ice crossing the chalk range through a depression running from north to south in the direction of the present valley of the Bain, it turns suddenly to the south-east as it approaches the lower ground, instead of overflowing the latter, as it must have done had that course been open to it. The separation between the Jurassic and the Chalky Drift is as clearly marked in Lincolnshire as it is in East Anglia. Produced from the former district to the latter, the line dividing them *runs diagonally across the mouth of the Wash.* The author has, moreover, traced a trail of Neocomian erratics for 100 miles in the same direction from the plain of the Witham to the neighbourhood of Ipswich.

These facts suggest the existence of two confluent but distinct ice-streams travelling, *pari passu,* from N.W. to S.E., that which occupied the Jurassic plain being sufficiently the stronger to thrust on one side the ice descending from the Wolds, diverting it towards Norfolk, mounds of Chalky Boulder-clay more or less parallel with the escarpment being accumulated between the two as a medial moraine near Horncastle. This view explains why, at the period in question, the North Sea ice was unable to enter East Anglia through the Wash Gap.

The absence of the intensely Chalky Boulder-clay of South Lincolnshire from the Lincolnshire plain to the west of Market Rasen, where the escarpment is unbroken and more than 500 feet high, indicates that no ice overflowed the Wolds near that place, nor did any cross from the North Sea to the north of the Humber.

It must therefore have been the region south of that river, and north of Caistor, where the Wolds have been broken up and eroded, which supplied the grey flint and hard chalk (other than that of the Norfolk Drift), which is found everywhere in the Chalky Boulder-clay over such an enormous area. So prodigious is the total amount of this débris that, were it brought together, it would almost bridge over the depression now dividing the Lincolnshire from the Yorkshire Wolds.

From the Fenland the Great Eastern glacier fanned out in all directions: to the east over Suffolk, overflowing also the chalk escarpment from Newmarket to Hitchin, from which it travelled down the dip-slope south-eastward into Essex, and southward towards Finchley and St. Albans. To the south-west it occupied the basins of the Welland, the Nene, and the Ouse with a confluent ice-sheet overspreading the higher ground which separates them. Moving along the strike of the Oxford Clay up the valley of the Ouse, it filled that region with Boulder-clay of which the matrix is prevalently Oxfordian; further to the north-west the glacial drift contains a larger proportion of Liassic detritus. The Boulder-clay which covers the chalk region immediately below the crest of the escarpment is, as a rule, very chalky, as is the drift to the west of the Lincolnshire Wolds, and for the same reason, viz., that it was principally the upper and cleaner portion of the ice-sheet which mounted the slopes of the chalk hills. Some Jurassic débris from the Fenland was, however, carried over into Essex, but not enough to give the drift of that region a typically Jurassic character.

Another and an important branch of the Great Eastern glacier passed up the Trent basin. One portion of this climbed the marlstone escarpment near Grantham, and spread Chalky Boulder-clay over the high land to the south of that place; another part followed the Trent valley towards the south-west until it met the ice streams of the Dove and the Derwent, the combined ice-flow being thence southwards up the valley of the Soar. Glacial drift containing, on the one hand, Pennine and Mount Sorrel erratics, and, on the other, Jurassic and Cretaceous débris, may be traced for many miles to the south and south-west of Leicester towards Rugby and beyond.

At one time it was believed that the crescentic moraines of York and Escrick represented the greatest extension of the Teesdale ice. Now, the driftless area to the south of York notwithstanding, it is admitted that the ice reached as far as Barnsley and Doncaster; the comparative absence of drift immediately to the south of those places cannot, therefore, have any value as evidence, in the face of the fact that Chalky Boulder-clay sets in again in great force still further to the south. The enormous area covered by the moraine of the Great Eastern Glacier, 10,000 square miles in extent, is inconsistent with the view that it can have been wholly due to ice crossing the Wolds at the two places named. We seem, therefore, driven to admit the existence of a great ice-stream continuous from the mouth of the Tees to the Fenland, and from the Pennines to the Yorkshire moorlands and the Wolds.

The study of the glacial deposits of the East of England does not appear to support the view that mild interglacial conditions obtained at any time in that region between the deposition of the Cromer Till and the 'cannon-shot' gravels which overlie the Chalky Boulder-clay.

II.—Lake Oxford and the Goring Gap. By F. W. Harmer, F.G.S.

DEEP borings at Sandy, Newport, and Hitchin, and further west at Stony Stratford, reveal the existence of drift-filled valleys, extending in one case to a depth of 140 feet below sea-level, which were probably connected with that of a pre-glacial river running in a north-easterly direction towards the North Sea. Similar deep borings at Boston, Fossdyke, and Long Sutton may represent the mouth or the seaward extension of such a valley.

As far as the Midland Counties are concerned, the gorge at Goring is unique. At no point between Newmarket, in Suffolk, and Blandford, in Dorset, in the one case, or between Lincoln and Bradford-on-Avon on the other, have the Cretaceous or Oolitic ranges been cut down to the base-level of the plains, nor does water run through them from one side to the other. Cases similar to that of Goring occur, however, at three of the places named, as well as at Ancaster, and at Ironbridge, in Shropshire. All these are of a distinct type from the dip-slope valleys of the Oolitic and Cretaceous ridges, and they must have originated in a different manner. They have certain striking features in common. Not only do they cut continuously through the ridges, at right angles to the natural drainage of the plains, but they form narrow, sharply cut, U-shaped gorges, having an extremely modern appearance, as distinguished from the older-looking, wider, and more gradually shelving basins of the dip-slope rivers. They are invariably accompanied by lake-like depressions, lower than the general level of the plains, opening into trumpet-mouthed gorges, through which the former are drained.

Dealing first with the gorges at Lincoln and Ancaster, the effect of the advance of the Vale of York glacier to Barnsley and Doncaster, and the obstruction of the gap separating the Yorkshire from the

Lincolnshire Wolds by the North Sea ice, as explained in a former paper, must have impounded the drainage of the Trent basin and caused the formation of a lake, the overflow of which could only have escaped over some part of the Lincoln ridge. Unless the Lincoln and Ancaster gaps were already in existence, which seems to the author improbable, some such overflow must have been initiated at that time. The continuous advance of the Trent glacier southwards would eventually have blocked the Lincoln gorge, probably with drift, and the Ancaster gap would have been originated, being afterwards similarly blocked, in its turn, as the ice moved on. These channels, however, would have been reopened successively, and probably deepened, when the ice retreated.

Referring next to the case at Goring, we find scattered over the low country round Oxford a number of isolated hills, generally capped by gravel, the origin of which it is not easy to explain on the hypothesis of the fluviatile erosion of the Oxford plain; they present no such difficulty, however, if we regard the latter as the site of an ancient lake, the bottom of which has been gradually lowered.

It has been long known that the gravels in question contain Triassic pebbles, but it is still more important to notice the presence in them, often in great abundance, especially as they are traced towards the gap, of grey Lincolnshire flint.

This flint drift connects itself with a great trail of such detritus extending continuously from Buckinghamshire to the Wolds, being exceedingly common both in the Chalky Boulder-clay of the Ouse basin and in the gravels into which the latter passes towards the south-west.

The grey flints occur in the highest part of the Oxford gravels, at elevations exceeding 400 feet, as, for example, on a hill immediately to the south-west of that place, and at Basildon, near Goring, above the narrowest part of the gorge. The erosion of the Oxford plain, and of its outlet below that level, cannot, therefore, have commenced until after the arrival of the glacial drift in that region.

Other gravels, also containing Triassic pebbles and Lincolnshire flint, occur at a somewhat lower level, representing a later stage in the deepening of the bed of Lake Oxford and of the Gap.

The south-westerly advance of the Chalky Boulder-clay glacier up the Ouse basin, preventing any possible drainage to the east through the Stony Stratford Valley, must have caused the formation of a lake over the comparatively low ground which probably then existed between the Chilterns, the White Horse, and the Cotswold Hills. That the drainage of this lake was from the first in the direction of the present gorge is shown by the presence of flint gravel immediately above it, near the 400 foot contour; it occurs also within it at a lower level. Once started, the drainage has continued to run in the same direction to the present day. The swirl of the water, swollen, especially in summer, by the melting of the ice-sheet which lay close at hand, converging constantly to one point, eventually produced the trumpet-shaped opening which formed such a marked feature of the Gap.

The bottom of the lake, composed of soft Jurassic clay, was gradually deepened, *pari passu* with the excavation of the gorge, the deepest part being always, as shown on the contour maps, near the mouth of the latter, where the erosive power of the escaping water was the greatest.

REVIEWS.

I.—GEOLOGY: EARTH HISTORY. By T. C. CHAMBERLIN and R. D. SALISBURY. Vol. II: Genesis–Paleozoic; pp. xxvi, 692, with 306 illustrations. Vol. III: Mesozoic–Cenozoic; pp. xi, 624, with 576 illustrations. (London: John Murray, 1906. Price 21s. each net.)

IN continuation of the account of "Processes and their Results," reviewed in our August number, we now call attention to the second and third volumes. They complete this great geological work, and aim at giving an interpretation of the record of the rocks, based on acquired knowledge. In the second volume the story opens with matter that is necessarily more or less imaginative or speculative, matter requiring astronomical, physical, and chemical knowledge, not of great practical moment to the geologist, but full of interest to those who wish to start "In the beginning," with Nebular and Meteoritic hypotheses of the earth's origin; with Cosmology in fact, about one-fifth part of the volume is occupied; and many points briefly mentioned in the first volume are here amplified.

The authors adopt a modified Nebular, or Planetesimal, hypothesis, and mark out the stages of the earth's evolution as (1) astral, (2) molten, and (3) lithic eons, with a practically solid globe; leading on to (4) a primitive volcanic eon, accompanied at first by prodigious volcanic activity, and later attended by sedimentation and the introduction of life. In this last eon we pass from the unknown into the partially known; into the oldest accessible formations, classed in the Archeozoic era. This is the era of schists and granitoid rocks, a complex series including outflows of lava, volcanic tuffs, igneous intrusions of various types, together with sedimentary rocks; all more or less highly metamorphosed, crumpled, and deformed. The presence of life is suggested by carbonaceous shales, certain iron-ores, limestones and cherts, similar to those which owe their origin in part to organic action. This era, it is thought, may have exceeded that of all subsequent time.

Between the Archeozoic and the next era represented in the rocks, there is everywhere great unconformity. This next phase is termed the Proterozoic (a synonym for Algonkian as used by the U.S. Geological Survey). The term is apt to be confused with that of Protozoic suggested by Murchison in 1839, and adopted by Lapworth for the Lower Palæozoic (Cambrian, Ordovician, and Silurian).

In this Proterozoic era it may be said that geological history practically begins, and the authors deal with the records especially as they are exemplified on the North American continent. The principles which they seek to teach are those applicable to all continents, one object being "to combine dynamical discussion with the phenomena which it is to explain, as these phenomena unfold themselves stage by stage." Thus they deal not only with the local characters of the strata, their subdivisions and their distribution in other areas, but with their physiographic relationships, the features of ancient lands, with sources of sediments, and their mode of derivation. They treat also of the permanence of oceans and continents, and of periodicity in great deformative movements. Evolution and the distribution of faunas and floras are discussed apart from the stratigraphy.

Many interesting comparisons are made and suggested in the course of the work. No distinct physical or organic break is recognized between Cambrian and Ordovician. The Old Red Sandstone is regarded as a phase of the Devonian, some portions of it not improbably having been of subaerial rather than subaqueous origin. Both phases are represented in America.

It is noteworthy, with regard to the basal Devonian, that there is a difference of opinion as to whether the Helderberg formation should be classed as Silurian or Devonian. It has a strong Silurian facies, but the species, as now known, are all new, except *Leptæna rhomboidalis* and *Atrypa reticularis*—the "Methuselahs of Paleozoic times." The authors remark that "the Helderberg formation is largely limestone, which suggests that subaërial erosion was not taking place at a rapid rate, and that the principal formation of the epoch, as far as our continental area is concerned, was extracted from the sea-water." The question of the mechanical derivation of calcareous mud is not apparently taken into consideration.

It is interesting to compare the latest stages of the Carboniferous, locally "Upper Barren Coal Measures," with approximately equivalent strata in England. Great movements were likewise inaugurated at about the close of the Carboniferous period in America.

The Permian, "often regarded as a part of the Carboniferous," was formed in waters either in the form of lakes and inland seas or in connection with the open ocean. The Permo-Carboniferous glaciation in Australia, India, and Africa is spoken of as "the first well deciphered glaciation," though mention is made of that in the Cambrian or pre-Cambrian era. The prevalent red sandstones in the Newark Series show points in common between the Trias in America and England. The Rhætic beds (grouped with the Trias) have not been recognized in America. Jurassic formations have nowhere been determined in the eastern half of the continent, but in western America they occur in nearly the same areas as the Trias. The earliest Liassic fauna is not derived from the locally preceding forms of life, but has the aspect of European Lias, and of the Liassic fauna in Timor Island and in Argentina. In the higher stages *Aucella* and other forms connect with the Upper Jurassic of Russia.

The term 'Comanchean' is applied to the Lower Cretaceous, to include eras from the European Wealden to Cenomanian; the Upper or true Cretaceous being limited to the European Turonian, Senonian, and Danian. The Cretaceous includes the Laramie Series, with sandstone, shale, and coal, also other divisions of clay, greensand, and chalk. It has yielded a remarkable assemblage of vertebrates, especially Saurians (including sea serpents), and birds.

The Cenozoic era is divided into Tertiary (Eocene to Pliocene) and Quaternary (Pleistocene or Glacial, and Recent or Human). Interesting accounts are given of the Eocene and Oligocene faunas and floras. As a rule, the Oligocene has not been differentiated from Eocene in North America, but reasons are given to render the division desirable. It is remarked that pronounced provincialism was inaugurated in the Oligocene, and continued throughout the remainder of the Cenozoic era. The correspondences between the faunas of the western and the eastern sides of the Atlantic during the Miocene period appear to have been "due partly to intermigration and partly to parallel evolution." As pointed out by Dall, the Miocene fauna of North Germany compares well with that of Maryland, while the Mediterranean Miocene is closely allied to the more tropical fauna of the Duplin Beds of the Carolinas. The history of the land animals in Tertiary times is full of interest.

The giants of the Pliocene period were the Proboscideans. "The mastodons seem to have occupied all the continents during the Pliocene, but it is doubtful whether the elephant reached the American continent before the Pleistocene." There must have been migratory routes between Eurasia and America, but there are outstanding problems as to the extent and continuity of the connections at the north-west and north-east.

The Pleistocene is regarded as of shorter duration than the average geological period. "Ice-sheets spread over six or eight million square miles of the earth's surface." More than half of this area was in North America, and more than half of the remainder lay in Europe. The authors remark that "it is not strange that the glacial theory was resisted for half a century, though the iceberg and other glacio-natant hypotheses urged in its stead seem no more credible, and far less adequate. But the cumulative force of a vast mass of evidence, rigorously scrutinized under the promptings of this critical and reluctant attitude, has become overwhelming, and the days of reasonable doubt are passed." That there was a succession of ice-invasions due to fluctuation in the actual limits of the large masses of land-ice, the temporary retreats being accompanied by great floods arising from the melting of the ice, is held by the authors to be borne out by the careful studies of later years; but geologists are not agreed on this part of the subject. "It is not yet known how far the ice retreated in the intervals between the advances," and consequently there are differences of opinion "respecting the estimate to be put upon the importance of the interglacial intervals." In connection with this subject Mr. Lamplugh's recent address to Section C of the British Association at York will be read with interest.

The consideration of the Pleistocene leads us to the Human epoch. At present no evidence has been obtained of man's existence during the Glacial period in America. It is true that implements of 'palæolithic' type have been found, but the term can only be held to indicate a stage of early art; no implements have been discovered in undisturbed deposits of Glacial age.

The sections, maps, the photographic and other illustrations of fossils, and lastly the photographic views of scenery and of rock features, are excellent and most instructive. Vol. ii is accompanied by a small but useful colour-printed geological map of the United States and part of Canada.

Geologists will be grateful for the full and carefully prepared index that accompanies each volume; these indexes will be invaluable aids for reference to the many new and unfamiliar names of local geological formations, rocks, and fossils, as well as to the many topics of interest so lucidly discussed in these volumes.

II.—Ceylon Administration Reports, 1904: Part IV, Education, Science, and Art. Mineralogical Survey: Report of Mr. A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director, Mineralogical Survey.

SOME indication of the excellent work which has been carried out in Ceylon by the Director, Mr. Coomáraswámy, and the Assistant Director, Mr. J. Parsons, under the auspices of the Imperial Institute, is afforded by this interesting report. The extraordinary richness of the island in interesting minerals, including most of the gem varieties, has been long known, but has hitherto not been officially recognised. We hope we may see in a few years the establishment of a permanent Geological Survey. Perhaps the most generally interesting part of the report is that dealing with the minerals containing rare elements. The discovery of Thorianite, which is so rich in thoria, is likely to be of immense commercial importance. We must also allude to the general account of gemming. The richness of the island in gem-stones is evidenced by the fact that upwards of £300,000 worth are exported annually.

The value of the report is increased by the admirable reproductions of photographs with which it is illustrated.

III.—Geological Survey of Western Australia. Annual Progress Report for the year 1905. With two figures. Folio. (Perth, 1906.) Bulletin No. 21: The Geology and Mineral Resources of the Norseman District; Dundas Goldfield. By W. D. Campbell, Assistant Geologist. 8vo; pp. 1–140, with a two-sheet geological map, 5 plates, and 19 figures. (Perth, 1906.)

THE Report, for which Mr. A. Gibb Maitland is responsible, begins with an account of the administrative work of the

Department, including field and laboratory work, geological and mineralogical collections, and publications. These are followed by a detailed account of the principal results of the year's field operations under the heading of "Mineral Resources."

A detailed examination of some of the mining centres in the Pilbara Goldfields was made by Mr. Talbot, and the newly-opened tin-field of Wodgina (of which a sketch-map is given in the Report) was also investigated.

The Mount Margaret Goldfield was examined and reported upon by Mr. C. G. Gibson, who found that the auriferous reefs and lodes occur in 'greenstones,' basic rocks which are essentially hornblendic, and exist both in the massive and schistose state; being similar to those usually forming the auriferous series of the Eastern Goldfields. The "New Find" district, visited by Mr. Gibson, gave very little promise of successful results.

Mr. H. P. Woodward reported upon a portion of the Broad Arrow Goldfield, giving statistics relating to the shafts sunk to reach the reefs at different levels, and particulars of the yield of gold to the ton of ore.

Mr. Woodward also visited the Wagin district for the purpose of reporting upon the possibilities of coal occurring, and upon the reputed phosphatic deposits. From this report, which is given *in extenso*, it appears that the occurrence of coal deposits is somewhat problematical, and that the alleged phosphatic deposits do not contain sufficient quantities to be worked for fertilising purposes.

A very favourable report is given upon the "Sunbeam Lease" gold-mining property, in which the yield has been of the most encouraging character.

The Northern district was visited by Mr. Woodward for the purpose of examining and reporting upon certain gold discoveries. His work was confined to the examination and sampling of those localities where gold was reported to have been discovered. The district as a whole, however, was not found to present any promising signs of good results being achieved by its being worked.

The Report concludes with analyses of various minerals by Mr. E. S. Simpson, mineralogist and assayer to the Survey. These minerals include tantalum, natural nitrates, crocidolite, graphite, and chromiferous laterite.

The work dealt with in Bulletin No. 21 combines both the geology and topography of the district explored, which covers an area of about 46 square miles, embracing, as far as it is understood, the productive area of Norseman.

That portion of the Dundas Goldfield embraced by Mr. Campbell's work consists essentially of a series of metamorphic sedimentary rocks, estimated to reach a thickness, making allowance for repetition by folding, of not more than 800 feet, which occupies a strip of country skirting the west side of Lake Dundas. Some of these ancient sediments appear, according to Mr. Campbell's observations, to have been permeated by secondary silica and oxide of iron, and are now in places represented by the bands of laminated quartzite and the very ferruginous jaspers, which make a pronounced feature in the field. Associated with the metamorphic sedimentary rocks (some of which are conglomeratic) is a large area of amphibolites, which appears to be embedded with the former; as some of these are distinctly amygdaloidal, there seems very good reason for believing them to be ancient lava-flows. In addition to the amphibolites are a series of diorites and epidiorites, which are apparently interbedded with the sedimentary rocks and amphibolites in such a manner as to suggest the possibility of their being intrusive sills and dykes. Another very important feature is the occurrence of a large number of quartz-porphyry dykes, which traverse the whole of the area mapped in a general north-east and south-west direction. These porphyry dykes in all probability form the apophyses of the large granite mass which lies to the east of, and just outside, the limits of the area mapped.

Although the Norseman district affords no direct evidence as to the geological age of its older basic and acidic rocks, there is good reason to suppose that they all form part of the same series as those which are so largely developed in other parts of the Eastern Goldfields.

Norseman has proved a good mining field, the auriferous quartz reefs being distributed over a large extent of country. Many of the reefs are very rich in gold. Up to the end of 1904 the area embraced by Mr. Campbell's labours has produced 266,004 oz. of gold, or at the rate of 1,019 oz. for every ton of ore crushed. The superficial deposits have yielded only a limited amount of alluvial gold, the total reported from 1899 to 1904 being 1662·37 oz.

This report contains much valuable information relating to the history, topography, water supply, and other details of the district covered. There are also tables of analyses, lists of mineral and geological specimens, and an index to the names of places, mines, leases, reefs, etc. A. H. F.

IV.—Memoirs of the National Museum, Melbourne. No. I: On a Carboniferous Fish Fauna from the Mansfield District, Victoria. By Arthur Smith Woodward, LL.D., F.R.S. 8vo; pp. 1–32, 11 plates. (Melbourne, January, 1906.)

THIS interesting memoir contains a description of a collection made in 1888, at the request of the late Sir Frederick McCoy, by Mr. George Sweet, F.G.S. The specimens, which are in a very imperfect state of preservation, were originally described by McCoy, who selected with great judgment the material for the plates which accompany the memoir. His preliminary determinations (Rep. on Palæont. for 1889, Victoria: Ann. Rep. Sec. Mines, 1889 (1890), pp. 23–24) and his conclusions as to the affinities of the fish-fauna prove, however, to have been almost entirely erroneous. Far from displaying a "mixture of Lower Devonian, and types related to some of the Calciferous Sandstone Series," as McCoy supposed, the Mansfield fishes are typically and essentially Carboniferous. "Of the six genera represented in the collection, one (*Eupleurogmus*) is too imperfectly known for discussion; four of the others (*Acanthodes, Ctenodus, Strepsodus,* and *Elonichthys*) have hitherto been discovered only in the Permian and Carboniferous of Europe and in the Carboniferous of North America; while the sixth (*Gyracanthides*) is related to an essentially Carboniferous fish in the northern hemisphere, and bears every mark of belonging to the same late Palæozoic period." *Gyracanthides,* which McCoy was correct in recognizing as a close ally of *Gyracanthus,* is regarded by Dr. Smith Woodward as a remarkable discovery. The new specimens prove *Gyracanthides* to be a typical Acanthodian belonging either to the Diplacanthidæ or to a distinct family marking the culmination of this series. The fins exhibit peculiarities indicating a high degree of specialization, which was analogous to that observable in later geological periods among Selachians and Teleosteans.

The Mansfield fishes are such as often occur in estuarine and fresh-water strata in the northern hemisphere, though all the genera are occasionally found in sediments of marine origin. Their association with the remains of land plants suggest estuarine conditions.

The systematic descriptions are illustrated by 11 lithographic (rock-colour tinted) plates, with three figures in the text, one of which is a restored drawing of the remarkable Acanthodian *Gyracanthides Murrayi.*

The following are the species described and figured:—

Gyracanthides Murrayi, sp. nov.
Acanthodes Australis, sp. nov.
Eupleurogmus Creswelli, McCoy.
Ctenodus breviceps, sp. nov.
Strepsodus decipiens, sp. nov.
Elonichthys Sweeti, sp. nov.
E. gibbus, sp. nov.

A. H. F.

CORRESPONDENCE.

THE MODE OF ACCUMULATION OF THE SOUTH DEVON RED SANDSTONES AND CONGLOMERATES.

Sir,—I am glad to see that Mr. Hobson[1] has attacked the perplexing problem of the mode of accumulation of the Devonshire red conglomerates. The remark of mine which he quotes was not intended to throw any doubt on the fact that water was the agent: the difficulty is to conceive any probable mode of action. The Torbay evidence is much as follows. In the English Channel, a few hundred yards south of Berry Head, is a rocky islet, and in its limestone there is apparently a pipe, or small swallow-hole, filled with red sandstone. In the eastern face of Berry Head there is, if I remember aright, a small fissure filled with sandstone. In the

[1] See Geol. Mag., July, 1906, pp. 310–320 (Pl. XXIa).

Berry Head quarries there stood for long a large dyke of red rock left isolated by the quarrying of the limestone, This, I believe, was subsequently carried off to build a church with. All these I have only observed from the water. On the strand under the old Naval Hospital are the celebrated intersecting Permian dykes, and near the breakwater there is a massive dyke in the low cliff. There appears to be a mass of sandstone in the quarry between Brixham and Fishcombe Cove; and in the northern boundary limestone of the Fishcombe Valley and Cove there is a pipe filled with sandstone. Small dykes occur in the rocks between Elbury and Broadsands, and north of Broadsands there is an outlier of pure sandstone abutting on the limestone under the railway. All the foregoing are fine sandstones. But a few hundred yards further north, in Saltern Cove, we have the celebrated case of the stratified conglomerate lying on the planed edges of the Lower Devonian thin-bedded slates and grits.

Then on the south face of Roundham Head we have the section figured by Mr. Hobson,[1] but further east on the same face we find a much more intricate and incomprehensible example of the most complex false-bedding, with contemporaneous erosion and alternate beds of rough conglomerate. Then on the Paignton side of Roundham Head there is, or was, a cliff-face showing their bedding with one rippled surface; and I once noticed a slab on the beach with what I took for rain-pittings. Sun-cracks are occasionally discernible. Nearer Torquay, on the coast south of Livermead Head, I noticed a bed of fine sandstone which had been channelled and covered with a bed of conglomerate filling the channel. At Corbons Head, near the Torquay railway station, we have some Poikilitic sandstone. Lastly, at Labrador, north of Teignmouth, we have the volcanic breccia overlying the ordinary conglomerate; some of this breccia being of peculiar altered rocks with blue tourmaline, whose origin of derivation has never been positively located. Further on, beyond Teignmouth, we have the often described large masses and blocks, associated with the conglomerates. Now between placid lake shores and the most raging torrents any one of the above cases could be tentatively explained; but to account for every variety of water action, from sun-cracks and ripple-marks to torrential action over scores of miles in area, this is difficult.

Two or three details clash with authority, and at first sight with the laws of nature, especially of hydrostatics and mechanics. No alternate currents in opposite directions could produce the Roundham Head false bedding, and for a current to cover and fill up channels of fine sand with stones is contrary to the axiom that it takes a more rapid current to carry away stones than it does to remove sand.

In a paper privately printed some years ago I described an hour's experiments with currents and sand, and pointed out how there may be two and even three parallel streams at the same time rolling sand both to right and left and producing intricate overlapping

[1] See July Number, Pl. XXIa, Fig. 1.

stratula of false bedding. Then, by varying the depth of water and the rate of current, one can secure almost any deposition, such as coarse over fine, and any contemporary erosion. But at Roundham Head the difficulty is that the variations in the conditions are so numerous and so extreme. Added to this there is the marvel throughout the Red Sandstones of an apparently inexhaustible supply of ready-made material. Hundreds of feet of deposition follow each other with apparently little denudation and erosion from lack of material. The millstones are rarely left to grind each other's faces for lack of meal.

It is clear that the fissures in the limestones were washed out clean before being quietly filled with fine Permian sand. But, *per contra*, the conglomerates seem to have planed at least one Devonian surface smooth, and then to have deposited themselves, horizontally bedded, upon it. That of itself is not a very intelligible operation.

With reference to the visit of the Geologists' Association to Devonshire in 1900, I have always felt that I owed an apology to the Association for accepting the office of a director both at Torquay and for the Dartmoor walk. I had never attended a meeting and did not understand the duties of the directors, and regarded myself solely as a local guide. It had never occurred to me that I should be expected to say anything on the geological problems encountered, but only to show the way on the moorland walk by devious paths, and to do the honours of Kent's Cavern at Torquay. My remarks on the conglomerates were only an expression of my own ignorance, and of satisfaction that Dr. Teall had a torrential hypothesis to suggest. The physics of the Devonshire Red Sandstones are at present most inscrutable.

A. R. Hunt.

TRIMMINGHAM CHALK.

Sir,—The coming Winter is possibly the last in which the 'North Bluff' will continue to exist, and in view of Professor Bonney's rejection of my observations as to the 'grey chalk' I hope that some geologist or geologists of recognised position will visit the locality this Autumn to test my accuracy as far as it is still possible. I shall be only too glad to meet anyone on the spot with this object. It is unfortunately no longer possible, owing to the ravages of the sea during the past year, to trace (as I have traced inch by inch and over and over again in the 70 odd visits I have made in the last six years) a continuous sheet of grey chalk from the most westerly point of Professor Bonney's block E to the most easterly point of the original bluff, but I think I can still show them enough to make it reasonable to accept as to such continuity the statement of a mere student of fossil polyzoa—if that is a fair description of me. R. M. Brydone.

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NOVEMBER, 1906.

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GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. III.

No. XI.—NOVEMBER, 1906.

ORIGINAL ARTICLES.

I.—On the Stratigraphical Relations of the Dufton Shales and Keisley Limestone of the Cross Fell Inlier.

By J. E. Marr, Sc.D., F.R.S.

NOTWITHSTANDING all that has been written concerning the Keisley Limestone, its exact relations with the older Dufton Shales have never been clearly ascertained. I accordingly devoted a few days of the Easter vacation to the study of these relations in company with Messrs. W. G. Fearnsides, R. H. Rastall, and T. O. Bosworth, whose help I gratefully acknowledge.

For many years the Dufton and Keisley groups were referred to the 'Coniston Limestone,' and no attempt was made to separate them, although it was clear that the great differences existing between them required explanation. In a paper by the late Professor Nicholson and myself "On the Cross Fell Inlier"[1] we remarked of the Keisley Limestone, "the occurrence of some forms which have not been found nearer than the Chair of Kildare may indicate that we have here a fossil zone which is not represented by fossiliferous beds in the central part of the Lake District."

In a paper on "The Coniston Limestone Series"[2] I divided this series into three groups, namely, the Ashgill Group at the top, the Sleddale Group in the centre, and the Roman Fell Group at the base, placing the Keisley Limestone in the central and the *Staurocephalus* Limestone in the upper group. Furthermore, I stated (p. 101) that if the suggestion that the representative of the Keisley Limestone occurs at the top of the ordinary Sleddale Limestone in the main part of the Lake District be correct, "a further division of the Applethwaite Group may be made into a lower stage characterized by the ordinary Applethwaite fauna, and an upper stage characterized by the fauna of Keisley and the Chair of Kildare." This Applethwaite Group, it should be stated, is the upper division of the Sleddale Group.

[1] Quart. Journ. Geol. Soc., vol. xlvii, p. 511.
[2] Geol. Mag., Dec. III, Vol. IX, p. 97.

Our knowledge of the fauna of the Keisley Limestone was largely increased by the papers on that limestone written by Mr. F. R. Cowper Reed.[1] He there maintains that this fauna shows that the limestone must be removed from the Middle Bala and placed among the Upper Bala Beds—in other words, that it belongs to the Ashgill Group and not to the Sleddale Group. There is no doubt as to the correctness of this contention. Our recent observations show that the beds from which Professor Nicholson and I obtained our '*Staurocephalus* Limestone' fossils in the Cross Fell Inlier are *in* the Keisley Limestone and not *above* it. Mr. Reed found that the fauna possessed a strong affinity with that of the *Staurocephalus* Limestone, and we cannot now hesitate to refer the Keisley Limestone to the *Staurocephalus* Limestone.

The main results of our work at Easter were: (i) the discovery of the Keisley Limestone in Swindale Beck; (ii) the discovery of Dufton Beds in the Keisley Quarry; (iii) the detection of a low zone of Skelgill Beds above the Keisley Beds of the quarry. Attention may first be directed to our work in Swindale Beck.

In the section down this beck given in the plate appended to the paper "On the Cross Fell Inlier," the Dufton Shales are indicated as passing into the *Staurocephalus* Limestone and the latter into the Ashgill Shales. This is correct, but the existence of the Keisley Limestone here was not then suspected by us. Its non-detection is perhaps pardonable, for in summer the stream at this portion is so well-wooded that it is difficult to see the character of the beds in the dim light. At Easter, however, there is no such difficulty.

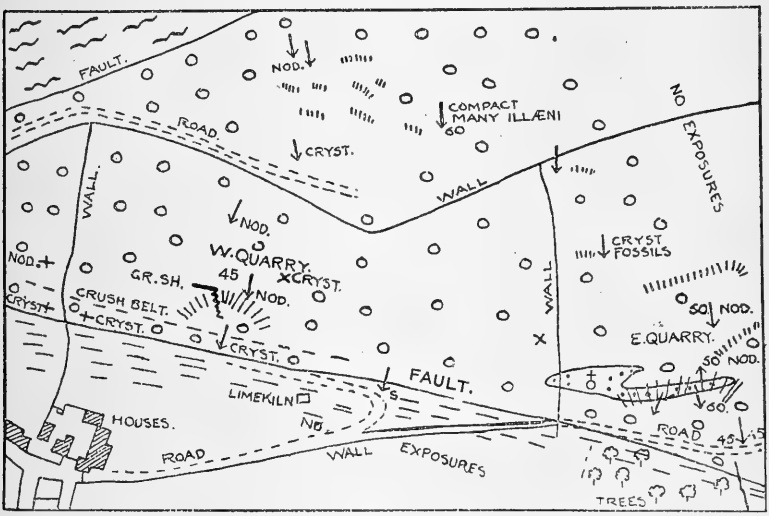
We stated that "at a point where a tributary stream (Rundale Beck) enters Swindale from the east the Dufton Shales are succeeded by a very calcareous deposit," which we refer to the *Staurocephalus* Limestone. The junction between the two is, indeed, close to this stream, but the highest beds of the Dufton Group occur on the south-west side of the stream and of a wall which bounds it. These beds consist of dark, almost black, limestone. Above them we measured approximately forty feet of grey compact limestone, of a nodular character, the nodules being most marked towards the base. This limestone exactly resembles that of the Keisley Quarries, where the latter has not become crystalline. In it, as stated above, are the more argillaceous beds, which furnished us with the fossils which we record as belonging to the *Staurocephalus* Limestone. The grey and nodular limestone is itself sparsely fossiliferous. We have found therein *Illænus* and one indeterminable *Trinucleus.* The occurrence of the latter is interesting, as it has not been found at Keisley. Notwithstanding its presence in Swindale, identity of lithological characters leaves no doubt that this Swindale Limestone is the Keisley Limestone. At the top it seems to pass perfectly conformably into undoubted Ashgill Shales, in which Mr. Fearnsides found *Phacops mucronatus.*

Professor Nicholson and I recorded the *Staurocephalus* Limestone in Billy's Beck. Here it is underlain by Dufton Shales (with

[1] Quart. Journ. Geol. Soc., vol. lii, p. 407, and liii, p. 67.

black limestones), the summit of which is not shown, and above it is a grey nodular limestone of the Keisley type, followed by a fault, on the other side of which the Browgill Shales occur. This section, therefore, also proves that the beds which we referred to the *Staurocephalus* Limestone are not above the Keisley Limestone.

We now pass on to the important sections of the hill behind Keisley hamlet. The accompanying plan, on the scale of 17½ inches to the mile, shows the distribution of the rocks. The two faults come together a little to the west of the plan, and no rock is seen in the portion between them in the triangular wedge not included in the plan.



Skelgill Beds.

Keisley Beds.

Dufton Beds.

Rhyolite.

S = position of fossils in Skelgill Beds.
CRYST = Crystalline Limestone.
NOD. = Nodular Limestone.
$\frac{+}{\circ}$ = position of fossils in Dufton Beds.

Arrows (→) represent the dips, and crosses (×) show where observations were made but no dips recorded.

FIG. 1.—Plan of part of the hill behind Keisley. Scale 17½ inches to a mile.

Two large quarries are now seen on the hill-side north of the hamlet, of which the more easterly is termed "Old Quarries" on the 25 inch Ordnance Map, while the westerly is simply marked "Quarry." I shall refer to these as the east and west quarries.

Beginning with the east quarry, we find an anticlinal fold exposed at its northern face, with black shales and limestones in the centre. At its western end these black limestones and shales are seen in a series of folds, as exhibited in the accompanying section, and their relationship to the Keisley Limestone clearly shown. It will be seen that, save for a wisp of shale, the highest bed of the dark series is a limestone. I have long known these beds, and believed them to belong to the Dufton Shales, and it is noteworthy that a calcareous band forms the summit here as in Swindale. All doubt as to the Dufton age of the beds has been set at rest by Mr. Fearnsides' discovery of fossils in some calcareous shales belonging to the group, in some excavations which he made on the hill-side about 20 yards west of the quarry at the point marked ♁ on the plan. The following is a list of fossils obtained from these excavations:—

Stromatoporoid?
Streptelasma? Common.
Heliolites tubulata, Lonsd. Common.
Heliolites sp. One specimen.
Dalmanella sp. Rare.
Orthis Actoniæ, Sow. Common.
Platystrophia biforata, Schloth. Common.
Triplesia spiriferoides, M'Coy.
Plectambonites sericea, Sow.
Trinucleus seticornis, His. Common.
Cybele verrucosa, Dalm. Common.
Calymene senaria, Conrad. Common.
Proetus cf. *ramisulcatus*, Niesk. One specimen.
Dalmanites sp. One specimen.

The fauna is clearly that of the Dufton Shales. The three common trilobites are those which are found in great abundance in the Dufton Shales of other exposures. Most of the other fossils have also been recorded from those shales, and those which have not are (with the exception of the *Dalmanites*, which is possibly new) found in the corresponding Sleddale Group of the Lake District. The supposed Stromatoporoid is clearly identical with a form recorded by Salter[1] from Coniston under the name of *Stromatopora striatella*, D'Orb.

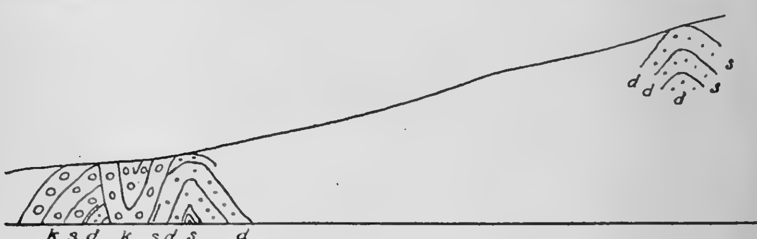


Fig. 2.—Section across west end of Dufton Inlier, showing folds.
Scale 1 inch = about 12 feet.

k. Nodular Keisley Limestone.
d. Limestones of Dufton Beds.
s. Shales of Dufton Beds.

We may now pass on to the consideration of the west quarry.

A crush belt with broken and silicified limestone crosses the floor of this quarry in a general W.N.W.–E.S.E. direction, with highly

[1] Cat. Camb. and Sil. Foss., p. 40.

crystalline limestone to the south of it at the west end of the quarry. To the north of this belt is the fine exposure of the northern face. The beds are dipping almost due south at an angle of 45°. They consist essentially of nodular grey limestone, which, however, is in places stained pink with hæmatite. Similar staining occurs in the limestone of many other parts of the hill. Where unstained, the limestone, as before stated, closely resembles the nodular limestone of Swindale Beck and Billy's Beck. Dipping with the limestone is an olive-green shale, which, however, is affected by many contortions, which cause it to undulate on the face of the quarry. It contains a number of nodes of limestone which will be further considered at a later stage, and is crushed to so great an extent as to break into papery sheets with very glossy surfaces. No fossils were seen in this, but a similar rock in a less crushed condition, occurring west of the wall which bounds the west end of the quarry, yielded some indeterminable fossils to Mr. Fearnsides' hammer. The rock there closely resembles the Swindale Beck rock to which Professor Nicholson and I originally restricted the term "*Staurocephalus* Limestone," and as the two occur in the Keisley Limestone they further increase the resemblance of the Swindale section to those of the Keisley Quarries.

Two or three years have elapsed since I detected graptolites of Skelgill Shale age in the road cutting east of the Old Limekiln and south-east of the west quarry (at S.). At Easter Mr. Fearnsides obtained a number of graptolites from this locality, and was able to prove that the zone was that of *Dimorphograptus confertus*. The beds are dipping a little west of south. As there is not enough room for the Ashgill Shales between this exposure and the nearest outcrop of Keisley Limestone, there is undoubtedly a fault separating the Skelgill Beds and the Keisley Limestone.

So far as the relations of the Keisley Limestone to other strata are concerned, our observations show: (i) that the highest beds of the Dufton Series are marked by calcareous black limestone with subordinate shales, the limestones containing few fossils save crinoids; further, that these calcareous beds occur in the Keisley section and in that of Swindale; (ii) that the change from the dark Dufton Beds to the lighter-coloured Keisley strata is abrupt, but there does not appear to be any unconformity; (iii) that the Keisley Beds consist mainly of fairly pure limestone, but that more argillaceous beds are interstratified with the purer limestone; from these more argillaceous beds Professor Nicholson and I extracted the fauna of our *Staurocephalus* Limestone; (iv) that the Keisley Beds of Swindale appear to be succeeded conformably by the Ashgill Shales.

I now turn to a consideration of the peculiar development of the Keisley Limestone in the Keisley exposures. I have elsewhere argued that it is a 'knoll' of limestone which has been thickened by folding and taken on peculiar structure during that folding, and recent examination tends to confirm this view.

The section figured shows that folding on a considerable scale has affected the rocks of the east quarry, and abundant minor folds are proved to exist in the west quarry by the puckering of the shales.

In the east quarry the Keisley Beds of nodular type are dipping southward from the Dufton Beds, to pass below the Skelgill Beds. Some of the upper beds of the Keisley Limestone may be faulted out here, but the beds which actually exist are not more than forty feet thick, and therefore no thicker than the beds of this age in Swindale, where they appear to present a normal sequence. To the north of the anticline which brings up the Dufton Beds, the Keisley Beds dip nearly due north for a very little way, and still further north there is a continuous southerly dip at angles varying from 60° to 75° for a distance of about 200 yards. Unless a fault exists along the line where the dip in the Keisley Beds changes from north to south, the Dufton Beds should come to the surface at no great distance to the north of the change of dip. There is no sign of any such fault, and the alternative explanation is that the Keisley Limestone is here folded into a series of isoclines, with the Dufton Beds concealed beneath at no great distance below the surface.

It is well known that the bulk of the Keisley fossils have been obtained from a highly crystalline whitish limestone, though here and there they occur in compact limestone, as in the case of the abundant *Illæni* in a horny limestone whose position is marked on the plan. One would naturally expect that the crystalline and compact limestone belonged to different beds, and at the outset we attempted to prove that the crystalline limestones were above the nodular and compact limestones. A further examination proved that they were quite irregularly distributed, as shown on the plan, where the principal exposures are indicated, the crystalline limestones being marked 'cryst.' and the compact nodular limestones 'nod.' Further search proved that this irregular distribution was traceable on a very small scale, so that at times a hand-specimen could be obtained with one portion compact and the other crystalline, the two being separated by very irregular junctions, with no traces of bedding-planes. It seems impossible to escape the conclusion that the compact limestone was the original rock, and that crystallisation, as the result of subsequent change, has affected it sporadically in this Keisley tract, where there is clear proof of much thickening by folding, whereas in the Swindale section, where there is no evidence of thickening, the crystalline variety is absent.

It is interesting to note that little knolls of crystalline limestone occur in profusion in the shale-band of the lower part of the northern face of the west quarry, in a way which recalls similar little knolls which I elsewhere described in the shales associated with the limestone of the Draughton Quarry of the West Riding of Yorkshire.[1]

The question arises, why should the limestone be thickened and crystallised at this point and not in Swindale? In connection with this I would point out that elsewhere the Dufton Shales show evidence of much repetition, and the limestone may have resisted folding when sandwiched between the soft Dufton Shales below and the Ashgill and Skelgill Shales above. Here the Dufton Shales are

[1] "On Limestone Knolls in the Craven District of Yorkshire and elsewhere": Quart. Journ. Geol. Soc., 1899, vol. lv, pp. 336–338.

faulted out to the north of the mass, so that the Keisley Beds come into contact with the rhyolite of Keisley Bank. There is little shale above, and the massive Browgill Shales soon succeed the thin Skelgill Beds. During the movements, owing to the absence of the Dufton Shales by faulting on the north, the Keisley Beds and the calcareous top of the Dufton Shales would be pressed against the hard rhyolite, and would in all probability tend to fold against it.

Whatever be the origin of the structure of parts of the Keisley Limestone, the exact position of that limestone in the stratigraphical succession must be regarded as definitely established. The limestone and the more argillaceous beds intercalated with it belong to the *Staurocephalus* Limestone group, and occur between the Dufton Shales and the Ashgill Shales.

II.—Notice of some Fossils from Singapore discovered by John B. Scrivenor, F.G.S., Geologist to the Federated Malay States.

By R. Bullen Newton, F.G.S.,
of the Department of Geology, British Museum (Nat. Hist.), Cromwell Road, S.W.

(PLATE XXV.)

Introduction.

As representing the first fossils yet recorded from Singapore, these specimens are of considerable interest. They principally consist of marine Lamellibranch remains accompanied by an obscure indeterminable Gasteropod, and a few fragmentary terrestrial plants. Their condition, however, as casts and impressions renders them most difficult to work out satisfactorily, more especially the shells where only external features of the valves are available for study. Some of the specimens, however, retain certain points of structure or contour which appear to have an important bearing on their probable geological age. The association of land and marine organisms would at once suggest an estuarine or lagoon origin for the beds containing them, more especially as the mollusca belong to genera or families which may be regarded as of shallow-water habit, whilst the plant-remains might be accounted for by the close proximity of land or the transporting agency of river action. Among the shells, that referred to *Goniomya* is of chief interest, since it belongs almost exclusively to the Mesozoic period, being particularly characteristic of Jurassic rocks and of much rarer occurrence in deposits of Cretaceous age.

Although exceedingly rare, *Goniomya* has also been found in Palæozoic rocks, Krotow having figured and described *G. Artiensis* from the Russian Permian (Soc. of Naturalists Imp. University of Kasan, 1885, vol. xiii, p. 225, pl. iii, fig. 20), and an unnamed form from rocks of similar age in the Central Himalayas has been more recently recorded by Dr. Carl Diener (Palæontologia Indica, 1903, ser. xv, vol. i, pt. 5, p. 126, pl. v, fig. 19, and p. 176, pl. viii, fig. 11).

The plant structures, although obscure, are also important. A leaf-like body has been referred to *Podozamites* cf. *lanceolatus* (Lindley & Hutton), a genus and species which enjoyed an extensive geographical distribution during the Bajocian stage of Jurassic times, having been recorded from Yorkshire (Haiburn Wyke); Spitzbergen; Orenburg; East Siberia; Astrabad, Persia; India (Upper Gondwana Beds); China; Japan; and Korea.

Podozamites is but one member of a large group of similar plants, generally included under the Cycadaceæ, which were of abundant occurrence in the Mesozoic period, and of which *Williamsonia* may be regarded as the type. Such a flora has been described by Feistmantel as typical of the Upper Gondwana deposits of India, and it is of further interest to note that marine molluscan remains have been also found in some of those beds associated with the plants (R. D. Oldham's edition of Medlicott & Blanford's "A Manual of the Geology of India," 1893, p. 180).

The Singapore Clays, therefore, with their estuarine contents, may be of Middle Jurassic age, and about the horizon of the Inferior Oolite of England or the so-called Bajocian of Continental geologists. They possibly represent an extension or outlier of the Upper Gondwana rocks of India, as well as forming part of the other fossiliferous areas of Eastern Asia, including Korea, Japan, and Siberia, which have yielded a similar vegetation.

Mr. John B. Scrivenor, the discoverer of these fossils, has furnished the following account of the beds and locality, stating that the specimens were obtained "from a 2 ft. (*circâ*) bed of silty clay with obscure plant-remains, forming a part of the series of shale and sandstone beds which embraces all the known sedimentary rocks of Singapore Island apart from surface deposits, and exposed in a big quarry on the north flank of Mount Guthrie, Tanjong Pagar, Singapore Town.

"What remains of Mount Guthrie is likely to disappear before long; in fact, the original hill extended over the spot where I found the fossils. The specimens take some time to collect, as they are sparsely distributed. I send the best fossil leaf I could find and also an object which may be a fruit. I also saw obscure vegetable remains in shale at Tanjong Malang, close by; and at Mount Wallich, also close by, I saw one piece of badly-preserved fossil wood. In the Mount Guthrie quarry, about 50 yards from the fossiliferous horizon, I found a 6 inch seam of very poor brown coal.

"The shale and sandstone series is very highly inclined in this part of Singapore; in one section I saw the beds are vertical. At Mount Guthrie the strike is N.N.W.–S.S.E., the dip about 75° W.S.W.

"The strike and petrological characteristics of the series wherever seen suggest a connection with the shale and sandstone of the Federated Malay States; but, again, were these rocks situated in Sarawak [Borneo] the petrological evidence and the presence of the obscure vegetable remains would not be sufficient alone to separate them from the shale and sandstone of Upper Sarawak and Santubong" [Borneo].[1]

Description of the Fossils.

The matrix containing the fossils is a light drab-coloured compact clay, varying slightly in tint and particularly soft to the touch, marking everything as if it were chalk, although according to the acid test no calcareous constituents are present. Dr. G. T. Prior, of the British Museum, who has examined the material, has detected some minute particles of silica entering into its structure.

The specimens herewith described and figured have been mainly collected by Mr. John B. Scrivenor, although a second series from the same locality and beds was subsequently furnished to the writer by Dr. R. Hanitsch, of the Raffles Museum, Singapore, three of which are represented on the Plate by Figs. 3, 4, and 17. Through the good services of both Mr. Scrivenor and Dr. Hanitsch the specimens selected for illustration have been presented to the British Museum. A word of praise should be extended to the artist, Mr. A. H. Searle, for the excellent drawings he has constructed from obscure and difficult material, and which, thanks to the collotype process, have been satisfactorily reproduced on the Plate.

LAMELLIBRANCHIA.

Cucullæa Scrivenori, sp. nov. (Pl. XXV, Fig. 13.)

Shell small, compressed, inæquilateral, subquadrate, oblique; umbo very anterior; dorsal margin horizontal, short; anterior area short, deep, obliquely and roundly truncated; posterior region wide, produced, rounded, and bearing an elongate oblique depression, with an angulation at the posterior end of the hinge-line; ventral margin nearly parallel with dorsal line; ornamentation consisting of extremely fine concentric growth-lines crossed by a series of delicate radial striations.

Dimensions.—Length 13, height 7 mm.

The specimen referred to this form is a small, rather compressed right valve, embedded in the rock, and, like the other specimens from this locality, only showing external characters. It appears to differ from previously described forms of this genus by its very inæquilateral character, the umbo being within a small distance of the anterior margin, and the relatively long and narrow posterior depression. The sculpture markings are obscure, but when properly shaded the valve shows decussating striations.

Collector.—Mr. J. B. Scrivenor.

[1] These Borneo Beds have been examined and reported upon by Mr. John B. Scrivenor, and the results issued in a Government paper (No. 8) published at Kuala Lumpur by the Geological Department of the Federated Malay States on the 19th January, 1905, entitled "A Report on the Geology of the Residency of Sarawak, and of the Sadong District, Borneo, with special reference to the occurrence of Gold and Coal."

ARCA sp. (Pl. XXV, Fig. 14.)

Shell narrow, elongate; hinge-line horizontal and parallel with ventral border; umbo depressed, anterior, oblique; carinated obliquely and obtusely from umbonal region to postero-ventral margin; anterior end rounded, posterior truncated, and area depressed; sculpture consisting of very obscure concentric lineations without evidence of radial striæ.

Dimensions.—Length 20, height 8 mm.

This description applies to a natural cast of a right valve embedded in the rock showing the external surface. Narrow forms of *Arca* are fairly common in Jurassic deposits, but they are invariably ornamented with radial striation; as no such sculpture exists in the Singapore fossil it may be inferred that none was ever present, although it is possible that the counterpart, which does not appear to have been preserved, might have yielded a better interpretation of the original surface structure.

Collector.—Mr. J. B. Scrivenor.

GERVILLIA HANITSCHI, sp. nov. (Pl. XXV, Fig. 4.)

Shell lanceolate, subcylindrical, curved at ventral margin, moderately convex at carina; anterior area, shortest, with an acute cuneiform termination, narrow and produced posteriorly; umbonal region terminal; dorsal area, constituting a long narrow obliquely striated depression, entirely bordered within by an obtuse carina, and above by an obscure lengthened hinge-line; growth-lines slightly impressed.

Dimensions.—Length 54, height 12 mm.

This interesting specimen consists of a natural cast and counterpart, showing external surface of a left valve, which resembles in many of its characters some Jurassic forms of the genus, such as *G. monotis*, Deslongchamps, from the Bathonian of Britain and Europe, or *G. acuta*, J. de C. Sowerby, of Bajocian age. From the former it appears to differ in its lesser convexity and longer hinge-line, and from the latter in its less oblique and more lengthy hinge area.

Collector.—Dr. Hanitsch.

VOLSELLA cf. COMPRESSA, Goldfuss. (Pl. XXV, Fig. 5.)

Mytilus compressus, Goldfuss: Petrefacta Germaniæ, 1837, vol. ii, pl. cxxxi, fig. 11, p. 178. Morris & Lycett: Mon. Pal. Soc. (Great Oolite Mollusca, part 2), 1853, pl. iv, fig. 7, p. 40.

In general contour and flatness this shell is closely related to *Mytilus compressus* of Goldfuss, originally described from Hanover and the Stonesfield Slate. The principal distinction appears to be in the concentric lineations, which are fewer and more distant in the Singapore fossils, although some obscure ones are traceable between the more important striæ, especially on the lateral areas. The umbo is not terminal as in *Mytilus*, so that this form is recognized as a true *Volsella* (= *Modiola*). The specimen shows an external view of a left valve embedded in matrix.

Dimensions.—Length 20, height (maximum) 10 mm.

Collector.—Mr. J. B. Scrivenor.

? NUCULANA sp. (Pl. XXV, Fig. 7.)

A figure has been drawn of a fragmentary valve which may represent either a *Nuculana* or an *Anatina*, that is if the shell can be assumed to have possessed a rostration as indicated by the dotted lines. The specimen shows an external view of a compressed right valve with a short and rounded anterior area and a horizontal dorsal line which forms the boundary to an obtusely angled, elongate area, extending posteriorly from the rather flattened umbonal region. The surface of the valve is delicately striated concentrically, and slightly wrinkled posteriorly.

Supposing the specimen originally to have been rostrated, then the concentric lineation is finer than usually obtains in *Anatina*, being perhaps more applicable to *Nuculana*, although even in that genus the dorsal line appears to be too horizontal, an obliquity being usually apparent descending from the umbo before proceeding in the posterior direction.

Collector.—Mr. J. B. Scrivenor.

? NUCULOID SHELL. (Pl. XXV, Fig. 6.)

The "Nuculoid shell" here referred to is an external view of a narrow, lanceolate right valve, buried in the matrix, and preserved as a natural cast together with the counterpart. The umbo is very anterior, small, and scarcely rising above the hinge-line; the dorsal and ventral margins are subparallel; anterior margin short and rounded; posterior oblique, produced, and subacuminate; sculpture consisting of delicate striæ of growth, concentrically arranged; no crenulations observable on the hinge area.

Dimensions.—Length 20, height 8 mm.

It is not possible to determine more closely the shell which is here figured and briefly described. Probably it is a form related to *Nucula*, but the absence of crenulations at the hinge area renders such a supposition very doubtful. Further, there is a resemblance in general contour to Conrad's Palæozoic genus *Nuculites*, the casts of which in common with the specimen from Singapore bears a narrow notch-like cavity in the anterior region beneath the umbo; but, again, the want of cardinal crenulations would create a difficulty if included in such a genus. With better material at some future time this shell may eventually be identified.

Collector.—Mr. J. B. Scrivenor.

? LUCINA sp. (Pl. XXV, Fig. 15.)

The specimen referred doubtfully to the genus *Lucina* is a small, subcircular, rather compressed, right valve, showing a nearly mesial rounded umbo directed obliquely forward, and having its surface ornamented with numerous, closely-set, microscopical, concentric striations, which are more obvious on the ventral and lateral areas than on the umbonal region. In the postero-ventral direction the valve is imperfect; this has been indicated in the figure by a dotted line. It is impossible to suggest to what shell this fragmentary valve might be related, although interesting for reference as one of the species found in the Singapore Clays. This specimen may be also said to resemble some small forms of *Unicardium.*

Dimensions.—Length 11, height 10 mm.

Collector.—Mr. J. B. Scrivenor.

Astarte Scrivenori, sp. nov. (Pl. XXV, Figs. 11, 12.)

Shell subquadrate, slightly convex; umbo anterior; dorsal line slightly oblique; posterior area depressed, sloping, and angulated below; ventral margin nearly parallel with dorsal; anterior area rounded and short. Ornament consisting of from 10–12 nearly horizontal costal ribs, obtusely angled on both sides, and separated by rather wide sulcations; anterior costæ crowded and finest in front.

Dimensions.—Fig. 11, length 14, height 11 mm.; Fig. 12, length 11, height 7 mm.

This form is represented by two right valves of different ages, the younger showing a much finer and more crowded system of costæ (Fig. 12), whilst the older shell (Fig. 11) possesses a bolder and coarser sculpture. The lateral angles of the costæ present a feature of interest in the sculpture which is apparently not known among typical astartiform shells, hence it has been regarded as a new species. In addition it may be mentioned that this species shows a certain resemblance in contour and structure to *A. interlineata* of Lycett, from the Great Oolite of Minchinhampton (see Mon. Pal. Soc., 1854, pl. ix, figs. 14, 15, p. 87).

Collector.—Mr. J. B. Scrivenor.

Astarte Guthriensis, sp. nov. (Pl. XXV, Fig. 9.)

Shell small, subelliptical, moderately convex; umbo anterior; front area short, rounded, slightly excavated beneath the umbo; posterior margin elongate, oblique; ventral border thickened, rounded; sculpture consisting of about 10 wide, elevated, concentric costæ, bearing minute lineations, divided by smooth sulcations of nearly equal width.

Dimensions.—Length 11, height 6 mm.

This specimen is embedded in the matrix and exhibits an external view of the right valve. The dorso-posterior margin is rather imperfect, otherwise the specimen is fairly seen and its ornamentation is well displayed. The raised concentric and striated ridges divided by the prominent smooth sulcations and without any evidence of radial lines, are the chief sculpture characters of the valve.

Collector.—Mr. J. B. Scrivenor.

Astarte Guthriensis, var. nov. (Pl. XXV, Fig. 10.)

Shell with similar sculpture to *A. Guthriensis*, but of rather quadrate form, and considerably less oblique posteriorly.

Dimensions.—Length 10, height 7 mm.

This variety is represented by an external surface of a right valve in which the umbo is not preserved, but the excavation beneath is well marked.

Collector.—Mr. J. B. Scrivenor.

Goniomya Scrivenori, sp. nov. (Pl. XXV, Fig. 1.)

Shell narrow, convex, subcylindrical, umbo anterior, vertical, and not prominent; dorsal margin gently sloping from umbo on each side, anterior end rounded, posterior truncated; sculpture consisting of a regular series of about 16 V-shaped, slightly curved, oblique costæ, which are elevated, rounded, funiculate, and divided by prominent sulcations, bearing closely-set, obscure, longitudinal striations; some of the costæ at the anterior end are angulated inwards.

Dimensions.—Length 21, height 7 mm.

This specimen, represented by an external view of a left valve embedded in the clay-matrix, is beautifully marked, the costæ showing a delicate cord-like structure; it is of narrowly elongate form, and appears to differ from all other members of the genus by its non-prominent umbo, the presence of angulate costæ at its anterior end, and the funiculate ornamentation of the costal ribs. The limits of the ventral margin are not defined.

Collector.—Mr. J. B. Scrivenor.

Goniomya Singaporensis, sp. nov. (Pl. XXV, Figs. 2, 3.)

Shell elongate, slightly convex; umbonal region very anterior, obtuse, vertical, slightly elevated at summit; posterior dorsal margin oblique, long; anterior area obliquely margined from the summit, short, rounded; sculpture consisting of a series of V-shaped, sharply angulated costal ribs arranged beneath the umbonal area, separated by sulcations, which are finer and closer on the anterior side and wider apart and divided by broader grooves posteriorly; the ribs are elevated, rounded, and slightly curved outwards; surface of grooves bearing fine longitudinal striations with obscure indications of striæ on the anterior costæ.

Dimensions.—Length 32, height (from umbo to thirteenth angulation) 11 mm.

Two out of the three specimens representing this form are shown in Figs. 2 and 3, the former, an excavated impression of a right valve, being the most perfect, though deficient in ventral details; whilst Fig. 3 applies to a fragmentary natural cast of a left valve in which the angulated costæ and the short anterior region are well displayed.

This species differs from *G. Scrivenori* in its more anterior umbo, its much shorter anterior area, more oblique posterior margin, and its less defined ornamentation. It was probably a cylindrical form resembling such a species as Agassiz's *Goniomya sulcata* from the Jurassic rocks of Switzerland, which also possesses very anterior umbones, but differs in having coarser ribbing and a more prominent umbonal area, which is inclined to obliquity. In the absence of dental characters it is impossible to say whether the Singapore specimens might not belong to *Trigonia*, as some forms of that genus exhibit a V-shaped ribbing, such as have been described by Dr. Kitchen from the Oomia Beds (Upper Jurassic) of India (Palæontologia Indica, 1903, ser. ix, vol. iii, p. 70, pls. vii, viii), but the finer and more regular ornamentation would in any case at once distinguish them from the Indian shells.

Collectors.—Mr. J. B. Scrivenor (Fig. 2) and Dr. Hanitsch (Fig. 3).

? Thracia sp. (Pl. XXV, Fig. 8.)

I have placed doubtfully under the genus *Thracia* the largest of the shell remains found in the Singapore deposits. Unfortunately the umbo is wanting, and its exact position is very uncertain, although it was possibly more or less mesial. The specimen consists of a considerably fractured natural cast representation of the left valve of an elongate shell, rounded anteriorly, with a probably nearly horizontal dorsal margin, and possibly an elliptically curved base. It has the appearance of having had originally an oval outline, and in the posterior region, where the principal characters are merged, there is an obtusely angulated area descending obliquely from the umbonal region to the median angulation of the truncated margin, producing a cuneiformity of outline which is repeated within by the concentric growth-lines.

Dimensions.—Length 62, height (about) 33 mm.

Collector.—Mr. J. B. Scrivenor.

PLANTÆ.

Podozamites cf. lanceolatus, Lindley & Hutton. (Pl. XXV, Figs. 16, 17.)

Zamia lanceolata, Lindley & Hutton: Fossil Flora Great Britain, 1836, vol. iii, pl. 194.

Podozamites lanceolatus, Seward: Catalogue Mesozoic Plants British Museum, The Jurassic Flora (Yorkshire Coast), 1900, p. 242, text-figure No. 44 on p. 245. H. Yabe: Journ. Coll. Sci. Imp. Univ. Tōkyō, Japan, 1905, vol. xx, Article 8, pl. iv, figs. 1–5, p. 17.

The largest of the two specimens appearing to bear a relationship to *Podozamites lanceolatus* consists of a long leaf-like body embedded in the clay-matrix, much crushed and bent about at its widest end, and diminishing rather rapidly at its other extremity for probable attachment to a rachis, whilst a series of parallel lines or venations traverses the entire surface of the organism. There is no indication of a stem, although the peculiar narrowing of the supposed basal end would suggest that that part would form the point of attachment. The broader end is not complete, so that the original length is uncertain, but the maximum width of the pinna can be given as 16 mm. Although much broader than the pinnæ of typical examples, this specimen is by no means the widest known, Dr. Yabe having recently figured some specimens from Korea with a measurement of 20 mm.

The second specimen represents another fragmentary pinna, which is of smaller dimensions, being only 7 mm. wide. It is, however, of interest, since a well-rounded, slightly notched, basal margin can be seen, as well as the characteristic parallel venations, the more lateral of which curve slightly inwards at the termination. Unfortunately the apical region is incomplete, and there is no means of ascertaining the exact length of the fossil, although it is probable that it was a much shorter form, such as has been figured by Dr. Yabe from Korea and compared with *P. pulchellus* of Heer from Spitzbergen (Kongl. Svensk. Vetensk.-Akad. Handl. [Stockholm], 1876, vol. xiv, No. 5, p. 38, pl. ix, figs. 10–14). A slight resemblance can also be traced to a pinna recently figured by Mr. Seward from the Stonesfield Slate as *P. Stonesfieldensis* (Catalogue Mesozoic Plants British Museum, Liassic and Oolitic Floras of England, 1904, pl. iii, fig. 4, p. 123), in which a basal notch has been likewise observed.

Remains of this plant are frequently found in a poor state of preservation, and only detached pinnæ as a rule are obtained, these being sometimes damaged at their terminations like the Singapore specimens. The species is a very variable one, the pinnæ differing considerably in dimensions and the number of parallel venations never being quite the same. Its geographical distribution is extensive. Originally described from the Yorkshire Oolites, it has since been recorded from European countries, Spitzbergen, Siberia, Persia, India (Upper Gondwana Beds), China, Japan, and Korea. For an exhaustive synonymy of the species Mr. Seward's British Museum Catalogue should be consulted.

Collectors.—Mr. J. B. Scrivenor (Fig. 16) and Dr. Hanitsch (Fig. 17).

Carpolithes sp. (Pl. XXV, Fig. 18.)

An isolated seed, buried in the matrix, of apparently a Cycadean character has been provisionally referred to the genus *Carpolithes.* It is of rather oblong contour with nearly parallel sides, and bearing a longitudinal rounded ridge on the right margin, which may represent a fractured edge of the outer cuticle of the seed. The central oval and convex body, which is possibly the naked seed itself, is minutely and concentrically striated, especially on the sides.

In connection with the remains of *Podozamites* it is interesting to find a seed of this character in association, as the assemblage is suggestive of a Lower Oolite flora, such as characterise the rocks of the Yorkshire coast, Stonesfield, and the more distant Jurassic regions.

Dimensions.—Width 7, height 8 mm.

Collector.—Mr. J. B. Scrivenor.

EXPLANATION OF PLATE XXV.

Fig.

1. *Goniomya Scrivenori,* sp. nov. External view of a left valve. × 2.
2. *G. Singaporensis,* sp. nov. External view of a right valve drawn from a wax cast of original impression. Nat. size.
3. *G. Singaporensis.* External aspect of a fragmentary left valve. Nat. size.
4. *Gervillia Hanitschi,* sp. nov. External view of natural cast of a left valve. Nat. size.
5. *Volsella* cf. *compressa,* Goldfuss. External view of a left valve. × 2.
6. [? Nuculoid shell.] External view of a right valve, showing obscure anterior notch. Nat. size.
7. ? *Nuculana* sp. External view of a right valve, the dotted line showing probable rostration. Nat. size.

FIG.

8. ? *Thracia* sp. Natural cast of an imperfect left valve showing external features. Nat. size.
9. *Astarte Guthriensis*, sp. nov. External view of right valve. × 2.
10. *A. Guthriensis*, var. Outer view of a right valve. × 2.
11, 12. *A. Scrivenori*, sp. nov. External views of right valves. Fig. 12 drawn from a wax cast of original cavity. Nat. size.
13. *Cucullæa Scrivenori*, sp. nov. External view of right valve. × 2.
14. *Arca* sp. External view of a natural cast of a right valve. Nat. size.
15. ? *Lucina* sp. Outer aspect of a fragmentary right valve. × 2.
16. *Podozamites* cf. *lanceolatus*. An incomplete pinna showing the probable base as tapering to a point where attachment to the rachis might have been effected. Nat. size.
17. *Podozamites* cf. *lanceolatus*. A more imperfect fragment of another pinna with an obscure indication of a basal notch. × 2.
18. *Carpolithes* sp. Longitudinal view of a seed showing on the right margin the remains of a possible outer integument. × 2.

Note.—Specimens represented by Figs. 3, 4, and 17 were collected and presented to the British Museum by Dr. R. Hanitsch; the remainder were collected by Mr. J. B. Scrivenor and similarly presented by him to the same institution.

III.—The Carboniferous Succession below the Coal-Measures in North Shropshire, Denbighshire, and Flintshire.

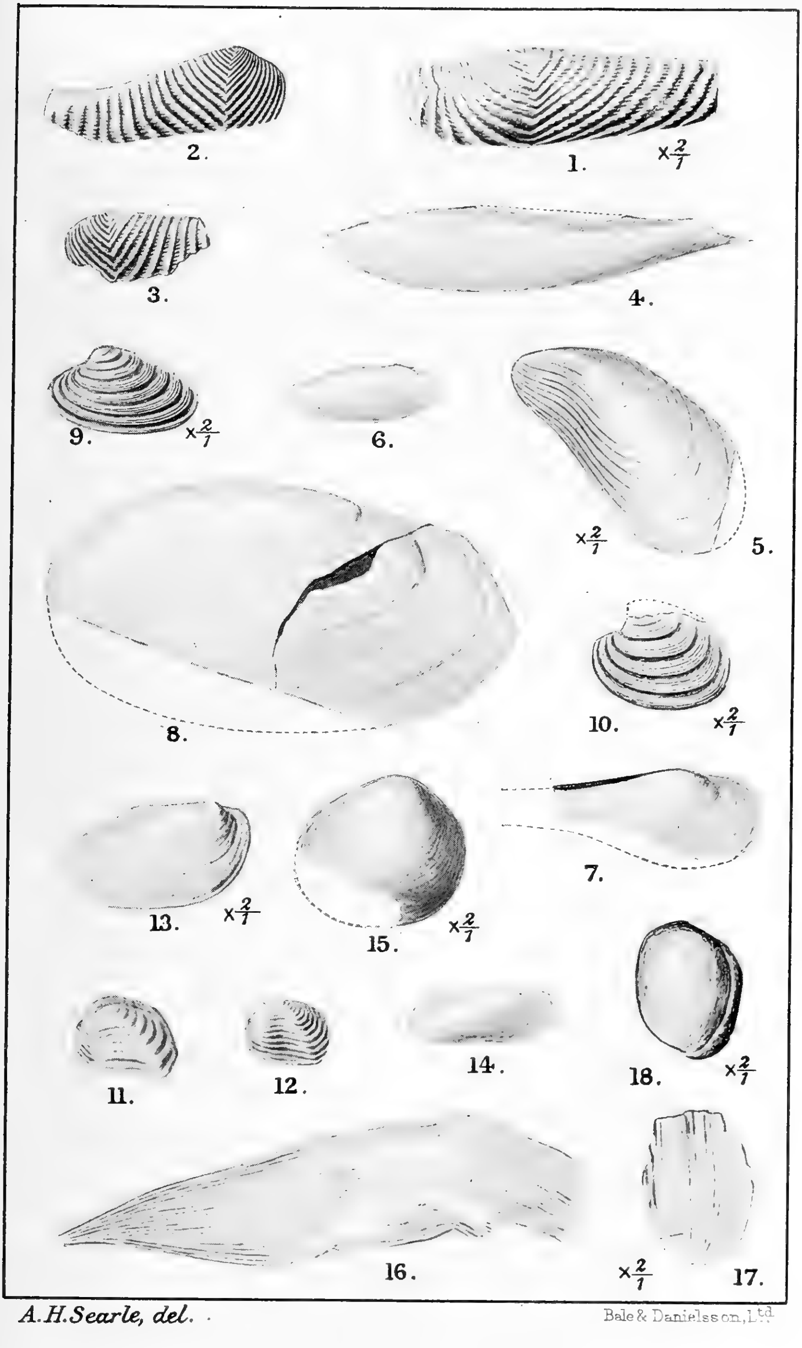
By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and John T. Stobbs, F.G.S.

(*Concluded from the October Number, p. 459.*)

5. Comparison of the Palæontological Sequence of the Carboniferous Rocks of North Wales with that which occurs in other Carboniferous Areas in England and Wales.

The palæontological succession of the Carboniferous rocks of North Wales is practically identical with the succession in the Pennine area, and to a certain extent with that which obtains in the Bristol–Mendip area.

Dr. A. Vaughan has demonstrated that in the latter district the distribution of the Corals and Brachiopoda affords a definite basis for the subdivision of the Carboniferous Limestone into life-zones (Quart. Journ. Geol. Soc., vol. lxi, pp. 180–307). We have found the corals most valuable indices during our work in North Wales. Apparently the vertical distribution of the Carboniferous corals demonstrates a progressive evolution, and both genera and species have a definite vertical range and are therefore time indices. They can on that account be safely relied upon for the correlation of beds in faulted or widely separated areas. With regard to the Brachiopoda, here again within limits certain definite mutations of a form, which evidently have a certain genetic relationship, appear only at particular horizons and have a definite vertical range. Unfortunately many of the names of the Brachiopods selected by Dr. Vaughan as the zonal indices belong to species which were founded on specimens which occurred at much higher horizons than those to which he would have referred them in the Bristol area. They are therefore the last mutation of the genus of the peculiar species rather than one of



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Mesozoic Fossils from Singapore.

the earlier mutations. The specific names must be strictly kept for the special form occurring in the beds whence the type-specimens were derived. We instance, more particularly, *Schizophoria resupinata*, Martin, *Syringothyris cuspidata*, Martin, *Spiriferina octoplicata*, Sow., the types of which came from beds in Derbyshire which belong to the higher coral zones. It will be a very easy matter to indicate in some simple way or other the precise mutation which is typical of the lower beds without introducing any ambiguity.

With regard to our researches in the Carboniferous rocks of North Wales, certain very definite results obtain. We find that there is no evidence that any beds belonging to the series which come on below the *Dibunophyllum* zones in the Bristol–Mendip area are represented in North Wales, except possibly some few feet of the Upper *Seminula* beds.

The Basal Conglomerate, containing derived fossils only, which lies between the Silurian rocks and Carboniferous Limestones in some localities, is unconformable to the Lower rocks, but conformable to the limestones. Although red in colour it therefore represents a time late in the Carboniferous period, judged from the Bristol–Mendip succession, and consequently is in no way the homotaxial equivalent of the Old Red Sandstone.

The Conglomerate is due to purely physiographical conditions, and represents the initial deposits laid down upon a sinking land surface, a fact indicated by the petrological study of the pebbles which enter into its composition (Strahan & Walker, Quart. Journ. Geol. Soc., vol. xxxv, pp. 268–274). These conglomerates appear locally on the western side of the Vale of Clwyd, and the thickest section appears to be at Ffernant Dingle, where a fairly complete succession can be made out. At other places, as at Minera quarries, the Carboniferous Limestone rests unconformably but immediately on beds of Bala age. At Llangollen Mr. Morton estimated that the beds which he then called Old Red Sandstone, were 50 feet thick.

Comparative sections of the Carboniferous Limestone show that this series thins out rapidly from north to south, and while the upper beds can be traced across the whole district by their zone fossils, the lower beds are wanting in the south. This must have been due to the fact that the southern part of the sinking land surface was higher than that to the north, and consequently only received the deposit later on. Hence it follows that the base of the Carboniferous Limestone in North Wales does not represent the same horizon in every locality, and further that the Basal Conglomerates, where present, are not necessarily all of the same age in point of time, owing to the fact that deposition took place on an uneven and irregular floor.

It is questionable whether the *Seminula* zone of the Bristol area is represented at all in North Wales. It is true that the zone fossil, *Seminula ficoides*, Vaughan, is fairly abundant south of Dyserth, between Pentre-bach and Pentre Cwm (mentioned in the Memoir of the Geological Survey, "The Geology of the Coasts adjoining

Rhyl, Abergele, and Colwyn," p. 9), where it occurs with *Archæosigillaria Vanuxemi*, Göpp., and other plant-remains. This shell was evidently alluded to as *Athyris Royssii* in the memoir.

The absence of *Caninia* makes it definite that only the top of the *Seminula* beds, if any, can be present. In the Bristol area *Seminula* is still present in the Lower *Dibunophyllum* zone. It is therefore certain that the lowest limestones of the North Wales sequence cannot be lower than the junction of the *Seminula* and *Dibunophyllum* zones of Bristol.

In North Wales *Daviesiella* (*Productus*) *Llangollensis* characterises the lowest beds of limestone at Llangollen and Minera, but it is found some little distance above the base, and associated with *Seminula* at Llandulas. The internal characters of *Daviesiella* (*P.*) *Llangollensis* closely resemble those of *Chonetes* aff. *comoides*, Vaughan, which that writer proposes to call *Choneti-productus*. It is important to note that the one species in North Wales and the other in Bristol occur apparently at the same level, i.e. practically at the junction of the Upper *Seminula* and Lower *Dibunophyllum* zones.

Hence we arrive at the important conclusion that the whole of the Tournaisian Series as represented in the Bristol area, and nearly all, if not all, of the *Seminula* beds, were not deposited in North Wales, and we may reasonably infer that this area was not submerged during the time that these beds were being laid down in the south-west of England. This fact is of great importance, and clears away many of the great difficulties that the distribution of the Carboniferous corals in the Pennine area and the Lower Limestone Series of Scotland apparently opposed at first to Dr. Vaughan's conclusions. It was a well-known fact that the more highly evolved corals, the Dibunophyllids, Clisiophyllids, and *Lonsdaleia*, in fact the upper coral fauna, were found at the base of the Carboniferous Limestone, Westmoreland (Shap) and in the Lower Limestone Series of Scotland. It was also puzzling why the lower faunas of the Bristol area had not been found in the Midlands. The succession of the Lower Carboniferous rocks of North Wales evidently furnishes a very simple solution of the problem, and that the whole of the Carboniferous Limestone Series of the Pennine area and Scotland belong to the *Dibunophyllum* and *Seminula* zones, with the possible exception of the Basement beds below the Ash Fell Series of Westmoreland. Hence the contention of Dr. W. Hind that the limestones of the Pennine area are characterised by *Productus giganteus* and its varietal forms is practically correct (GEOL. MAG., Dec. IV, Vol. V, p. 69).

In the Bristol area Dr. Vaughan estimates the *Dibunophyllum* zone to be 400 feet thick. It is probably about 500 feet thick in North Wales, but in the Midlands may be from 1,500 to 2,000 feet thick.

The *Dibunophyllum* zone of North Wales can be everywhere divided into an upper and a lower sub-zone as at Bristol, but certain local differences are present.

In the Bristol area *Productus giganteus* with its varietal forms has its maximum towards the base of the Lower *Dibunophyllum* sub-zone, whereas in North Wales this group of shells is not at all common at this horizon, but occurs in the greatest profusion at the top of the Upper *Dibunophyllum* sub-zone. At the quarry at Waenbrodlas, immediately below the *Cyathaxonia* beds, this species occurs in millions, and curiously enough the named varietal forms of this shell occur with it in the same beds. It is apparent, therefore, that the evolution of varietal forms of this species does not afford any help for the purposes of zoning.

The typical transverse forms of *P. giganteus*, as figured by Martin, with long ear-like processes and fine ribs, are accompanied by the broad flat-ribbed form named *P. Edelburgensis* by Phillips, and others less transverse like the specimens figured by Davidson (Brit. Foss. Brachiopoda, pt. v, pl. xxxvii, figs. 1–3).

The Lower *Dibunophyllum* zone is marked by the presence of *Cyathophyllum Murchisoni* in abundance. *Lithostrotion Martini* and its mutations are also fairly abundant. *Dibunophyllum* θ and *D.* ϕ are also present.

Productus hemisphericus and *P. Cora* are also frequent.

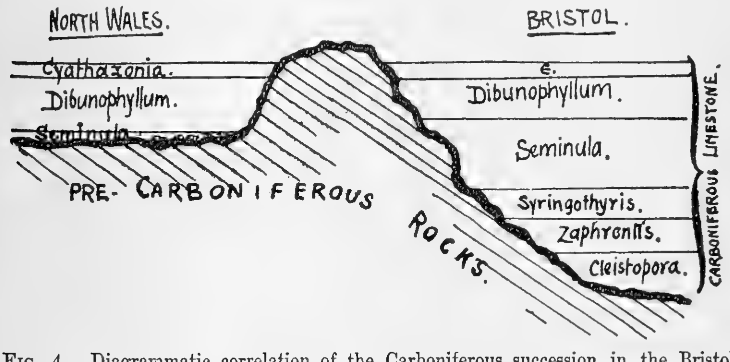

FIG. 4.—Diagrammatic correlation of the Carboniferous succession in the Bristol district and in North Wales.

The Upper *Dibunophyllum* sub-zone is characterised by all the typical fossils of the Bristol equivalent: *Lonsdaleia floriformis, L. rugosa, Cyathophyllum* cf. *regium, C. Murchisoni, Lithostrotion Martini, L. irregulare, L. junceum, L. Portlocki, L. ensifer, Alveolites septosa, Dibunophyllum turbinatum,* and *Phillipsastræa radiata.* The fauna is, however, much richer in genera, species, and individuals than that which is present in the Upper *Dibunophyllum* zone of the Bristol area. *Spirifer* and its allies are abundant: *S. trigonalis, S. bisulcatus, S. planicostata, S. striata, Reticularia lineata, Martinia glabra, Athyris planosulcata, A. expansa, Seminula ambigua, Dielasma hastata,* and various forms of *Pugnax* and *Camarotœchia.*

Schizophora resupinata is very abundant and of large size, but *Syringothyris cuspidata* is decidedly rare.

It is in this sub-zone that the well-known rich Carboniferous fauna of Derbyshire, North Staffordshire, and Yorkshire occurs, and it is an important question as to what conditions determined the paucity of species and genera at the same horizon in the Bristol area.

The presence of *Lonsdaleia*, *Cyathophyllum*, and the smaller species of *Lithostrotion* indicate the line which separates the Upper and Lower *Dibunophyllum* sub-zones in North Wales.

The upper part of the latter zone is characterised by important corals which mark off a definite sub-zone, the importance of which is great because these corals occur at the same horizon in other areas in the Midlands.

These corals are *Cyathaxonia* and a new form which Dr. Vaughan has described as *Amplexi-zaphrentis* (Quart. Journ. Geol. Soc., vol. lxii, p. 215). The history of the latter is of interest, as it was on his determination of these specimens, which I knew came from beds at the very top of the Carboniferous Limestone, to be *Zaphrentis Phillipsi* that we doubted the value of the latter as a zone fossil.

Externally this coral cannot be distinguished from a small *Zaphrentis*, but sections demonstrate structural differences, the septa in full-grown forms not reaching the centre and being attached to the wall by broad bases. They possess tabulæ with a fossula-like depression. Dr. A. Vaughan has published figures of these corals, op. supra cit.

Both *Cyathaxonia* and *Amplexi-zaphrentis* are abundant in the upper beds of the Carboniferous Limestone and in the calcareous shales at the base of the Pendleside Series with *Prolecanites compressus*, at Bradbourne, Derbyshire, near Warslow and Wetton, Staffordshire, in the banks of the Hodder near Stonyhurst, and also at Whitewell, and immediately below the *Posidonomya Becheri* beds in a little stream south-east of Hill Skelterton, near Cracoe. I have also found them at the same horizon at Rainhall Quarry, Barnoldswick, and at the quarry half a mile south of Switchers and one and a half miles W.S.W. of Hellifield.

The range of *Cyathaxonia* and *Amplexi-zaphrentis* denotes the passage beds between the Carboniferous Limestone Series and the Pendleside Series. At Lady McLaren's Quarry, Prestatyn, they lived on until *Pterinopecten papyraceus* appeared.

In North Wales this passage series is complicated by the local presence of the chert beds. The chert beds themselves contain but few recognisable fossils beyond abundance of sponge spicules (*vide ante*, p. 393), and they are immediately succeeded by the black shale and limestones which represent the Pendleside Series in North Wales. We should expect a careful examination of these cherts to yield Radiolarians similar to those which occur in the Culm Series of North Devon, which are probably of the same age.

Just as the oncoming of the deposit of the thick mass of Carboniferous Limestone was gradual and gave rise to local differences in the deposit, so the commencement of the deposition of the thick shale series, the substitution of a detrital for a purely organic deposit, produced divergences which have made correlation somewhat obscure. One fact, however, seems to become more and more firmly established, that is to say, the cherty deposits of North Yorkshire at the top of the Yoredale Series, the cherts of the Sykes in the Trough of Bolland, North Staffordshire, Derbyshire, the rotten-stones of Glamorgan, and the cherts of Codden Hill, Devonshire, appear from palæontological evidence to be homotaxial and contemporaneous. These cherts succeed beds with a Viséan, or, to be more precise, an Upper *Dibunophyllum* fauna, and in every case except that of North Yorkshire (near Leyburn) are succeeded by the *Posidonomya Becheri* beds of the Pendleside Series. In North Yorkshire it is known that *P. Becheri* beds are absent, this deposit never having been found hitherto in such high latitudes. We do not propose to discuss here the origin of the North Wales cherts. It is sufficient for our purpose to say that the cherts themselves are finely and regularly stratified, that the quantity of chert varies from a high percentage to a small one, that the limestones below the chert are largely impregnated with this mineral, and probably the chert is a replacement mineral.

At the inlier of Carboniferous Limestone at the Sykes in the Trough of Bolland massive cherts, most closely resembling those of North Wales, lie on the top of the upper beds of the Carboniferous Limestone, and are succeeded by black shales of the Pendleside Series. We are not aware that a cherty deposit occurs to that extent anywhere else in that district, but chert is present on the top of the inlier at Withgill. At Pendle Hill the Pendleside Limestone contains numerous strings and nodules of chert. These are of course higher up in the series. At the Sykes the beds are remarkably unfossiliferous, but we obtained sufficient evidence to demonstrate that the limestones belong to the Upper *Dibunophyllum* zones.

In North Derbyshire remains of a large deposit of chert are to be seen near Pindale, east of Castleton, but on the western flank of the Staffordshire–Derbyshire inlier chert is very irregular in its occurrence. It is, however, present at Mixon below beds with *Posidonomya Becheri*, and in beds, as strings and nodules, containing *Cyathaxonia* and *Amplexi-zaphrentis* at Warslow, and as a cherty limestone on the eastern flank of Thorpe Cloud. On the eastern flank of the Pennines massive chert occurs at Bakewell at the top of the Carboniferous Limestone and above the *Cyathaxonia* beds, in which the black marble of Ashford occurs, this Black Limestone probably being on the same horizon as the 'Aberdo' Black Limestone of North Wales.

In South Wales the Black Limestones of Oystermouth Castle contain *Amplexi-zaphrentis*, and are the representatives of the *Cyathaxonia* zone in South Wales. These beds are in turn succeeded by the rotten-stone beds of Bishopton, evidently decomposed cherts, the equivalents of the Flintshire cherts.

At Bishopton the rotten-stones are succeeded by a black shale series which has a limited but definite Pendleside fauna, *Posidoniella lævis* and *Glyphioceras bilingue*.

[It is necessary to inquire as to what beds, if any, are the representatives of the cherts in those parts of North Wales where they do not occur. The question is one that can only be solved by palæontology. Wherever the cherts are present in North Wales in sequence we find that they rest on limestones with the *Cyathaxonia* fauna, that is, the uppermost part of the *Dibunophyllum* zone. There are three sections in North Wales which show this sequence; the most easterly is in the road from Brynford to Holywell, where cherts are seen to rest on whitish limestones of the *Cyathaxonia* beds, to be succeeded by black shales and limestones of the Pendleside Series with a typical fauna. Here the cherts are probably not more than 30 to 40 feet thick. Further west, about one mile north-west of Holywell, is the section at the Grange Quarry, Holloway. Here there is the following succession (*vide ante*, pp. 394–395):—

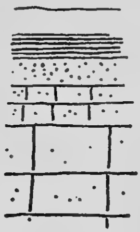

Fig. 5.—Grange Quarry, Holloway. See also Fig. 1 (xvii).

That is to say, shales with a Pendleside fauna appear between two chert series.

The quarry at Trelogan, four miles further north-west, shows the same sequence. At Pentre, near Gronant, and Talacre the chert beds are very thick, much more evenly bedded than the beds further south-east, and it is not apparent on what beds they rest, but we collected in the cherts *Productus longispinus*, *P. punctatus*, and a spinose form. At these places the cherts are succeeded by black calcareous shales with a Pendleside fauna. At Waenbrodlas the cherts succeed the *Cyathaxonia* beds, and there is no black shale series intercalated in them. In the upper decomposed cherts we collected the fauna, p. 396 (xix), which has a distinctly Upper Carboniferous Limestone character, rather than a Pendleside facies. The fish are certainly Lower Carboniferous forms. South of Waenbrodlas, about ten miles, is a chert quarry at Pant-y-Terwyn, resting on the calcareous pebbly grit of Graianryd, which we think represents the *Cyathaxonia* beds.

So far, then, whenever the chert beds occur they rest on the *Cyathaxonia* beds of the limestone, and the fauna, sparse though it be, has a Carboniferous Limestone facies; but when we examine the sequence in the neighbourhood of Prestatyn, Gwaenysgor, and Teilia we find that its lithological character is completely changed.

Resting apparently conformably on the *Cyathaxonia* beds are some 70 feet of dark limestones of peculiar character, different in numerous details (*vide ante*, p. 451) from the dark limestones of Aberdo character, which it must be remembered also contain a *Cyathaxonia* fauna. The limestones are seen at Teilia, Gwaenysgor, and the hill above Prestatyn. The fauna and flora of these limestones at once fixes their horizon to be the base of the Pendleside Series, and we find the limestones occupying the same relation to the *Cyathaxonia* beds that we do in various localities in North Staffordshire, Derbyshire, and Yorkshire, i.e. limestones and shales with *Posidonomya Becheri* and *Pterinopecten papyraceus* succeed beds with *Cyathaxonia* fauna. Here, then, the cherts do not succeed the *Cyathaxonia* limestones. Apparently there is no unconformity. The sections at Teilia, the hill above Prestatyn, and Lady McLaren's Quarry opposite Nant Hall seem to point to the sequence being perfectly normal. It must be admitted that the *Posidonomya Becheri* limestones near Prestatyn are far less carbonaceous than beds with a similar fauna which succeed the cherts further east, and that *P. Becheri* itself is much rarer near Holywell than it is at Prestatyn.

Three solutions, neither of which are absolutely satisfactory, offer themselves to this question. One that the cherts near Holywell are the homotaxial equivalents of the *P. Becheri* limestones. Another, that the cherts have been cut out by an unconformity or some result of earth movements.

In favour of the first view: The cherts and *P. Becheri* beds rest everywhere, apparently conformably, on the *Cyathaxonia* beds of the Upper *Dibunophyllum* zone. Where cherts are present the Pendleside Series is characterised by black shaly limestones, which always succeed them. That the limestones and chert beds are both thin-bedded and the beds very finely stratified. That plant-remains have been obtained from the base of the cherts.

On the other hand, the typical Pendleside fauna has not been obtained from the cherts, but the fauna they do contain indicates a somewhat lower horizon.

If the north flank of the hill be followed from Prestatyn eastwards to Lady McLaren's Quarry the section given on p. 451 is seen. These beds rest on *Cyathaxonia* limestones, which are exposed a few yards further west. Continuing eastward along the hill, the outcrop of the *Posidonomya Becheri* limestones is seen as far as Top Nant Farm. East of this farm is a shallow pit, from which similar limestones were obtained. Some 200 yards south of this pit is another shallow excavation which shows chert débris, and in such condition and quantity as to indicate the broken up bed of chert. No junction is seen, but it would seem that a bed of chert may here overlie *P. Becheri* limestones. The general dip of the beds is north-east, and this outcrop of chert is about 470 feet above O.D. The next most easterly exposure of chert is a quarter of a mile away in a dingle west of the road over the hill to Teilia and Gwaenysgor. This is in the 200 feet contour, and the beds are dipping very highly and evidently near a fault.

For the present, then, the precise reason for the absence of the cherts immediately in succession of the *Cyathaxonia* beds is not apparent, and it is possible that they are the homotaxial equivalents of the *Posidonomya Becheri* limestones.

The difficulty of correlation has been enhanced by the unfortunate assumption that Black Limestones were all on the same horizon. There are no less than three series of Black Limestones each with a definite fauna: the Black Limestones of the Holywell shales and

Teilia Beds with *P. Becheri*, the Black Limestones (Aberdo) of Holloway and Trelogan with *Cyathaxonia*, and the Black Limestones of Prestatyn with *Zaphrentis* aff. *Enniskilleni*. Probably the latter two are nearly on the same horizon, and both must be included in the Upper *Dibunophyllum* zone. This Zaphrentoid coral has occurred in the same zone at Bradbourne, Derbyshire, and Rush, co. Dublin. There is no doubt that the cherts overlie the lower set of Black Limestones, but it is their relation to the *Posidonomya Becheri* limestones which has been questioned. The idea that the cherts are the homotaxial equivalents of the Millstone Grit is obviously untenable on palæontological grounds, the more so if *P. Becheri* beds occur above them.

The third solution of the question is that the chert beds occur at different horizons in the series at different localities, that they are higher at Pentre and near Gronant than they are near Holywell, Trelogan, and Waenbrodlas. We know that cherts occur at many horizons in the Upper *Dibunophyllum* beds of Derbyshire, both in and below the *Cyathaxonia* zone. It is of the utmost importance that the junction of the *Cyathaxonia* beds and the *Posidonomya* beds should be recognised and mapped, because the junction is the division between the Upper and Lower Carboniferous Series in the Midlands. At this point the great faunal change takes place, at this point the new fauna comes in, and moreover the faunal change corresponds with well-marked change in lithological characters, provided that the mere colour (black) is not allowed to cause confusion of limestones on two distinct horizons.]

6. The Pendleside Series.

In the neighbourhood of Prestatyn and Holywell the Pendleside Series is well represented, typical fossils, flora and fauna, being common. Immediately above the cherts are peculiar black limestones of definite character (*vide ante*, pp. 450, 454), which are exactly similar to those found in the lower part of the Pendleside Series anywhere in the Pennine area.

We have not yet found the lowest zonal fossil of this series, *Prolecanites compressus*, in North Wales, except possibly at Teilia. *Posidonomya membranacea*, *P. Becheri*, and *Pterinopecten papyraceus* are abundant in many localities. The first two species may be considered as absolutely characteristic of this horizon, having never yet been found in higher beds.

At Teilia Quarry the following plants have been obtained, and Mr. Kidston gives the following list, op. supra cit. A fine collection is in the Grosvenor Museum, Chester, and we owe our thanks to Mr. A. Newstead, the Curator, for an examination of the specimens.

Adiantites antiquus.
Sphenopteris Teiliana.
**S. subgeniculata*.
S. striata.
**S. pachyrachis*.
* ,, var. *stenophylla*.
? *S. Schlebani*.
S. affinis.
Rhacopteris glabellata.
R. inequilatera.
? *Archeopteris* sp.
**Asterocalamites scrobiculatus*.
Lepidophloios sp.

Those species marked by an * have been obtained from beds containing the same fauna at Poolvash, Isle of Man, Pendle Hill, and North Staffordshire.

The number of specimens found in various localities is remarkable when the marine character of the deposit is considered. The presence of drifted plants at any place must be purely due to currents and the proximity of land.

There can be no doubt, then, that the palæontological evidence definitely correlates the Teilia Beds with the lower part of the Pendleside Series of the Midlands and the *Posidonomya Becheri* beds of the Culm. Between Holywell and Bagillt the shaley division of the series is well developed and reaches a normal thickness. The beds are difficult to examine in detail, but we know that the peculiar mutation of *Productus Cora* which characterises beds of this horizon elsewhere is present in abundance (*vide ante*, p. 454).

From Holywell south the black shale series are only occasionally exposed, as they occupy the flat country east of the limestone escarpment.

In the ravine of Nant Figillt Wood, shales with *Lingula* and obscure fish-remains appear to succeed limestones containing *Amplexi-zaphrentis* and *Cyathaxonia*, and the brick-pits near Hendre gave a dark earthy limestone crowded with *Posidoniella lævis*, *Glyphioceras reticulatum*, and *Dimorphoceras Gilbertsoni*, so that here we get evidence of a zone of the Pendleside Series much higher in the succession than the *Posidonomya Becheri* beds, which corresponds to the black fossiliferous limestones of Horsebridge Clough, High Green Wood, near Hebden Bridge. South of Hendre exposures of the shale series are very few. The Survey mentions the occurrence of *Posidonomya* and *Goniatites* in shale with cement stones in the River Terrig, some miles further south. It is to be regretted that the species were not determined.

All through the Midlands and North Wales the southern limit of the Pendleside Series is marked by a very rapid thinning-out, and it is rather singular that this practically coincides with a latitude of 53° N. The following table illustrates the remarkable variation of thickness in these beds that takes place within about ten minutes of latitude :—

Locality.	Latitude N.	Thickness, feet.
Holywell, Co. Flint	53° 16′ 20″	1000
Near Buxton, Co. Derby	53° 16′ 0″	(about) 1000
Morridge, Co. Stafford	53° 7′ 0″	1000
Llangollen, Co. Denbigh	52° 58′ 0″	18–50
Lilleshall, Co. Salop	52° 44′ 40″	absent
Ticknall and Grace Dieu, Co. Leicester ...	52° 48′ 0″	30 to 40

It is interesting, therefore, to note in this particular also the intimate relation of the North Wales development of the Pendleside Series with the larger Pennine area.

7. Notes on the Palæontology.

Daviesiella (*Productus*) *Llangollensis*, Davidson, sp. Waagen (Mem. Geol. Surv. India: Palæontologica Indica, ser. XIII, vol. i, No. iv, p. 613) says: "I create this genus for the reception of such forms as *Productus Llangollensis* and *Chonetes comoides*, Sow., which are characterised by cardinal teeth and a second pair of adductor impressions in the ventral valve. The other characters are like those of *Productus*."

He has omitted two very important characters which are present in the former species. These are a well-marked area and a hollow beneath the beak of the brachial valve, two characters which in addition separate the species from *Productus*. The extraordinary thickness of the brachial valve of this species is very remarkable, reaching in some cases to one inch.

Productus giganteus. A good deal of detailed work requires to be done on the shells which come under this group name. It is questionable whether all really, *sensu stricto*, can come into the genus *Productus*. In some specimens there is a distinct area and other characters which point rather to an affinity with *Chonetes*. We have mentioned in the text that the group which we temporarily allude to as *P. giganteus* lived together, and that the variant forms or mutations have no value as an index of time.

Productus antiquatus. A very elegant reticulate form belonging to this genus is not uncommon throughout the *Dibunophyllum* zone of North Wales. We know it from the Midlands at the same horizon. It is distinct enough to deserve a specific name, which will doubtless be given to it when the genus is revised.

Productus Cora. We have retained this name for the present, on the statement of de Koninck that D'Orbigny's type from Bolivia was identical with the Belgian species, although neither the original description nor figure is good.

The careful search for fossils in the North Welsh Carboniferous rocks has yielded no new forms, but certain details of the fauna are worth recording.

In the limestone the number of species of each group of organisms, except the corals, is much less than are present at the same horizons in the Derbyshire and Staffordshire inlier of Carboniferous Limestone. Of the Mollusca the Cephalopoda are only represented by about half a dozen species, and individuals are extremely rare. Both Gasteropods and Lamellibranchs are comparatively as rare as the Cephalopods. Morton quotes about 30 of each family. The Brachiopoda, as might be expected, are more common, and are represented by about 50 species. In this group individuals are frequent, but not so common as in the Midlands.

The only species which occurs in North Wales and has not yet been found in North Staffordshire or Derbyshire is *Allorisma maxima*, Portl., sp., the *Sanguinolites clava* of Morton's list. In the paucity of species and individuals North Wales agrees with the Bristol–Mendip area. Conditions, therefore, must have been very similar.

P. membranacea has a very limited vertical, but a wide horizontal, range. It is always found in black shale or dark limestone immediately succeeding beds with a Viséan fauna. It has been found in this position from the west coast of County Clare to Clavier in Belgium, and it must therefore be regarded as a definite zonal index of the lower part of the Pendleside Series.

8. Summary.

In conclusion, the main results of our researches in the Lower Carboniferous rocks of North Wales may be epitomised as follows:—

1. The classification of these rocks here given is absolutely based on palæontological data: it has been shown that all the errors in previous work can be traced to the subordination of palæontology to the lithological features of the strata.

2. The sequence exhibited in the area under examination is perfectly normal to that obtaining in other areas of the North Midlands, which afforded the key to the simple explanation of the succession in this district. For the purposes of correlation the perfection of the geological record has exceeded our most sanguine expectations.

3. The Holywell shales have been proved to be the equivalents, lithologically and palæontologically, of the Pendleside Series.

4. The lower series of the Carboniferous Limestone as developed in the Bristol area was never deposited in these parts, whose lowest beds are characteristic of a comparatively late phase of the Carboniferous Limestone period. Whether this was altogether due to irregular configuration of the ocean floor of that age, or to contemporaneous earth-movement of a specially regional character, it is much too soon as yet to argue with assurance.

Our thanks are largely due to Dr. A. Vaughan, who has kindly looked over a large number of Corals and Brachiopods and compared them with the forms occurring in the upper portion of the Bristol Carboniferous area. We also have to thank Dr. A. Smith Woodward and Mr. R. Kidston for the determination of some fossil fish- and plant-remains.

IV.—The Zones of the Lower Chalk.

By A. J. Jukes-Browne, B.A., F.G.S.

In the September number of this Magazine Mr. T. O. Bosworth raises some questions with regard to the zoning of the Lower Chalk in general, and of Cambridgeshire in particular. As I am responsible for the subdivision of the Lower Chalk of this country into zones I suppose the matter concerns me more than anyone else.

The two main questions raised by Mr. Bosworth are (1) the zonal position of the Totternhoe Stone, (2) the propriety of using *Holaster subglobosus* as an index for the higher zone. He may be sure that both these points were fully considered by me when compiling the account of the Lower Chalk for the Geological Survey Memoir on Cretaceous Rocks, and he is probably aware that the second point was discussed in the second volume of that Memoir (chapter ii, p. 17).

With respect to the Totternhoe Stone, Mr. Bosworth should explain why he uses the term "Burwell Rock"; this name may be current at Cambridge, but it cannot supplant the older name of Totternhoe Stone, and his own diagrams show that he accepts the identity of the stone beds at Totternhoe and Burwell.

Next as regards the zonal position of the Totternhoe Stone. The reasons for placing it in the higher rather than in the lower zone were stronger than he imagines them to have been. If he had referred to my first paper on "The Subdivisions of the Chalk"[1] he would have found that under the head of Totternhoe Stone a special point was made of the occurrence of a nodule bed at its base, and attention was drawn to certain fossils as characteristic of the stone. The reasons which weighed with me when compiling the General Memoir were the following:—

1. The frequent signs of current erosion at or near its base, and the change of physical conditions thus indicated.

2. The presence of certain fossils which are generally characteristic of higher beds and are rarely or never present in the Chalk Marl of those counties in which the Totternhoe Stone is typically developed. The chief of these are *Acanthoceras rotomagensis*, *A. cenomanensis*, *Haploceras Austeni*, *Actinocamax lanceolatus*, *Pecten Beaveri*, *P. elongatus*, *P. fissicosta*, *Lima echinata*, *Enoploclytia Imagei*, and more rarely *Holaster subglobosus*.

3. The fact that the stone passes upward into the overlying chalk without any sign of physical change.

Mr Bosworth has a curious method of estimating the affinities of a fauna, for he does not deal with the actual fauna of the Totternhoe Stone, but takes the fossil assemblages in the beds below and above it, and calculates how many species of each occur also in the intermediate band. This is certainly not the usual way, and can only be interesting as throwing a kind of sidelight on the subject, and this only when the comparison is fairly made. With this object Reptilia should be excluded, seeing that none occur either in the Chalk Marl or in the Totternhoe Stone of Cambridgeshire.

When only the same classes of animals are allowed to enter into the comparison the results are different from those given by Mr. Bosworth. The proportion of Chalk Marl species which range up is the same, namely 92 per cent., but the proportion of the species ranging down from the higher beds into the Totternhoe Stone is 33 out of 42, i.e., 78 per cent. instead of only 67.

If, however, the usual and more rational method is employed, and a larger area is included by taking in the lists from the counties of Bedford and Hertford, where the Totternhoe Stone is typically developed, we shall certainly get a more reliable estimate of the relations of the fauna of that stone to those of the beds above and below. Excluding reptiles but including fish the fauna of the Totternhoe Stone (as recorded in the General Memoir) comprises 96 species; of these only 23 range downward into the Chalk Marl of the counties mentioned, while no fewer than 45 range up into the overlying beds[2]; in other words, twice as many range upward as downward, and the natural conclusion is that the fauna of the

[1] Geol. Mag., Dec. II, Vol. VII (1880), p. 251.

[2] This number includes those recorded by Mr. Bosworth, but omits three Cephalopoda which have only been found at Orwell in a quarry which may or may not be above the Totternhoe Stone.

Totternhoe Stone has much more affinity with the beds above than with the beds below.

I record this result as an answer to Mr. Bosworth's peculiar mode of dealing with the matter, but I do not wish to lay much stress on the argument, for I regard mere percentages as deceptive and unsatisfactory tests, unless the abundance of characteristic species is taken into account. I am quite disposed to give due weight to the fact that *Schlœnbachia varians, Scaphites æqualis,* and several species of *Turrilites,* which are important members of the southern Chalk Marl fauna, occur also in the Totternhoe Stone. Indeed, I regard this stone as a band of rock developed at the junction of the two zones at a time when some species were dying out and when others were coming in, so that it might with equally good reason be placed in either zone.

I have stated the reasons which originally induced me to regard it as the base of the higher zone, and I do not see that any clearer idea of its real position as a passage bed would be gained by transferring it to the zone of *Ammonites varians.* My own feeling is that the matter had best be left where it stands until a larger body of evidence has been obtained.

I have next to deal with Mr. Bosworth's statements regarding the recorded occurrences of *Holaster subglobosus* and *H. trecensis,* some of which are certainly incorrect, while others require confirmation.

He states that *H. subglobosus* is nearly as common in the zone of *A. varians* as in the beds above throughout Hampshire, Wiltshire, Isle of Wight, Sussex, and Kent! So far as I know this is only true of the Isle of Wight, and the rest of the statement absolutely contradicts that made by me in the General Memoir above mentioned (vol. ii, p. 17). It is true that Mantell recorded *H. subglobosus* from Middleham, Maddock found it in the Chalk Marl of Eastbourne, and Etheridge in that of Folkestone, but so far as I know these records have not been confirmed by later collectors. On the other hand, this urchin is a common fossil in the central part of the Lower Chalk throughout Kent and Surrey, as well as at Lewes and Eastbourne in Sussex. If Mr. Bosworth has any special information about the distribution of this fossil in the counties mentioned he should publish it.

Again, I am obliged to contradict his statement that *H. subglobosus* is a rare fossil above the Totternhoe Stone in Lincolnshire and Yorkshire. Such an idea can only be due to careless reading of the records and descriptions given by Mr. W. Hill and myself. In the General Memoir (vol. ii, p. 20) I wrote: "*Holaster subglobosus* is not uncommon in these beds both in Yorkshire and Lincolnshire, but it is equally common in the zone of *Am. varians,* so that it will be more convenient to take *Offaster sphæricus* as the index of the zone in these counties."

With respect to *H. trecensis* I shall be glad to know on what authority Mr. Bosworth asserts that in Dorset and Devon this species "is plentiful in the beds above the *A. varians* zone, . . . is almost confined to the zone and could well be used as the zone fossil." So far as my experience goes it is not plentiful in either zone, but is occasionally to be found in Dorset near the base of the *A. varians* zone and near the top of the *H. subglobosus* zone. As regards Devon I am at a loss to know what he means!

Mr. Bosworth also states that *H. trecensis* "is common throughout the [upper] zone in Hants, Sussex, Kent, and the Isle of Wight." He writes as if this was a well-known fact or could easily be gathered from a perusal of the Survey Memoirs, whereas I do not think that any such statement has been made either in these memoirs or in any other publication, except with regard to the Isle of Wight. In Sussex it would seem to be a scarce fossil, for I was not able to record the occurrence of a single specimen from the zone of *H. subglobosus.*

The only satisfactory and useful part of Mr. Bosworth's article is the record of his own observations near Cambridge. I have no reason to doubt the accuracy of these, and am quite ready to accept his statement that *H. trecensis* is more abundant than would appear from the lists in the Memoirs of the Geological Survey, and also that it occurs chiefly in the upper half of the zone, while *H. subglobosus* occurs more abundantly (if not exclusively) in the lower half.

I believe that the same distribution of these two species prevails in Hertfordshire, Bedfordshire, and Buckinghamshire, as well as in Hampshire, Surrey, and Kent. This is a point which is well worth further investigation, and if their relative abundance proved to be the same as in Cambridgeshire, it might lead to the establishment of the two subzones which are suggested by Mr. Bosworth.

I do not think, however, that his proposal to substitute the term "Lower Holaster zone" for the zone of *H. subglobosus* will meet with acceptance. There are several obvious objections to it which it is hardly necessary to specify, and, in fact, he does not seem satisfied with it himself, for in the table with which his article concludes it is replaced by the designation of "Two Holasters zone." He might at least have made up his mind to use one or the other and not both.

I am quite prepared to admit that *H. subglobosus* is not a satisfactory index to the zone, but the real question is, can a more satisfactory one be found?

This question was briefly discussed in the introductory chapter to the second volume of the Memoir on Cretaceous Rocks, and I wrote that "so far as we know at present there is no species which is restricted to the upper part of the Lower Chalk, and is at the same time common enough in every district to be a useful index." When preparing that memoir I hoped that *Haploceras Austeni* would prove to be such a fossil, for though it is not very common it would have served well enough if its range had been limited to the zone. Unfortunately, however, near Lewes, in Sussex, it occurs in the zone of *A. varians* and has not so far been recorded from the higher zone in that county.

Sharpe, in describing his *Ammonites Austeni,* states that it is common in the Guildford district of Surrey, but no one has yet ascertained in which zone it there occurs. It is fairly common in the zone of *H. subglobosus* of Wiltshire and Berkshire, but has not yet been reported from Hampshire, Kent, Isle of Wight, Dorset, Oxfordshire, Buckinghamshire, or Hertfordshire.

With regard to *Acanthoceras rotomagensis* it cannot be regarded as a better guide than *H. subglobosus,* for in many of the southern counties it is fairly common in the zone of *A. varians.* North of the Thames, however, it seems to be restricted to the higher zone until we reach Norfolk, where it again occurs in the zone of *A. varians,* as it does also in Yorkshire.

There remains only the larger form of *Discoidea cylindrica,* a species which is generally much more common in the upper part of the Lower Chalk than in the lower part. In the south of England it has only been recorded from the zone of *A. varians* in Dorset and Somerset, and by Mantell from Hamsey in Sussex (not since confirmed). It is indeed a common fossil of the lower zone in Yorkshire, Lincolnshire, and Norfolk, but the form there found is the depressed variety, and if any constant structural differences can be found to distinguish this variety from that which prevails in the higher zone the latter might perhaps be utilised as an index for that zone.

To sum up, therefore, it would seem that our knowledge of the distribution of the fossils of the Lower Chalk is not yet sufficiently complete to enable us to decide on any substitute for *H. subglobosus* as an index. It may be that *Haploceras Austeni* would be a better one in spite of its occasional occurrence lower down, or it may be that the taller hemispheric variety of *Discoidea cylindrica* will be preferable. More information is required about both, and meantime I am sure that it would be undesirable to make any alteration in the current nomenclature, and I do not think that the terminology proposed by Mr. Bosworth would at any time be an improvement.

V.—The Source of the Waters of Geysers.

By J. Malcolm Maclaren, B.Sc., F.G.S.,
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PROFESSOR SUESS has somewhat recently stated his belief that the waters of all geysers and boiling 'pulsating' springs and of some mineral springs are of 'hypogene' or direct magmatic origin (Abstract Geog. Journ., vol. xx, p. 518). I am unfortunately unable in this backwater of science to verify the abstract by reference to the original (Gesell. Deutsch. Naturforscher und Aertze, 1902). With his belief, however, several prominent Continental and American geologists have expressed their concurrence, and some have indeed amplified the hypothesis to cover the origin of metalliferous deposits near igneous contacts. For example, W. H. Weed (Trans. Amer. Inst. M.E., vol. xxxiii, p. 746) says:—

"I hold that the metallic contents of such veins are not gathered by ordinary meteoric water, as maintained by Van Hise. The water content of the sedimentary rocks (ground-water) present at the time of eruption was expelled by contact-metamorphism. The ore-forming solutions were in part of direct igneous origin (i.e. primitive or igneogenous; the geyser waters of Iceland, New Zealand, and the Yellowstone regions are probably mainly of this character, as maintained by Suess); these primitive hot vapors and waters rise and penetrate the zone of circulating meteoric waters, heating the latter and charging them with both metallic salts and with fluorine, chlorine, bromine, and other mineralizing agents."

Recent geyser phenomena in New Zealand have led me to doubt more than ever the validity of this inference of Suess. New Zealand contains one of the most active of fumarolic areas, and, curiously enough, the life-history of its greatest geyser—the greatest also that the world has yet known—is strikingly illuminative of the subject under discussion. For confirmatory details of the history of this geyser I am indebted to the courtesy of Mr. Colin Fraser, of the New Zealand Geological Survey. Waimangu Geyser was discovered in January, 1900, but it had doubtless been in existence for a short time prior to that date. Its basin was then some 130 feet long and 80 feet wide, at ordinary times full of black muddy water. Although it played almost daily, its eruptions were most irregular in character, sometimes expending their energy in a single outburst, hurling a mass of water estimated at 800 tons to a maximum height of 1,500 feet, at other times playing lightly and intermittently for five to six hours. The intervals between eruptions were rarely more than 30 hours. For more than four years after its discovery Waimangu was in active eruption, but during July and August, 1904, it remained quiescent for nearly two months. After this period of inactivity it recommenced its eruptions with unabated and indeed often increased energy, and so continued until 31st October, 1904, when, with the exception of a feeble eruption on the following day, it ceased spouting, and now remains dormant or is extinct—a flowing pool with a temperature of 130° F.

The modern history of Tarawera Lake, four miles to the north-east of Waimangu, is important in this connection. The explosive eruption of Tarawera Mountain in June, 1886, threw a great ash barrier across the valley which formed the natural outlet for the waters of Lake Tarawera. (For a graphic description of this Tarawera rift area, *vide* Geog. Journ., April, 1906.) The level of the lake at once rose some 28 feet, and after some time, as the outlets through the ash barrier became choked with débris, continued to rise still further. By the end of October, 1904, the waters had risen another 14 feet. At that height and on the 1st November, *the day on which Waimangu last played,* the waters overtopped the barrier. On the following day the level of the lake had fallen three feet, and on the 3rd November the barrier was carried away. The waters of the lake rushed over the Tetauahape escarpment and escaped by an old channel at the rate of more than a million and a half cubic feet per minute, forming, for the few days they lasted, a stupendous cataract. The level of the lake is now eleven feet below the maximum height of 1904, and its waters now escape by the normal subterranean channels, which from Maori legends are known to have been in existence for centuries.

In Waimangu Geyser itself there has been no recrudescence since the breaking away of Lake Tarawera, and in the immediate vicinity there has been one outburst only. This took place on 21st February, 1906, at Frying Pan Flat, but lasted only a few hours. Frying Pan Flat is, however, an old geyser crater that had been in eruption during the period of Waimangu activity. Thermal relief along the Tarawera rift is now effected by comparatively mild eruptions, the character of which would seem to indicate expulsion from slowly filling subterranean reservoirs.

Other large geysers in the New Zealand area show or have shown a degree of dependence on superficial waters. Dr. Wohlmann, Government Balneologist, instances the case of the Crow's Nest Geyser at Taupo, on the banks of the Waikato River, near its emergence from Lake Taupo. When the Waikato River is in flood the Crow's Nest Geyser plays every 40 minutes. With low waters the interval is increased to two hours. At Orakeikorako, some fifteen miles to the north and also on the banks of the Waikato River, the great geysers last played when the Waikato River was abnormally high. Thermal manifestation at Orakeikorako has since been confined to hot springs.

Every gradation from Waimangu through boiling springs to faintly bubbling warm pools are known in the New Zealand area, and it seems impossible to make any genetic distinction between the most active and the more lethargic members of the series. Yet some of the latter are obviously dependent for their waters on surface supplies. The heat necessary to create the motive force of these geysers lies certainly at no great depth. For many years after the 1886 eruption it was possible to char wood by plunging it into a crevice in the ash beds. While, therefore, the heat supplied to the geysers may certainly be considered magmatic, it is nevertheless directly applied, and is not carried to the geyser tube by magmatic waters and vapours such as have been called into existence in the passage quoted in the first paragraph of this communication.

Nor even in this New Zealand region, the evidence from which points to the meteoric origin of geysers and hot springs, is the evidence of contemporaneous metallic deposition lacking. By the courtesy of the New Zealand Geological Survey I am enabled to publish two interesting analyses, or rather assays, made by the Colonial Analyst, of fumarolic deposits from Whakarewarewa, immediately south of Rotorua. Siliceous sinter taken from the sides of a trough used to conduct hot water from a large pool behind the Geyser Hotel gave —

	dwts.	grs.	
Gold	0	12	per ton.
Silver	15	3	,, ,,

while a sulphurous sinter formed on the edge of the spring showed :—

	ozs.	dwts.	grs.	
Gold	0	1	4	per ton.
Silver	4	0	18	,, ,,

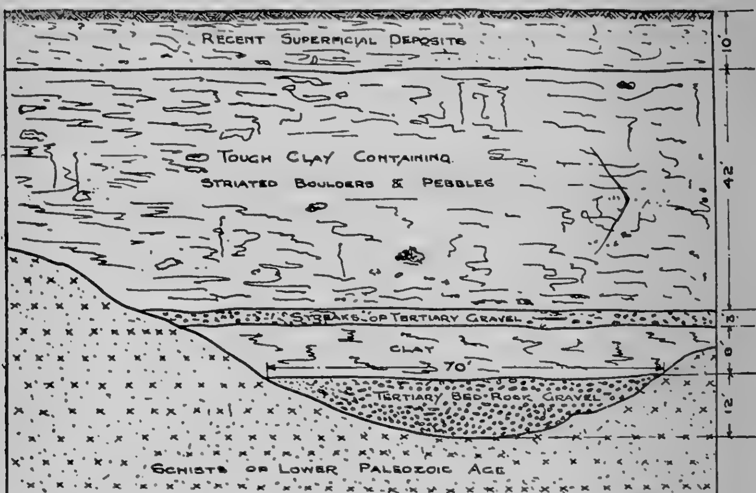
both most suggestive results.

While it is at once admitted that the foregoing facts are not in themselves sufficiently correlated to justify the assumption of a meteoric origin for all geysers and most metalliferous solutions, they may nevertheless be considered sufficiently suggestive to give pause to the most imaginative of magmatic secretionists. In view of the undoubted connection between heated waters and ore deposition, further detailed and scientific study of these fumarolic areas is greatly to be desired.

VI.—Some Further Considerations of the Genesis of the Gold Deposits of Barkerville, B.C., and the Vicinity.

By Austin J. R. Atkin, Esq.

SINCE the publication of my paper "The Genesis of the Gold Deposits of Barkerville,"[1] the frequency with which it has been suggested to me that the gold in the placers spoken of might have been precipitated *in situ* has led me to place before you the reasons for ascribing to it the origin therein stated.



SECTION OF FILLING, ANCIENT CHANNEL, LOWER WILLIAMS CREEK. CARIBOO. B. C.

In propounding the theory of precipitation to explain the occurrence of nuggets in the Australian 'leads' Professor Newberry took into account the fact that it was only at considerable distances from the source of the leads that the larger nuggets were found. He also noted that the greatest accretions of gold were where the wood found in these old channels was most abundant; that as a rule the gold contained a nucleus of iron; that it was finer in

[1] Quart. Journn. Geol. Soc., vol. lx (1904), pp. 389–393.

quality than any found in the adjacent reefs. In the deposits the source of which I have tried to indicate, the very reverse of these conditions may be said to exist.

The general characteristics of these old channels, that is the filling of the ancient creek beds, consist of—

1. Pre-Tertiary gravels in the bottom.[1]
2. Tough clay containing striated boulders and pebbles, with streaks of pre-Tertiary gravels washed from upper portions of the creek during recessions of the ice-cap.
3. Recent superficial deposits.
4. No wood has been found in the channels.

The gravels in the creek bottoms are the harder detritus from the hill-sides, the softer having been disintegrated and removed by the heavy rains of later Tertiary times.

The gold occurrence has always been in the type of a deposit sorted in rapidly moving water.

The heavier and rougher pieces at the top become smaller and more water-worn as the creek is followed down from its source, while behind some of the larger boulders a remarkable concentration of gold has taken place.

The fineness of the gold varies in different creeks; and it can always be recognised, even when mixed, as below the junction of two channels.

In some instances different parts of the same creek were distinguished by varying grades of gold, while in one case there was a noticeable increase in returns below a large quartz reef, although this reef itself is now valueless, and the richness varied along the channel. This instance should be given due prominence when considering the possibility of a detrital or accretionary origin for the gold.

All the specimens submitted are from one creek. The larger nuggets, $\frac{A}{1}$, $\frac{A}{2}$, etc., are from the upper portion, those marked *B* are from the middle, while the smaller grains in the vial *C* are from the lowest ground worked.

It will be noticed that the specimens from the head of the creek are large and not much worn, $\frac{A}{1}$ scarcely at all, while $\frac{A}{2}$, $\frac{A}{3}$ are typical specimens of quartz gold such as may be chipped from any rich outcrop at the present time.

Specimen *D* is from a boulder found in Snowshoe Creek. This rock weighed over 250 lbs., and was extraordinarily rich. It shows gold intimately associated with iron pyrites and also in the quartz alone. Had this rock experienced sufficient attrition to set free the gold we would have had nuggets like $\frac{A}{1}$, $\frac{A}{2}$, etc., while the smaller pieces might have travelled further down the creek to become similar to the inbits *B* and *C*.

Specimen *E* contains gold panned by the writer from a quartz outcrop on Lowhee Creek, which would have yielded nuggets similar to those now found in the placers had the outcrop been eroded sufficiently.

[1] See section.

These specimens, which might be largely augmented if required, are sufficient to account for the origin of most of the gold.

The occurrences, graduating from coarse to fine, typical of water-sorted deposits, the variation in the quality of the gold in different parts of the same channel, the assay value varying between about 850 and 910 as it does in the reefs, must, taken together, place the detrital origin of the greater part of the gold beyond dispute.

It may still be suggested that some of the gold is a precipitate in the drifts. Even this seems unlikely in view of the shortness of the creeks and the small size of the nuggets found.

The largest nugget ever discovered in Cariboo County did not exceed 40 ounces in weight, and that was taken from Butcher Bench on Lightning Creek, the remains of a channel in which the water ceased to flow while the creek cut down through ninety feet of rock to the bed of the deepest channel.[1] Were the gold here of accretionary origin, surely the deepest channel would have contained the largest nuggets, instead of smaller pieces so scratched and worn as to distinctly show their origin to be detritus from a higher level, worn and broken up in the bed of a mountain torrent.

If it be argued that the deposits are too recent for any but small accretions to be found, exhibit $\frac{C}{2}$ is an instance of a small particle embedded in quartz which very little attrition might have set free to mislead investigators.

The small piece on the back of *D* would have been another piece whose true origin would with difficulty have been determined. Then, again, I am informed[2] nuggets are found in the clay, though this is not quite certain. These cannot be the result of percolating water, as this clay is very compact and quite impervious to solutions. The specimens shown to me as derived from this source had a large proportion of quartz in them, and are more likely to occur in one of the streaks deposited during recessions of the ice-cap, probably as fragments from such boulders as *D* came from, which it required the violence of the torrential waters from the melting ice-cap to disintegrate to the size of pieces whose gold contents saved them from further fracture, while the same torrents swept the smaller pieces down to the receptacle of the waters of that period, as Dr. Dawson suggests a lake occupying the basin from Soda Creek to the Nacahaco, while its western boundary reached to what is now the Kluskus-Ulgacho[3] watershed.

List of specimens submitted from Barkerville, B.C., and its vicinity.

Various nuggets marked $\frac{A}{1}$ $\frac{A}{2}$ $\frac{A}{3}$ $\frac{A}{4}$ $\frac{A}{5}$ $\frac{A}{6}$ $\frac{A}{7}$ $\frac{C}{2}$.

Piece of quartz showing free gold, marked *D*.

Bottle of quartz gold from Lowhee Creek, marked *E*.

Tube of gold from Middle Williams Creek, marked *B*.

Tube of gold from Lower Williams Creek, marked *C*.

[The above specimens have been received by the Editor Geol. Mag.]

[1] "Notes on the Gold Occurrences on Lightning Creek": Geol. Mag., March, 1905.

[2] R. S. Robinson, Resident Engineer, Cariboo Goldfields, Ltd., Alluvial Mining.

[3] Two Indian villages whose positions can easily be seen on maps.

NOTICES OF MEMOIRS.[1]

I.—On Faults as a Predisposing Cause for the Existence of Pot-holes on Ingleborough. By Harold Brodrick.

INGLEBOROUGH Hill consists of a large plateau of Carboniferous Limestone about 500 feet in thickness and capped by a cone of Yoredale rocks with a summit of Millstone Grit. On this plateau there are a large number of pot-holes or vertical shafts in the limestone: there are upwards of thirty of these at present known to exist, and it is probable that there are many more still covered with the deposit of glacial drift. Within the last few years many facts have come to light which prove that many, if not all, of the deeper pot-holes owe their existence to faults. Rift Pot, a pot-hole on the south-east side of the hill, was recently explored and found to extend to a depth of over 300 feet: the first portion consists of a vertical shaft 114 feet deep, the lower portion of which consists of a chamber 130 feet long and 25 feet broad; from the south end of this the pot descends for a distance of about 200 feet with a series of platforms of jambed stones wedged between the walls of a vertical fissure, finally ending in a short passage which at the end is waterlogged. The pot-hole at the surface takes the form of a fissure 60 feet long and from one to seven feet wide. At the northern end of this fissure, within a few feet of the moor level, the east wall is slickensided, and in the main chamber at the foot of the first shaft the east wall is also slickensided, over an area 50 feet in length and at least 20 feet in height. At the surface the slickensides occur along successive master joints, while those in the main chamber occur along another master joint at a horizontal distance of about 15 feet. These slickensides are horizontal, showing that the fault was one of horizontal displacement, and as a careful examination shows that the beds of limestone on either side of the upper part of the pot correspond, it is clear that no vertical movement accompanied the faulting. The slickensides near the surface are coated with clear crystals of calcite, which when removed leave the slickensides very clearly marked.

Only one fault is marked on the maps of the Geological Survey: this is a fault which runs from near Horton to God's Bridge, in Chapel-le-Dale. Along the line of this fault are several pot-holes, all of which have their longer axes in the direction of the fault. Sulber Pot, which is about 59 feet deep, and Nick Pot, which receives an inflowing stream, and has recently been explored to a depth of about 80 feet, exhibit no direct evidences of faulting; but Mere Gill, on the other hand, does. Mere Gill consists of a fissure, about 80 yards long, which is bridged in three places by rock. As a rule this fissure is filled with water to within 30 feet of the surface; in times of normal rainfall the water escapes through a tunnel below the water-level, which leads in a southerly direction (away from the valley); it then makes two vertical descents of 80 feet each and turns northwards to emerge in the valley near God's Bridge in the direct line of the fault. On the limestone, which is usually covered

[1] Abstracts of six papers read before the British Association, Section C (Geology), York, 1906.

by the stream falling into the pot, are crystals of calcite. These are very much water-worn, but clearly indicate the existence of a fault.

Gaping Gill consists of a vertical shaft, 365 feet deep, into which the waters of Fell Beck fall. At a depth of about 190 feet is a ledge some 12 feet wide: at this point a fault is very clearly to be seen; the fault has a downthrow of six feet to the south. The shape of practically all the pot-holes is a further indication that they have been formed as the result of faults: they are all much longer than they are wide, and thin out at each end into a narrow crack. It is also a noticeable fact that they occur in groups and in such positions that it would have been impossible for a stream to form more than one out of several.

II.—Jurassic Plants from the Rocks of East Yorkshire. By A. C. Seward, M.A., F.R.S.

Historical.—The work of Young and Bird, entitled "A Geological Survey of the Yorkshire Coast," was published at Whitby in 1822. William Bean, John Williamson, and William Crawford Williamson rendered excellent service in the early days of the geological exploration of the Yorkshire coast. Several specimens collected by local naturalists were sent to Adolphe Brongniart, and described by him in his "Histoire des Végétaux Fossiles," published in 1828. The publication in 1829 of "Illustrations of the Geology of Yorkshire," by J. Phillips, placed the geology of East Yorkshire on a sound scientific basis. Numerous species of Jurassic plants from the Yorkshire coast were figured and described in the "Fossil Flora of Great Britain," by Lindley and Hutton, which appeared in parts between 1831 and 1837. Important additions have been made to the knowledge of Yorkshire Jurassic plants by W. C. Williamson, Bunbury, Leckenby, Carruthers, Nathorst, and other writers.

Geological.—The East Yorkshire rocks of Lower Oolitic age may be said to consist of three important estuarine series, separated from one another by thin bands containing marine fossils. The majority of the plants have been obtained from the Lower Estuarine Series, which includes the famous plant-bed of Gristhorpe Bay.

Botanical.—I, Equisetales: *Equisetites columnaris* is one of the commonest and most characteristic plants of the Yorkshire flora. II, Filices: the Ferns are represented by numerous species, including examples referred to the Cyatheaceæ, Osmundaceæ, Schizæaceæ, Dipteridinæ, and Matonineæ. III, Ginkgoales: the genera *Ginkgo* and *Baiera* are both represented by several forms. IV, Cycadales: *Williamsonia*, *Nilssonia*, and *Otozamites* are the most conspicuous examples of this dominant class. V, Coniferæ: the conifers are less abundant than either the Cycads or Ferns, but the Araucarieæ appear to have occupied a prominent position in the vegetation.

The author next gives an account of the composition of the Yorkshire Jurassic vegetation as compared with that of the floras of the same geological age in other parts of the world, and makes suggestions for future work.

III.—Exhibition of a Remarkable Form of Sodalite from Rajputana. By T. H. Holland, F.R.S.

NEARLY every discovery in the interesting family of nepheline syenites shows some feature of unusual interest amongst igneous rocks. The latest discovered occurrence of these rocks in India is remarkable for the presence of a form of sodalite which has the property, apparently unique amongst minerals, of rapidly changing colour in bright daylight from carmine to pale grey or colourless, and of slowly recovering its carmine colour when kept in the dark. The mineral with these peculiar properties was discovered by Mr. E. Vredenburg as a constituent of the pegmatitic veins in a nepheline syenite intruded into the Aravalli schist series of Kishengarh in Rajputana. Along the same belt the sodalite, intergrown with nepheline in the pegmatite veins, is of the common blue variety, and nothing unusual is shown by chemical analysis of either variety. The carmine colour disappears as rapidly on exposure to light in a moist atmosphere as in dry air, in the cold weather as rapidly as at higher temperatures, and under bright electric light as in daylight. The mineral has apparently no effect on a photographic plate, and is not noticeably radio-active. The reappearance of the carmine tint takes place in a few weeks in some specimens, but requires some months' concealment in the dark in others. No explanation has been offered so far to account for this remarkable phenomenon, and the specimens are now exhibited with the hope of obtaining suggestions for a systematic investigation of the mineral.

IV.—On the Origin of the Trias. By Professor T. G. Bonney, Sc.D., LL.D., F.R.S.

THE three subdivisions of the Bunter, whether east or west of the Pennine Range, apparently unite to the south of it, and thin out as they approach the southern parts of Warwickshire, Staffordshire, and Leicestershire. Their equivalents are fairly well developed in Devonshire, but apparently thin out in a similar wedge-like manner towards the north and north-east, not reaching the Bristol Channel. The upper and lower members in the northern area are sandstones, generally red, often conspicuously current-bedded, but without pebbles, the grains being frequently wind-worn. The pebble-bed reaches a thickness of 1,000 feet near Liverpool—where, however, sand dominates over pebbles—is about 300 feet thick in the northern part of Staffordshire, and rather overlaps the Lower Bunter sand. The writer describes the lithological characters of the pebbles, and discusses the reasons for and against deriving them either from a southern or south-western source, like those in the Devon area, or from any region, either exposed or buried, in their more immediate neighbourhood, maintaining a northern origin to be the more probable. The Keuper group, both sandstones and marls, extended without interruption (except for the sea) from Devonshire to Yorkshire on the one hand, and Antrim on the other.

The author considers the Bunter to be fluviatile rather than lacustrine deposits, chiefly formed by large rivers. Two of these flowed from a mountain region, of which Scotland and the extreme north of Ireland are fragments, and a third from a similar region to the south-west of Britain. Deposits comparable with the Bunter, and especially the pebble-bed, may be found on the border of the Alps, and these rivers probably traversed (at any rate, early and late in the Bunter epoch) arid lowlands, from which, if not absorbed, they may have escaped by some channel now buried under south-eastern England. The Keuper sandstones, as he shows, indicate the setting in of inland sea conditions, the Red Marls being generally regarded as deposited in a great salt lake. These, like the clays of the Jurassic system, were probably derived from the mountain ranges, which had previously supplied sand and pebbles.

In fact, the physical and climatal conditions of the Trias—and the same perhaps may also be said of the Permian—were probably to some extent comparable with those now existing in certain of the more central parts of Asia, such as Persia or Turkestan.

V.—Notes on the Speeton Ammonites. By C. G. Danford.

A RESIDENCE of several years in the neighbourhood of Speeton has enabled the author to collect many fossils from the clays and shales underlying the Chalk. With regard to the Ammonitidæ, his results confirm the general succession given by Pavlow and Lamplugh, and add some further information.

The lowest portion of the Kimmeridge Clay which the author has been able to examine in exposures on the shore contains numbers of ill-preserved ammonites of the square-backed *Hoplites* group; while the higher part contains forms of a different type, belonging to the round-backed *Perisphinctes* and allied genera.

In the lower part of the zone of *Belemnites lateralis* Ammonites are extremely rare, and the author has no fresh information to offer; but in the upper part they become plentiful. The very globose forms of *Olcostephanus* (*O. gravesiformis*, *Keyserlingi*, etc.) occur mainly in the bed D 3 of Mr. Lamplugh's classification, but are usually in bad preservation. The overlying bed, D 2, is perhaps the most interesting of the whole series; at its base both the *Olcostephani* and the *Hoplites* are very numerous, the former being often in the condition of imperfect phosphatic casts. Above this band the round-backed Ammonites entirely disappear, though *Belemnites lateralis* continues to be fairly abundant up to D 1.

It therefore appears that the southern *Hoplites* obtained full possession of the area earlier than their associated southern Belemnites of the *jaculum* type, although rare examples of these Belemnites occur in the clays below D 2.

The lower part of the zone of *Belemnites jaculum*, besides yielding many *Hoplites*, contains occasional Ammonites pertaining to the genera *Holcodiscus* and *Astieria* (of the *Olcostephani*), and also to other genera. The higher beds are occupied by *Olcostephani* of the genus *Simbirskites*, but these beds have of late years been so poorly exposed that no further information can be given regarding the distribution of these forms.

In the zone of *Belemnites brunsvicensis* Ammonites only occur at the extreme base, where there are a few examples of one of the *Simbirskites*, and in its uppermost beds, where the genus *Hoplites*, represented by *H. Deshayesi*, reappears associated with forms of the genus *Oppelia*, the whole of the intervening deposits being apparently devoid of these fossils.

In the beds with *Belemnites Ewaldi*, which may prove to be a distinct zone between the *brunsvicensis* and *minimus* zones, no Ammonites have as yet been detected, but in the *minimus* zone *H. interruptus*, Brug., has been found.

The Criocerata have been found to exist in most, if not all, the deposits from the uppermost part of the *Belemnites lateralis* zone to the top of the *Belemnites brunsvicensis* zone, and are especially numerous about the middle of the *Belemnites jaculum* zone. They are, however, difficult to determine, being both fragmentary and ill-preserved.

The paper concludes with a list of the species of *Crioceras*, including those described in "Argiles de Speeton" and those met with by the author, and determined chiefly by Dr. A. von Koenen. This short list might, doubtless, be greatly extended by anyone conversant with the forms of this group.

VI.—Notes on the Glaciation of the Usk and Wye Valleys.
By the Rev. W. Lower Carter, M.A.

During a recent holiday the author was able to study the glacial deposits of the district to the north of the South Wales Coalfield. The gravelly deposits of Old Red Sandstone material which are characteristic of the valley of the Usk between Brecon and Abergavenny (see "Geological Survey Memoir") have been traced for some distance to the north-east of Brecon and up the valley of the Usk as far as Trecastle. Here the river breaks away from the old 'through' valley, which is continuous to Llandovery and rises in the Carmarthen Fans to the south. On the top of this red drift were found large numbers of erratics of volcanic ash and breccia, which the author supposes to have been derived from Ordovician outcrops to the west or north-west of the area in question. These blocks, which run up to two tons or more in weight, are found all down the Usk Valley below Trecastle, and over the col towards Llandovery, in the Gwyddrig Valley, as far down as 'Halfway.' The author has traced them on the flanks of the Brecon Beacon as high as Newadd (886 feet) and down to Talybont, where a large one was found close to the canal tunnel (400 feet). At Llangorse they form part of a moraine which dams back the drainage to form Llangorse Lake. They are found in large numbers at Talgarth, and were traced up Cwm Pwll-y-wrach as high as the 800 foot contour. Numbers of smaller boulders were found mixed with Old Red Sandstone material in gravel deposits near Three Cocks Junction, a little stream revealing good sections in mounds of rearranged and roughly bedded drift deposits. No trace of these foreigners was found in the valley of the Wye from Builth Wells to Three Cocks, nor were any found in fine sections of Boulder-clay examined at Llandrindod Wells.

The author hopes to continue the investigation of these deposits, but believes that sufficient evidence has been collected to point to a local glacier at first in each of the valleys of the Usk and the Wye. The Usk glacier was fed from the Carmarthen and Brecon Fans, but appears to have been overridden subsequently by a stream of foreign ice from the direction of Llandovery, bringing the brecciated erratics and pressing down the valley to Llangorse, Talgarth, and Three Cocks. It is to the pressure of this foreign ice that he would attribute the overflow of the Old Red Sandstone drift by the Cray Valley, on to the Carboniferous rocks of Penwyllt, and up Dyffryn Crawnon and through the faulted gap of Nant Trefil into the Rhymney and Sirhowy valleys (as reported by the Geological Survey). Among the erratics of the Wye Valley were tough green grits, which were subsequently found quarried at Builth, but marked on the geological map as 'Greenstone.' Several interesting stream diversions, owing to accumulations of morainic material, were observed. Amongst the more important were the diversion of the Usk from a wide valley to a narrow gorge at Aberyscir by a moraine at Cradog; of the Honddu at 'The Forge,' Brecon, to the glacial gorge which runs below the Priory Church; and the reversal of the drainage of the Afon Honddu and Olchon Brook at Llanvihangel and Pandy by the morainic gravels which block the wide valley between Bryn-aro and Skirrid-fawr, down which these streams no doubt flowed in pre-Glacial times to join the Usk at Abergavenny, whereas now they have been diverted into the Monnow, and so reach the Wye at Monmouth.

Only one case of a dry valley which had been a glacier-lake overflow was noted, and that was the little gorge called Cwm Coed-y-cerig, by which the drainage of Orwyne Fawr appears to have been carried off when the lower part of its present valley was obstructed by a lobe of ice from Crickhowell, but it was not cut deeply enough to continue to take the stream when the lobe was withdrawn.

REVIEWS.

I.—Smithsonian Institution: United States National Museum.

I. The United States National Museum: an Account of the Buildings occupied by the National Collections. By Richard Rathburn, Assistant Secretary of the Smithsonian Institution.

(Report of the U.S. Nat. Mus. for 1903, No. 132, pp. 177–309, with 29 plates; 8vo, Washington, 1905.)

II. Studies of the Museums and Kindred Institutions of New York City, Albany, Buffalo, and Chicago, with Notes on some European Institutions. By A. B. Meyer, Director of the Royal Zoological, Anthropological, and Ethnographical Museum in Dresden. (Report of the U.S. Nat. Mus. for 1903, No. 133, pp. 311–608, with 40 plates; 8vo, Washington, 1905.)

1.—Professor Huxley defined a museum as "a consultative library of objects." The National Museum is much more than this, for besides being a museum wherein natural history specimens are stored, it is also a distributing agency for the instruction of the people of the whole country, not only for institutions occupied exclusively with science, but also for those in which science is taught as an accessory to other branches of study. Duplicate sets of specimens are accordingly distributed, accurately named, and given to public institutions in all parts of the country.

The history of the museum may be divided into three periods; first, from its foundation in 1846 to 1857, during which time the chief object was scientific research by means of the materials gathered; second, from 1857 to 1876 the establishment became a receptacle for scientific material which had already been studied, a portion of it being exhibited to the public and thus made subservient to education; the third period witnessed the further development of the educational purpose of the museum by providing students of all countries with the means of pursuing their researches within its walls. These three functions are indeed essential to the life and progress of every museum, and they are promoted to a remarkable extent by the National Museum at Washington.

In order to meet the growing demands of the establishment and to relieve the congested state of the storage space in the old building, it was resolved in 1903 to erect a new one fully equipped with all the most recent appliances. This building will be rectangular in shape and faced with granite on all sides. It will have a length of 550 feet, a width of 318 feet, and a height above the basement floor of 77 feet. The exhibition space will occupy the two middle stories, the others being devoted to the many necessities of a large museum. The net floor area will be about 411,374 square feet, or about 9·44 acres.

The last twelve pages of the report contain a detailed statement of the space occupied by the museum on January 1st, 1904, arranged mainly in explanation of the plan of the two principal existing buildings.

2.—This very full and interesting description of Museums and Libraries is a translation of the original memoir published in Dresden 1900–1903. The author was commissioned by the authorities of the Royal Collections to undertake the work, and he appears to have accomplished his task with great efficiency. He considered that the libraries in the United States had in general attained a higher degree of development than the museums, and that they perhaps excel those of Europe in structural details and in administrative methods, but that this is not so decidedly the case with the museums. The opinion of the late Dr. von Zittel, of Munich, is cited to the effect that the Americans had begun (1883) to make their natural history treasures accessible to the public and to specialists in a manner worthy of admiration and of imitation. Again, Alfred Russel Wallace (1887) considered that the Museum of Comparative Zoology of Harvard University (known as the Agassiz Museum) far excelled all European museums as an educational institution for the public, for students, and for the special investigator. The author was much impressed with the administrative capacity of the Americans, and considered that museum affairs on the whole stood on a higher plane than in Europe. This view refers rather to scientific than to art institutions.

A few figures will best illustrate the development of libraries and museums in the United States as compared with Germany, France, and England. There are in the United States 8,000 public libraries, containing 50,000,000 volumes. The increase in the number of museums does not keep pace with these amazing results, although it has often been recommended that a small popular museum should be attached to each public library. There are 350 public museums, of which 250 are devoted to natural history. Germany has perhaps 500 or more, 150 of which are natural history museums. France has 300 of the latter, and Great Britain 250. A remarkable feature in some of the large American museums is a section specially adapted to the comprehension of children, and this is supplied also in nearly all of the large libraries. The object is to develop the minds of children and to inspire them with a love for nature. This idea had long ago been suggested by Louis Agassiz.

This voluminous paper is admirably illustrated with pictures of many of the museums and libraries visited by the author.

A. H. F.

II.—The Species of *Botryocrinus*. By F. A. Bather. Ottawa Naturalist, vol. xx, pp. 93–104; August 15, 1906.

THIS paper contains a comparison of all previously described species, with fresh diagnoses based on the dorsal cups. The species are:—Swedish, *B. ramosissimus*, Ang., *B. cucurbitaceus* (Ang.); British, *B. ramosus*, Bather, *B. decadactylus*, Bather ex Salter MS., *B. pinnulatus*, Bather, *B. quinquelobus*, Bather; Australian, *B. longibrachiatus*, Chapman; North American, *B. nucleus* (Hall), *B. polyxo* (Hall), *B. crassus* (Whiteaves), *B. americanus*, Rowley. All these are Silurian except the last two, which are Devonian and approach the Carboniferous *Barycrinus* in shape. American workers are invited to consider the relations of *Botryocrinus* to *Cosmocrinus*, *Barycrinus*, and *Vasocrinus*.

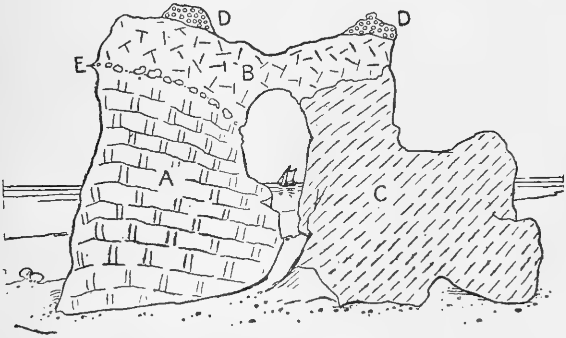
The Chalk Arch at Trimmingham, Norfolk, as seen in July, 1906.

CORRESPONDENCE.

TRIMMINGHAM CHALK BLUFFS.

(PLATE XXVII.)

SIR,—You may be interested to know that I spent a short fortnight in East Anglia. *Apropos* of Trimmingham I endeavoured to identify Mr. Brydone's photographs. He appears to have taken no notice of the extraordinary natural arch situated a few yards from the base of the cliff, a miniature 'Old Harry.' Enclosed is a rough sketch of this peculiar specimen of the Contorted Drift, which owes its preservation, in a great measure, to an intensely hard bed of flint pebbles (D). There are two fragments of this remaining, and during my visit two young Philistines were doing their best to destroy the one on the left hand. I preached them an appropriate sermon on the folly of destroying interesting natural objects, and they had the good sense to desist. I also send you photograph taken by Messrs. Tucker showing the natural arch as seen by me in July last (see Plate XXVII).

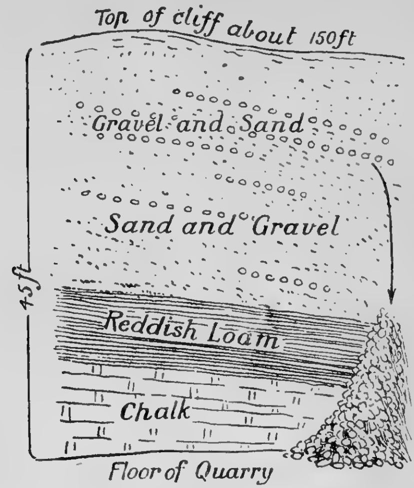


Natural arch on the sea-shore at Trimmingham.

A. Chalk *in sitû* unaltered and full of flints.
B. Modified Chalk with much impurity.
C. Pugged grey clay with some stones.
D. Conglomerate of flint pebbles.
E. The principal flint band.

This mass of marly Chalk in the Trimmingham cliff is situated just below the Crown and Anchor Hotel, the 'marl' being burnt for lime (July 31st, 1906). It is evidently a mass of squeezed and softened Chalk, but I did not notice flints in it. A quantity of flint pebbles, some very large, are obtained from the overlying gravels for road-mending, etc. There are several smaller lumps of softened

Chalk in the cliff hereabouts, and the cliff itself is much fissured and crevassed. The beds dip towards the north-east (approximately).



The elevation of the church at Trimmingham is marked in the old map as 195 feet, and the top of the cliff here is from 40 to 50 feet lower.

W. H. Hudleston.

Note.—The mass of Chalk forming the arch (see Pl. XXVII) was only entirely isolated and detached from the adjoining cliff early in this year. (See Mr. Brydone's Plates, Geol. Mag., 1906, Pl. II, Figs. 2, 3; Pl. IV, Fig. 7; Pl. V, Fig. 12; Pl. VIII, Fig. 13. See also description by Prof. Bonney in Sept. No., pp. 400–403, Fig. 1, A, and Fig. 2.)—Edit. Geol. Mag.

THE THICKNESS OF THE CIRCUM-POLAR ICE.

Sir,—Your reviewer of the first volume of Professors Chamberlin and Salisbury's Geology has the following sentence on p. 376: "We note that the thickness of the Greenland ice-dome at its centre is estimated at 5,000 feet or more, and we recommend the statement to the attention of the writer in this Magazine (March, 1906, p. 120) who has recently, on hypothetical grounds, revived the idea that ice cannot attain a greater thickness than 1,600 feet." May I again point out that the 5,000 feet ice-sheet is a pure assumption, whereas the 1,600 feet limit rests on physical experiment and direct field observation? Professors Chamberlin and Salisbury's statement, which your reviewer refers to with such satisfaction, is as follows: "The height of the land surface beneath [the ice-cap] is unknown, but it is unlikely that it averages half this amount [9,000 feet], and hence the ice is probably 5,000 feet or more thick in the centre. There is reason to think it is much thicker in Antarctica." This is simply an appeal to ignorance; and as regards the Antarctic, Captain Scott's observation that evaporation equals precipitation on the plateau leads one to infer that it is likely that the ice-cap there is quite thin. If the upholders of the 5,000 feet ice-sheet will produce the record of a tabular iceberg more than 1,600 feet thick, or if they will show that there is a valley 5,000 feet from crest to trough running under the flat ice-cap of Greenland—the observations at present available tending to show, on the contrary, that the deep valleys on the coast go but a short way inland and end abruptly on the edge of a plateau —then I will believe that physical laws have been suspended in their operation for the special benefit of glacialists.

Ernest H. L. Schwarz.

Rhodes University College,
Grahamstown, Cape Colony.

THE TRIMMINGHAM CHALK.

Sir,—It seems desirable to make a few comments on Professor Bonney's paper in your September number. On the question of "western and eastern" or "northern and southern" bluffs, I cannot see what the trend of the coast, ever varying from point to point and as you take it at the base or top of the cliff, can have to do with the relative position of two fixed points. A line drawn from bluff to bluff runs by the compass 5°–10° S. of S.E., so that I and any earlier writers who used *magnetic* bearings are accurate in speaking of "northern and southern" bluffs. Can it be that Professor Bonney is treating our magnetic bearings as if they were geographical, and supplying an instance of the very confusion I sought to forestall by a note obviously addressed to the general public. (Professor Bonney affects to regard it as addressed to him personally, but I can assure him that the paper by him and Mr. Hill gave rise to no alteration in the form or substance of mine.) On the East Coast it is in any case natural (and not inaccurate) to speak of points along the coastline as north and south, while they are no nearer due east and west than 10°–15° E. of S.E indicates.

I am less fortunate than Professor Bonney in having only found one place where the foreshore chalk has a skin of boulder-clay, the plastic clay having, under pressure from the cliffs above, crept over the chalk for a few yards in a depression. It seems a very natural thing to happen.

Professor Bonney has not fully grasped my theory as to his blocks A, C, and E. I believe that the eroded surface, unconformable to the lines of flint, of the *Ostrea lunata* chalk in these three blocks was formed in Cretaceous times, and then still in Cretaceous times the grey chalk was deposited on it, most thickly in the hollows, e.g. between C and E, and in the pocket in the seaward face of A shown by my figs. 13 and 16. On this theory no twisting of the grey chalk is required, nor is there any difficulty in its occurring still at the top and bottom of the sloping face of C. (As I have stated, it formerly covered the whole of this sloping face and was continuous *above* the sand with the grey chalk in E.)

I do not know with whom Professor Bonney is arguing that it is "more probable" that the thin slab is a separate boulder. I clearly stated this as my view (and see my fig. 17).

As to the grey chalk, I hold it to be of Cretaceous age because the soft matrix contains a pure Cretaceous fauna very abundant both in species and individuals, many of the perfect or well-preserved specimens being so delicate that the presence of one in a remanié deposit would be very remarkable, and the presence of two almost miraculous. Apart from the basement bed and the intimate mixture of very fine clay which causes the greyness, the grey chalk is absolutely pure throughout the thickness (maximum eleven feet) which has been exposed at the North Bluff. This makes a strong *primâ facie* case as yet unanswered. I have also good ground to believe that Clement Reid's sandy bed (which I have already found lying unconformably on *Ostrea lunata* chalk) is the basement bed of the grey beds which on the foreshore crop out from *under Ostrea lunata* chalk, and are not only identical with the grey chalk of the bluff in appearance, fossil contents, and peculiar flints, but are also, as I can now say, the only other beds in which I have found *Terebratula obesa, Ostrea inæquicostata,* or *Ostrea canaliculata.* The significance of this is obvious.

Professor Bonney ignores the direct evidence as to the North Bluff and presumptive evidence as to the South Bluff that they are in direct physical connection with large masses of the foreshore chalk, and abstains from discussing any palæontological evidence or the behaviour of the foreshore chalk. This of course simplifies the criticism of a theory based almost wholly on those three classes of evidence, but which when formed proved capable of application to the special case of the North Bluff.

It may be well to take this opportunity to point out (to the general public) that the arch sketched by Professor Bonney was formed in March last, and is not the arch of *Ostrea lunata* chalk and grey chalk over a pinnacle of clay referred to in my paper, and which was broken through on the 1st October, 1905. His line *g* is the coarse basement bed of the grey chalk, the continuation of which on the opposite side of the arch, where it is less coarse, he has missed.

Mr. Jukes-Browne's letters leave untouched my original proposition that *Terebratulina striata* is the best zone fossil. I am also still unready to admit that it is logical to combine several beds easily distinguishable palæontologically or lithologically, often in both ways, in one zone on the strength of a common peculiar fauna, and then to name the zone from a fossil which is most capriciously restricted to some only of these beds. The characteristic assemblage of fossils he quotes in the Survey Memoir, vol. iii, p. 12, can only be obtained in the *Ostrea lunata* bands, if in all of *them.*

R. M. Brydone.

16, South Audley Street, W.

9th October, 1906.

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DECEMBER, 1906.

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GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. III.

No. XII.—DECEMBER, 1906.

ORIGINAL ARTICLES.

I.—The Antarctic Ice-cap.

By H. T. Ferrar, M.A., F.G.S.,
Geologist to the late "Discovery" Antarctic Expedition,
of the Survey Department, Cairo.

In a recent number of the Geological Magazine, Dec. V, Vol. III, March, 1906, p. 120, there is an article by Prof. E. H. L. Schwarz which deals with the thickness of ice-caps during the various Glacial periods. At the outset Professor Schwarz takes the data furnished by Captain Scott's narrative of the voyage of the "Discovery" as the main support of the physicists' contention that an ice-sheet cannot exceed 1,600 feet in thickness.

It is true that at the present day no ice more than 1,600 feet has been recorded. Dr. Nansen estimates the thickness of the Greenland ice-sheet to be nearly four times that amount, and, judging by the size of the icebergs said[1] to have been met with in the Southern seas, maintains[2] that the Antarctic Ice-cap must attain a very great thickness. These estimates, however, may be neglected, as the recent expeditions seem to show that the size of icebergs recorded in the Antarctic seas has been exaggerated. Both Von Drygalski[3] and Captain Scott[4] show that in times past the ice-caps of Greenland and South Victoria Land respectively attained a much greater thickness than they do now, and if we wish to prove that ice-sheets ever exceeded the 1,600 feet limit we have only the traces left by previous Glacial periods to fall back upon.

The thickness of an ice-sheet or iceberg, estimated by means of the unsubmerged height, is only very approximate. Von Drygalski gives 300 feet as the maximum height above water, and maintains that any iceberg which is higher than 300 feet must have turned over. In high latitudes the air is commonly misty, though in certain

[1] H. C. Russell: Journal of the Royal Society of New South Wales, vol. xxxi (1897), p. 241, reference number 172.
[2] Nansen: *Nature*, vol. lvii (1898), p. 424.
[3] Drygalski: Greenland Expedition, p. 33.
[4] Scott: Geog. Journ., April, 1905, p. 360.

localities clear bright days predominate: under these conditions, when no shadows are produced, it is exceedingly difficult to be certain which was originally the upper surface of a disintegrated iceberg. The accompanying illustration shows an iceberg estimated to be 200 feet high which still has a portion of its original upper surface intact. If this portion were removed it would be extremely difficult to make sure whether the berg had turned over or not. To argue that such icebergs as those figured in a great number of publications have all turned over, is hardly safe, especially as bodies with diameters of unequal length appear, in the majority of cases, to float with the longer diameter horizontal. It therefore seems highly improbable that a berg would increase its height by turning over.

A berg, however, may increase its height, and probably often does so, in the following way. A newly calved iceberg usually has vertical sides; the waves beat against these and, undermining them,

Fig. 1.—An iceberg which has turned through nearly 90°.

cause pieces to split off. This splitting will probably take place along vertical planes, parallel to inherent planes of weakness, and this undermining is accelerated by the temperature of the water at the surface being raised by radiant heat from the sun. The visible part of the berg will thus be reduced in mass, and consequently the berg will rise. That this is a common occurrence may be seen in almost any of the narratives of polar voyages, where one constantly finds references to the toe of an iceberg.

For icebergs floating freely in the sea, Von Drygalski gives the proportion of normal glacier ice above water to ice below water as 1 is to 4. Rink[1] makes the proportion as 1 is to 6; Steenstrup as 1 is to 7; Sir John Murray as 1 is to 7; and Scott[2] as 1 is to 5. The cannonading performed upon an iceberg by H.M.S. "Challenger,"

[1] Rink: Danish Greenland, London, 1877, p. 358.
[2] Scott: Geog. Journ., April, 1905, p. 356.

showed that the density is not uniform. Our experience upon the Ross Ice-sheet proved that normal glacier ice could be capped by any thickness of *firn* or loose snow; and therefore of two bergs with equal volumes immersed, if the visible part of one consisted wholly of snow and that of the other wholly of ice, the ratios of the visible to the submerged portions would be widely different. Again, the temperature and salinity of the sea-water have some effect in buoying up the ice, but this may be neglected. However, the aeration of the ice varies greatly, but for normal glacier ice Helland gives 0·886 as the specific gravity, while my results show a specific gravity of 0·83. Therefore, in Antarctic sea-water with an average density of 1·025 grammes per cubic centimetre, glacier ice would float with four parts immersed and one visible. This figure agrees closely with the results of Von Drygalski and Captain Scott obtained by actual measurements at glacier snouts. The greatest ice-cliff observed by

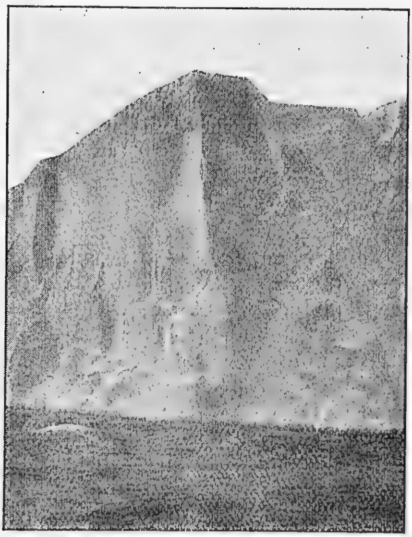


FIG. 2.—The edge of the Ross Ice-sheet near the point where it is thickest.

the staff of the "Discovery" was the edge of the Ross Ice-sheet floating in the vicinity of Cape Crozier. The height here was 240 feet and the depth of water 460 fathoms. As the surface here was unbroken and the cliff-face uncrevassed (see Fig. 2), it is hardly likely that this extreme thickness was produced by pressure as Professor Schwarz [1] suggests.

The question as to the limit of 1,600 feet being exceeded depends, as Professor Schwarz rightly points out, upon the temperature of the lower surface of the ice being below its melting-point. As far as I remember, the figure 1,600 feet is the height of a column of ice

[1] Schwarz: GEOL. MAG., Dec. V, Vol. III, March, 1906, p. 122.

which would by its own pressure liquefy its sole if the temperature were 1 degree Fah. below its normal melting-point, and therefore the limiting thickness of 1,600 feet is far *above* the maximum for ice resting on land at the melting-point of ice.

At the "Discovery's" Winter Quarters, under the shadow of Mount Erebus, latitude 77° 51′ S., longitude 166° 45′ E., the mean annual temperature was —4·6° F.,[1] and hence the point where a temperature of 32° F. would be found must be below the surface. Whether this point be well below the sole of the thickest ice has not been determined, but as the glaciers are practically stationary their ice must be out of reach of this temperature. A series of observations of the temperature of glacier ice at fixed depths was made. The observations were commenced in April, after the temperature of the ice had begun to fall, and extended throughout the following Winter and Summer, until the month of February, when the ensuing fall of temperature due to the increasing cold began. The highest temperature recorded at a depth of six feet was −9° C., and the lowest —24·4° C.

The large difference between the maximum and minimum temperatures recorded below the ice and the lag caused by the six feet of ice would seem to show that the point which is not influenced by seasonal variations is still deeper down. Now if we take a value once adopted by a British Association Committee for the earth's mean temperature gradient, we get a rise of 1° F. for every 64 feet increase of depth. Therefore, for a rise of 36 Fahrenheit degrees (our mean annual temperature below the freezing-point) the 32° F. isothermal would be at least 2,300 feet below the surface. On the inland ice Captain Scott's observations show temperatures of 10°, 15°, or even 20° below those registered simultaneously at Winter Quarters. Therefore the mean annual temperature on the inland ice would be below the mean at Winter Quarters and the 32° F. isothermal surface proportionally lower down.

Von Drygalski's results point to the same conclusion, but it must be remembered—(*a*) that some of his temperatures were recorded from crevasses which were open to the air and to water during the Summer thaw; (*b*) that in Greenland during Summer the air temperature remains above the freezing-point of ice for several weeks, and often rises 8 or 10 degrees above that point.

Professor Schwarz does not seem wholly in favour of the view that a warmer climate in the Antarctic would produce a thickening of the ice-cap, sufficient to exceed the physical limit.[2] The German Antarctic Expedition and other earlier expeditions which remained near the Antarctic Circle record a great snowfall as compared with that experienced by the British Expedition in higher latitudes.

[1] All the temperatures quoted are our uncorrected values. Reference should be made to the "Discovery" Reports on Geology and Meterology, which are to be published by the British Museum (Natural History) and the Meteorological Office respectively.

[2] Tyndall: "Heat a Mode of Motion," 1898, 11th edition, p. 231 ff.; "The Forms of Water," 1892, 11th edition, p. 154.

The amount of snow on South Victoria Land was observed to diminish in quantity as the "Discovery" steamed south along the coast, and in latitude 77° South the glaciers were found to be retreating. By means of graduated stakes (snow-gauges) and blocks of ice exposed to the air throughout the year, it seems to be established that the ablation of the ice is greater than the precipitation. The mean temperature for the two Summer months was $-4{\cdot}3°$ C., and it was only when the sky became overcast and the air temperature rose a degree or two above the mean that any measurable quantity of snow fell.

It is as evident to those of us who have been in high latitudes that the isotherm of 0° C.[1] (which is near the Antarctic Circle) is an effective barrier to the transport of snow to higher latitudes; as it is evident to those who have been on both coasts of Ireland, on the south coast of Africa and the Karroo, that the mountains are a shield and cut off the rain from districts further inland. Professor Schwarz uses the argument that a high temperature during maximum glaciation will consequently produce more running water, and

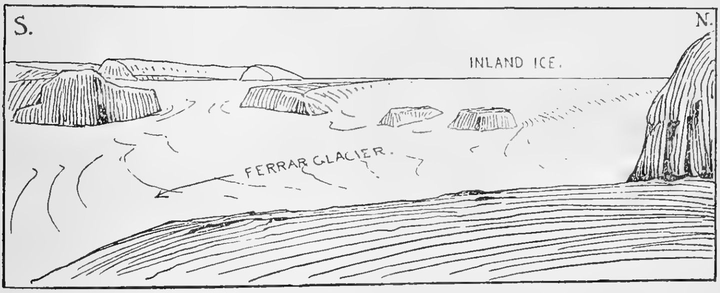


Fig. 3.—The inland ice falling down between nunataks from the inland plateau. From a sketch by H. T. Ferrar, greatly reduced.

attributes the deepening of glaciated valleys, not to the greater power of the ice, but to that of sub-glacial streams.[2] If this is so, then the deeply incised valleys of the Royal Society Range, with their stagnant glaciers, would afford additional evidence that a rise in temperature, and consequently a southerly migration of the zone of maximum precipitation, had taken place at some former period.

In his article, p. 123, Professor Schwarz says Scott found the highest points to sink below the horizon directly the level ice-cap was reached. Scott expressly says, on p. 414 of his narrative—"when we reached the interior plateau at a height of 8,900 feet we observed nunataks to the north standing above our own level." Mount Lister is given as 13,000 feet high, and stands on the edge of the plateau. The accompanying Fig. 3 is a sketch of the South Victoria Land ice-sheet as it falls together and becomes moulded into the Ferrar Glacier. The height between the graded surface of the

[1] Buchan: "Challenger" Reports, Physics and Chemistry, plates.
[2] Garwood: Q.J.G.S., vol. lviii, pl. xl.

glacier and the plateau is nearly 1,000 feet. Scott points out that this land at the back of the Royal Society Range appears to be higher than that to the north or to the south. This means that he thinks the Royal Society Range is the end of an elevated mass of land, with its length transverse to the coastline (i.e. east and west), and that a measure of the thickness of the Antarctic Ice-cap on this elevated transverse ridge would therefore be inaccurate.

That Captain Scott found it approximating to the physicists' maximum limit of 1,600 feet, no doubt is a very strong argument in favour of the view that the physicists' extreme limit is never exceeded. But when I repeat that the glaciation of South Victoria Land is approaching to a minimum, and that all glacialists require a great thickness of ice to explain the phenomena which they have described, I think it will be conceded that—(*a*) any thickness of ice may be accumulated so long as the loss by ablation, melting, and discharge is less than the gain by precipitation; (*b*) that the facts noted above are more in harmony with the glacialists' requirements than with Professor Schwarz' contention that the physicists' theoretical maximum of 1,600 feet cannot be exceeded.

II.—On the Interglacial Question.

By T. F. Jamieson, F.G.S.

A GREAT difference of opinion seems to exist among geologists, not only in Britain but also in other countries, in regard to the supposed occurrence of warm Interglacial periods during the age of ice. Those who incline to the views propounded by Adhemar and Croll as to the causes which produced the extraordinary climate of that time naturally look for alternations of cold and warm periods.

Precession of the equinoxes and variations in the excentricity of the earth's orbit are astronomical facts which must have had their influence, and the changes they might bring about in the direction and force of ocean currents, to which Croll attributed so much importance, have also to be considered. These astronomical causes and their accompaniments are not to be ignored, but their precise effect upon the climate of the period in question is still a matter of much uncertainty and one in regard to which our knowledge has made very little progress.

Mr. Lamplugh, in his recent address to the Geological Section of the British Association, lays much stress on the absence of any clear evidence of warm intervals or even of one such interval in the British Islands, and as no one is better acquainted with the drift beds of England his opinion must have much weight.

It seems to me that there is one important circumstance which may have led to this obscurity and which has not received the consideration it deserves, and that is the persistence of the vast masses of ice which accumulated during the intensity of the glaciation, and the consumption of heat required to dispel them. The Scandinavian glacier alone seems to have spread out in some directions fully 1,000 miles, and much of its thickness must be reckoned in thousands of feet. The North American ice perhaps attained even greater proportions. Just think of the amount of heat and the time it would take to thaw such masses. There is a huge difference between snow and ice in this respect. Snow, especially when newly fallen, thaws rapidly, but ice does not. It melts with extreme slowness, and so long as the thaw was going on and much of the ice-sheet remained, the temperature of the air in Northern Europe and America would not rise to any great degree. The accumulation represents a storage of cold during thousands of years, and the probability seems to be that the returning heat brought about by the precession of the equinoxes would not always be able to dispel the vast masses of ice left on the land by the preceding period of glaciation. In short, the heat would all be spent in but a partial melting of the glacial covering. Consequently the temperature in many places would never rise so far as to cause a complete reversal of climate, and thus no clear evidence of an interglacial warm period would be found, but merely indications of a large retreat of the ice-front. Croll, it is true, did not take this view of the matter, for he conceived that the reversal of climate would be complete, and that the ice would wholly disappear from one hemisphere when the other was under glaciation. In this, however, I think he may have been mistaken. At any rate, we have no certainty that such would be the case.

Now, in the north of Scotland we can show that the basin of the Moray Firth was at one time filled with ice to such an extent that the right flank of the mass flowed eastward along the coast of Moray and Banff and then wheeled round the corner of Aberdeenshire, where it appears to have surmounted a hill 769 feet high; while its left flank in like manner turned round over the lower part of Caithness, overflowing hills there some hundreds of feet in height, and producing the shelly boulder-clay of that district.[1] All this implies a thickness of ice in the basin of the firth to be measured by thousands of feet. Now we have further evidence that this great mass of ice afterwards disappeared, and that sea-water inhabited by mollusca of a northern type occupied the basin up to the very top at Inverness. The Northern and even Arctic character of many of the species found in these shell-beds seems to show that although an enormous amount of heat must have been long in action to dissipate such a mass of ice, yet this heat was not sufficient to introduce a decidedly warm climate, at any rate so far as the temperature of the sea-water was concerned; nor has any evidence as yet been obtained in the district to indicate a warm temperature on the land. This episode of an interglacial occupation of the Moray Firth basin by sea-water inhabited by mollusca of a northern type was afterwards followed by a return of the glacier in great force, which destroyed the shell-beds and covered them with heavy masses of boulder-clay, as we see at Clava and elsewhere.

[1] Journal of the Geol. Soc., vol. lxii, p. 13, Feb., 1906. T. F. Jamieson on the Glacial period in Aberdeenshire and the Southern border of the Moray Firth.

Here, then, it seems to me we have a case in point, affording good evidence of an interglacial period with abundance of heat, and yet not enough to cause a decided reversal of climate, but only sufficient to clear out the heavy mass of ice which filled the basin of the Moray Firth. Such a result certainly could not have been accomplished without the expenditure of an enormous amount of heat, which in districts where there was no ice to dispel would have produced a decidedly warm climate. During the thawing of the ice and its reduction into ice-cold water the air would remain cold, and not until the ice had completely disappeared would the climate become genial. Before this could happen in the Northern districts the interglacial spell of warmth might be passing away, and hence no genial climate would result.

Ellon, Aberdeenshire.

III.—On the Origin of certain Laterites.

By Malcolm Maclaren, B.Sc., F.G.S.

The various views put forth prior to 1893 to account for the origin of Indian laterites have been clearly and sufficiently discussed in Oldham's edition of Medlicott & Blanford's Manual of the Geology of India (pp. 369 et seq.). Since that year the only contribution of importance to the literature of lateritic genesis in India is a paper by Mr. Thos. H. Holland, F.R.S., the present Director of the Indian Geological Survey,[1] having for its text the conclusions of Bauer.[2] In it the author suggested that laterite might owe its origin to "some lowly organism," but no sufficient data were advanced in support of the suggestion. Bauer's specimens indicated a certain amount of dehydration in laterites, and this fact, together with the absence of hydration products from certain peridotites in Southern India,[3] was deemed to indicate a general dehydration for the bauxitic laterites of the Deccan. The gibbsite (Al_2O_3, $3H_2O$) of laterite was supposed to be dehydrated to diaspore (Al_2O_3, H_2O), and it was assumed that "this irregular loss of water is probably the cause of variation in bauxite."[4]

To account for the energy necessary for dehydration the ingenious theory of the possible superiority of "crystalline affinity" over "chemical affinity" was developed (loc. cit., p. 69), and the conclusion was drawn that "limonite and gibbsite must be regarded as unstable at tropical temperatures."[5]

Of late years valuable analytical researches on the constitution of laterite have been made by Dr. Warth,[6] who may justly be considered

[1] Geol. Mag., Dec. IV, Vol. X (1903), pp. 59–69.

[2] "Beiträge zur Geologie der Seychellen": Neues Jahr. für Min., vol. ii (1898), p. 163.

[3] Geol. Mag., Dec. IV, Vol. VI (1899), pp. 31, 542.

[4] Ib., Dec. IV, Vol. X (1903), p. 65.

[5] See, however, Geol. Mag., Dec. IV, Vol. X (1903), p. 139.

[6] Min. Mag., vol. xiii (1902), p. 172. Geol. Mag., Dec. IV, Vol. X (1903), p. 154; ib., Dec. V, Vol. II (1905), p. 21.

the pioneer in the investigation of the nature of Indian laterites, though their aluminous character had years before been suggested by Mallet.[1] Various analyses have also been made from time to time in the laboratory of the Geological Survey of India.[2]

A comprehensive genetic theory of lateritic deposition must reasonably account for any or all of the following features:—

(1) The restriction of the deposition of laterites, both geographically and in altitude.
(2) Their general superficial occurrence.
(3) Their internal structure—porous, vesicular, pisolitic, or concretionary.
(4) Their peculiar composition as regards—
  (*a*) The essential aluminous, ferruginous, or manganiferous hydrates or oxides.
  (*b*) The general presence of titanium dioxide.
  (*c*) The general absence of kaolin or silica.

The present writer's experience of Indian laterites is not geographically extensive, but is, nevertheless, fairly varied, including as it does the 'high-level' laterites of Chota Nagpur, Bengal, of the Southern Maratha country on the edge of the Deccan Trap, and of the Western Ghats, west of Belgaum, and the 'low-level' laterites of the Portuguese territory of Goa on the west coast of the peninsula. There is no necessity in this place to describe the physical aspect of laterite. A general description may be found in Oldham's edition of Medlicott & Blanford's Manual already quoted, and for fuller details the reader may be referred to the papers of Newbold[3] and of Lake,[4] which, despite the age of the former, remain by far the best descriptions of 'high-level' and of 'low-level' laterite respectively.

It was an examination of sections of the lateritic manganese deposits of Talevadi, on the edge of the Western Ghats and overlooking the Goa peneplain 2,500 feet below, that first suggested the theory of lateritic genesis presently to be outlined (see Fig. 1, p. 538). There, pits in search of manganese expose the laterite in process of formation and give sections of some 30–40 feet in depth. The bottom of a typical section shows a white decomposed friable sandy rock which, from exposures elsewhere, is regarded as a decomposed biotite-quartz schist. This passes upward without any abrupt change through a buff sandy clay to a reddish buff, soft rock containing small indistinct ferruginous secretions and minute manganese nodules. As the surface is approached the rock gradually acquires depth in colour, while the contained manganese secretions become larger and better defined until, at the surface, they are 2–3 feet across with a like depth. With increase of ferruginous content, the rock becomes so hard that, at the surface, it is often necessary to use explosives to disintegrate it. A few

[1] Rec. Geol. Surv. India, vol. xvi (1833), p. 113.
[2] Ib., vol. xxxiii, p. 178.
[3] Journ. As. Soc. Bengal, vol. xiii (1844), p. 990.
[4] Mem. Geol. Surv. India, vol. xxiv (1890), pt. iii, p. 17.

feet below it can be cut with a spade. Through the manganese secretions there ramify veinlets of gibbsite—Fig. 1 (1)—much of it of metasomatic replacement. It is, consequently, the last deposited product. In the immediate neighbourhood of the manganiferous laterites the writer found small areas of high-grade pisolitic bauxites. There are, therefore, in this neighbourhood all the ordinary forms of laterite—ferruginous, aluminous, and manganiferous. The last has not generally been distinguished, but it cannot be dissociated genetically from the other two.[1]

The low-lying country of Goa between the coast and the Deccan plateau furnishes extensive deposits of 'low-level' laterite, partly

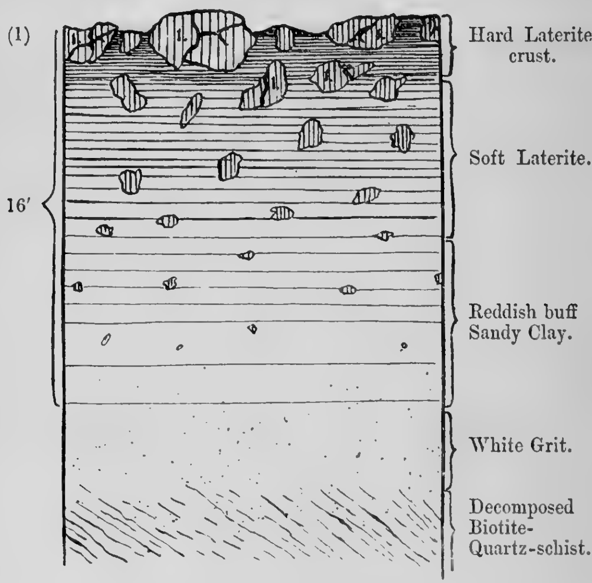


Fig. 1.—Typical Section of Laterite, Talevadi, Belgaum.
(1) Psilomelane with gibbsite veinlets.

detrital and partly secretionary in origin. Examination of this area elicited no further data than were collected by Lake for a similar coastal region further south in Malabar.[2] Two main forms, the vesicular and the pellety, were distinguished. The latter is often partly derived from the erosion of the former, but its final consolidation and cementation is due to the same agencies that gave rise to the first or vesicular form.

The rainfall of the edge of the Western Ghats and of the Goa country ranges from 120–180 inches in the year, but falls almost

[1] See, however, Mallet, Rec. Geol. Surv. India, vol. xvi (1833), p. 117; Bose, ib., vol. xxii (1889), p. 225.
[2] Mem. Geol. Surv. India, vol. xxiv (1890), pt. iii, p. 17.

entirely from June to October, a period of four months. At Karwar, for example, rain has fallen on 72 successive days, and yet the total number of rainy days in the same year has been no more than 120. The average shade temperature of the same region is a trifle below 80° F., with a monthly range of from 75° to 84° F. With such rainfall and temperature vegetation is naturally luxuriant, especially in the lower-lying regions. During the cold weather, the dry field season of India, little or no idea of the moisture precipitation of these regions can be gained. Especially is this the case on the higher lands. The Atli laterite plateau, north of Castle Rock, when seen in January was a dry and arid, hopelessly waterless, area. Fortunately the exigencies of *shikar* took the writer over the same area in late July. The plateau, so far as it could be seen for the driving rain and mist, was then, to outward appearance, a morass, though, through its thin covering, one thankfully felt the hard laterite crust beneath. Periods of dessication and saturation are thus very well marked.

Regions of abundant rainfall in tropical climates are well wooded, and humus being always abundant the proportion of carbon dioxide in solution in the soil is correspondingly high. Boussingault and Lewy[1] show that, in a temperate climate, the air of a soil rich in humus may contain more than one hundred times as much carbon dioxide as atmospheric air. Considering the greater rapidity of decay and chemical change in tropical regions, this factor is likely to be greatly exceeded in India. The amount of silica dissolved in underground waters may also be taken as a measure of the amount of carbon dioxide in solution, and Struvé[2] has shown that the amount of silica thus dissolved is much greater in regions of abundant vegetation than in those where it is absent or sparse.

There is no need in this place to discuss at length the action on silicates of waters containing alkaline carbonates and carbon dioxide in solution. Bischoff, fifty years ago, suggested that the silicates were decomposed by these agencies, and Kahlenberg and Lincoln[3] have recently shown that the resulting silica separates in the form of colloidal silicic acid.

The normal weathering change of felspars in temperate regions is undoubtedly to kaolin, as indeed is sufficiently indicated by the analyses of the Rowley Regis dolerite by Dr. Warth[4] in connection with this very subject. The general equation may be represented thus: taking, say, albite as a typical felspar, $2\,Na\,Al\,Si_3\,O_8 + 10\,H_2\,O + C\,O_2 = H_4\,Al_2\,Si_2\,O_9 + Na_2\,C\,O_3 + 4\,H_4\,Si\,O_4$. Where abundant carbonates are produced, as is apparently the general case in humid India, the change is not to kaolin but rather to a sericitic form:[5] thus, $3\,(Na\,K)\,Al\,Si_3\,O_8 + 10\,H_2\,O + C\,O_2 = (Na\,K)\,H_2\,Al_3\,(Si\,O_4)_3 + (Na\,K)_2\,C\,O_3 + 6\,H_4\,Si\,O_4$; and herein probably lies the explanation of the general absence of kaolinite from the purely

[1] Quoted by Merrill: "Rocks, etc.," p. 178.
[2] Pogg. Annal., vol. vii, pp. 341, 429.
[3] Journ. Phys. Chem., vol. ii (1898), pp. 77–90.
[4] Geol. Mag., Dec. V, Vol. II (1905), p. 21.
[5] Lindgren: Trans. Amer. Inst. M.E., vol. xxx, p. 614.

superficial deposits of India, though, in the form of lithomarge or halloysite, it occurs in abundance at shallow depths.[1]

The equation most fitted to Indian conditions is, however, one more in accordance with the general conclusions of Kahlenberg and Lincoln, and one also indicative of more energetic chemical action in the presence of abundant carbon dioxide. Here the silicates are completely decomposed, all the silica passing off as colloidal silicic acid. The action may, and doubtless often does, take place through an intermediate sericite or lithomarge stage, but the simplest expression is adopted.

$$2\,NaAlSi_3O_8 + 15\,H_2O + CO_2 = Al_2(OH)_6 + Na_2CO_3 + 6\,H_4SiO_4.$$

By this process of carbonation aluminium hydrate may similarly be derived from any other of the felspar family, from the micas, from the felspathoids, from the scapolites, and from many of the minerals of contact metamorphism. We have, therefore, no difficulty in finding an origin for all the aluminous hydrates of laterites. By carbonation also ferrous and probably manganese carbonates in like manner result from the decomposition of the ferro-magnesian silicates. It is, of course, not insisted that any of the resulting compounds are definitely formed, but rather that they are merely potential salts in ionized solutions.

So far the equations given are in accordance with numerous data and with generally accepted principles. The origin of the ilmenite and titanic acid met with in most laterites is by no means so clear, but it may at once be conceded that their manufacture is certainly a task from which even the stoutest-hearted of bacteria might recoil without incurring the odium of pusillanimity. Data concerning the alterations of titaniferous minerals are scanty. Rutile and ilmenite may, as suggested by Van Hise,[2] be derived from original sphene:

$$(1)\quad CaTiSiO_5 + CO_2 = CaCO_3 + TiO_2 + SiO_2\,;$$

$$(2)\quad TiO_2 + FeCO_3 \rightleftarrows FeTiO_3 + CO_2\,:$$

the last equation being reversible. A careful examination of thin sections failed to reveal any leucoxene in the laterite, but this form of titanic acid, unless under exceptional conditions, would be distinguishable with great difficulty from the bauxite matrix.

Titanic acid is, however, by no means confined to laterites and bauxites among superficial deposits. The extensive soil analyses of Dunnington[3] showed its presence in all the 72 soils gathered from many parts of the world and examined by him. The average percentage of TiO_2 obtained for the whole series was ·95. When to this normal percentage is added that collected by the exceptional facilities enjoyed by laterites for selective segregation, the high percentage contained by many bauxites is perhaps no matter for surprise.

We have thus derived by the agency of carbonating waters from

[1] [A more satisfactory formula to represent the process of sericitization in alkali felspars is that given by Van Hise (Metamorphism, p. 254): $3\,KAlSi_3O_8 + H_2O + CO_2\ KH_2Al_3Si_3O_{12} + 6\,SiO_2 + K_2CO_3$.—Edit. Geol. Mag.]

[2] U.S. Geol. Surv., Mon. 47 (1904), p. 227.

[3] Amer. Journ. Sci., vol. xlii (1891), p. 491.

underlying or adjacent rock masses, in solution, and probably in ionized solution, all the materials essential to the formation of laterite. There is now to be considered the machinery necessary to bring it to its resting-place at the surface. The conditions of successive dessication and saturation in regions of lateritic growth have already been indicated. During the former period the motion of ground waters is always from the region of greater to the region of lesser humidity, or, in this case, upward to the surface. Upward transmission is effected entirely by molecular attraction, resulting where conditions are favourable in capillary motion, that directly due to dessication being intensified by the needs of forest rootlets. The potency of capillary transmission may be gathered from the experiments of King,[1] who showed that molecular attraction, acting in capillary openings in a porous rock, was capable of raising from a depth of four feet an amount of water equivalent to an annual rainfall of 63·85 inches. The larger tubes anastomosing in laterite have often been described, and microscopic examination of both ferruginous and aluminous laterites discloses numerous tubular openings both capillary (·0002 – ·508 mm.) and super-capillary (exceeding ·508 mm.).

With the approach of ground waters to the surface and their consequent super-saturation in the dessicated region, separation of the contained solids takes place, at first, it would seem, on the tube walls and around pisolites. The minute tubes in the matrix of most laterites render it probable that some moisture passes entirely through the laterite crust and that a slight deposition takes place on the laterite surface exposed directly to the atmosphere, but by far the greatest amount of deposition must take place on the under side of the hard surface crust. During the dry season the whole of the contained load of the upward moving waters is thus deposited. There is at that time in the dessicated rock and soil but little metasomatic replacement, though segregation may readily take place as the solutions become more and more concentrated. During the period of saturation, however, all soluble constituents deposited during the previous dry season are dissolved and carried away. The insoluble constituents are thus left to obey in a moisture-saturated soil their natural laws of growth. They are further segregated, and deposited in most cases as fine bands around already formed concretions. Segregative action is well marked in the Talevadi sections, the lower zones, nondescript in colour and composition, passing upwards into well-defined ferruginous laterite, manganese ore (mainly psilomelane), pure bauxite, and gibbsite.

In the ordinary course of formation of laterite a surface crust is first formed which increases in purity, hardness, and depth with every successive dry season. The depth and hardness of the hard unaltering layer may, therefore, in areas in which laterite is still being formed, be some measure of the age of the deposit. All stages are met with. At Talevadi the hard crust is two to three feet thick, in the Central Provinces it is often 20–30 feet in

[1] U.S. Geol. Surv., 19th Ann. Rep. (1899), pt. ii, p. 85.

thickness, while in Goa it may often be cut from the surface with a spade.

From the foregoing it is evident that laterite must be regarded, not as the direct product of the decomposition of a rock *in sitû*, but essentially as the *replacement* of such a decomposition product, for though the ground waters may have derived their mineral content from the underlying rock, they may also have brought it from sources widely separated. A laterite may thus result from the individual or combined decomposition of basalts, gneisses, or schists, and there may, in its hardened upper surface, be no particle of the rock whose former place it now occupies.

The assertion of a previous writer[1] that there always is a sharp change from the soft decomposition product beneath laterite to the absolutely fresh rock below is not borne out by field sections. Such sharp changes certainly do occur, but they are exceptional, and occur only where the laterite is 'low-level' recemented detritus,[2] or occasionally where laterites overlie difficultly decomposable beds in the Deccan Trap. In the latter case, the downward rate of weathering of the trap is inversely as the lateritization, since, generally speaking, with increase of the latter, flow and ingress of surface waters, the only rapid weathering agent in the case of a solid homogeneous basaltic lava, are restricted. A sharply defined boundary, therefore, indicates the horizon at which the downward lateritization finally overtook the downward weathering.

Under the replacement hypothesis, all substances dissolved in the ground waters should be brought to the surface, and some explanation of the absence of silica from lateritic deposits is, therefore, necessary. As already seen, the silica formed is carried away as colloidal silicic acid, on the instability of which it is unnecessary to dwell. When not decomposed by simple "chemical after-effect," it is probable that the humic acids of the upper portion of the zone of weathering are competent to change its state and to precipitate it. Precipitation is always liable to take place in a region where the laws of mass-mechanical action—to which silica in solution is peculiarly subject—may operate. That much of the silica formed by carbonation is thus deposited we have evidence even in the lateritic regions of the Central Provinces, where both the Lametas (Upper Cretaceous) and the underlying crystalline rocks have been so thoroughly silicified as to render it often impossible to determine whether an area is to be mapped as Upper Cretaceous or as Archæan.[3] Limestones (both Lameta and Archæan), gneisses, and pegmatites are there so completely replaced by chert that only by the indications of the original structure can they be differentiated.

Though the foregoing explanation of the absence of silica is neither full nor satisfactory, yet the replacement hypothesis is not thereby vitiated, since, whatever the explanation, the facts remain that everywhere immense quantities of silica are being dissolved,

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 69.
[2] Lake: Mem. Geol. Surv. India, vol. xxiv (1890), pt. 3, p. 30.
[3] L. L. Fermor: Rec. Geol. Surv. India, vol. xxxiii (1906), p. 173.

and that nowhere, except in the thermal regions, are siliceous deposits brought to be deposited at the immediate surface of the earth.

The peculiar disposition in altitude of Indian laterites has always presented a difficulty to geologists, and many have called to their aid lakes, or even the sea, to account for the general horizontality noted. The 'high-level' laterite covers flat-topped hills, which may range from 2,000 to 4,700 feet above sea-level, and higher still on the Nilghiris, while the 'low-level' form occupies the eastern and western peneplains. In both upper and lower areas, however, adjacent laterite caps may occur at different levels,[1] indicating either disconnected deposits or differing age. In the region of the Deccan Trap, the widespread horizontality of the laterite is merely an expression of that of the Trap beneath (loc. cit., p. 261), which has filled up the inequalities in the surface of the older rocks. A consideration of the conditions of lateritic formation will show that only on level or approximately level surfaces can laterite form. Its growth is exceedingly slow, and only the surfaces of plateau basins or plains are stable for a sufficient length of time to permit of growth. Even a moderate slope changes its surface cover rapidly in a region of excessive rainfall. Again, it is only on an approximately level surface that the continued moisture saturation necessary for the solution of the soluble constituents and for the rearrangement of the deposited salts may be obtained. Judging, therefore, by the conditions under which laterite is considered to be forming at the present day, the 'high-level' laterite capping hills represent the level of ancient upland plains, or more probably flat broad basins, which abutted against or were enclosed by hills. It is the general recognition of the horizontality of many deposits that has given rise to the hypothesis of lacustrine sedimentary origin, an origin thought to be supported by the concretionary structure before noted. Concretionary or pisolitic structure, however, as a general rule, does not arise under open water conditions, but is characteristic rather of loosely coherent muds, clays, or moist sands. An analogy with the lake iron-ores of Sweden has been sought by some writers, and the presence of limonite-secreting bacteria in those deposits has probably suggested the Indian bacterial theory.

During the progress of denudation, the high hills in the neighbourhood of the basins, being unprotected by laterite, have disappeared, and their place is now occupied by valleys. Many of these ancient basin floors are situated in what are now dry regions, and it is probable in such cases that the vanished hills attracted the necessary amount of moisture. For example, in the neighbourhood of the laterite-capped Kappat Guda (3,007 feet), east of Dharwar, the rainfall is no more than 25 inches per annum, and no laterite is being formed at the present day. This region, lying at about the same height above the sea-level as the edge of the Western Ghats, incidentally illustrates well the nature of the surface products

[1] Oldham: in Medlicott & Blanford's Manual of Geol. India, pp. 374 et seq.

generated in areas of deficient moisture. Its soil is crowded with 'kankar'—small irregular concretions of carbonate of lime—which may, in the stream beds, form a calcareous tufa, while the rivulets that do run in the dry season through the black cotton soil are bitter with alkaline salts. These are exactly the products removed in regions of abundant rainfall.

Except when the humidity is great, the laterite crust supports a very scanty vegetation, and, even in humid areas, it is probable that much of the carbon dioxide essential for carbonation is derived from the decaying humus on the hill-sides above the laterite basins. The older laterites on the hill-tops are devoid both of vegetation and of soil.

The chemical aspect of the Indian aluminous and ferruginous laterites has been well developed by the analyses of Dr. Warth.[1]

Some little attention has been paid by the present writer to the nature of the minerals present. The bauxite, especially selected for examination since it promised to yield the most conclusive results, was one from Katni, Jabalpur district, which had been analysed in the Geological Survey Laboratory,[2] as follows:—

Al_2O_3	65·48
Fe_2O_3	3·77
H_2O	18·32
Moisture	1·06
SiO_2	0·38
TiO_2	11·61
MgO	trace
	100·62

The molecular ratio of Al_2O_3 to H_2O is lower (1 : 1·58) in this specimen than in any other analysed, and for this reason it was expected to show more clearly than any other the presence of diaspore, should the assumption of Warth and others, viz. that bauxite is a *mixture* of gibbsite and diaspore, be correct. Neglecting, as Warth has done, and with sufficient reason,[3] the consideration of the water due to possible limonite in the specimen, the foregoing ratio of 1 : 1·58 represents 29 per cent. gibbsite and 71 per cent. diaspore. It was, therefore, considered probable that a separation might be effected with a heavy solution, the specific gravity of gibbsite being 2·4 and of diaspore 3·4. Carefully and finely ground bauxite was treated with Sonstadt solution of 3·07 s.g. All except very fine black grains (ilmenite) floated. The specific gravity of the specimen as a whole was taken, and gave incidentally an excellent illustration of the porous nature of bauxite. A large fragment was soaked for a day in water with gentle heating, and gave a result of 2·487. Individual concretions from the same specimen gave 2·53, while the mean of three determinations of the fine powder gave 2·81. The last is taken as the true specific gravity of the Katni specimen.

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 158.
[2] Rec. Geol. Surv. India, vol. xxxii (1849), p. 179.
[3] Loc. cit. sup., p. 155.

The chemical analysis shows that at least 15 per cent. of the mass has, in the form of ilmenite and possible rutile, a specific gravity of more than 4·3. The remaining 85 per cent., therefore, has a specific gravity of not less than 2·65. But an intimate mixture of 71 per cent. diaspore and 29 per cent. gibbsite should have a specific gravity of 3·03. Rough though the calculation is, it is nevertheless sufficient to show that the two lines of deduction are hopelessly conflicting, and it must either be assumed that diaspore is not present or that the monohydrate, if present, is in a form physically different from diaspore. Additional evidence against diaspore lies in its absence from all thin sections examined.

Fig. 2.—Thin section of portion of a Bauxite concretion, Katni, Jabalpur, showing gibbsite crystals (colourless) in bauxitic (dark) groundmass.

A typical thin section of a concretion from the Katni rock throws considerable light on the structure and internal characters of bauxite (Fig. 2). The mass of the rock is made up of white opaque bauxite with a well-defined banded structure near the exterior of the concretion. Scattered through the interior and avoiding the outer band, are numerous irregular areas of gibbsite in rosette-like aggregates. Dispersed everywhere irregularly through the interior of the section, but disposed in more or less linear arrangement in the outer band, are numerous minute black and brown specks, too small, indeed, to be determined with ease or accuracy. The black grains are, however, almost certainly ilmenite, while the brown granules may be rutile, but, from comparison with other sections, are thought to be more probably the clove-brown micaceous ilmenite.

A consideration of the disposition of the gibbsite indicates clearly that it is being formed at the expense of the bauxite, and, indeed, the process may be traced in the section in all its stages. A slight clearing takes place in the opaque mass, and an irregular translucent microcrystalline area is formed. In this area, tiny flecks of gibbsite are developed, gradually coalesce, and finally fill the whole area. This process of crystal growth is especially well marked along the internal edge of the concretionary border, where the gibbsite is extending outwards into the newly accreted bauxite. That bauxite is being converted to gibbsite, and not the reverse, is confirmed by the occurrence of banded gibbsite on the walls of the pores that ramify through the mass.

The evidence of thin sections, therefore, shows that the change in laterites, so far from being one of dehydration to diaspore, as postulated by Holland,[1] is one of hydration to gibbsite. This conclusion is supported by the occurrences of gibbsite found by Messrs. Warth, Fermor, and the writer in widely separated parts of India, and all these show that, at least under the generally prevailing, comparatively humid Indian conditions, gibbsite is the stable hydrate of alumina. Strong negative evidence to the same effect lies in the fact that diaspore has not yet been recorded from India. As a matter of fact, the evidence against hydration quoted by the above writer, being drawn mainly from the petrological characters of certain rocks in the Salem and Coimbatore districts, is considered by the present writer to be inapplicable to the more humid parts of India. The average annual rainfall for Salem is but 39·20 inches per annum, while that for Coimbatore is even less (21·10 inches). At both stations rain fell during ten months of the year 1904. There is thus little opportunity for hydration, while dehydration might well be effected. But the argument derived from such a dry region can obviously not be applied to the lateritic deposits of the Western Ghats with their rainfall of 120–180 inches in four months of the year.

Finally, the conclusions to which the writer has been led in connection with laterite are the following:—

1. Lateritic deposits are restricted geographically, because they require for their formation—
   (a) Tropical heat and rain with concomitant abundant vegetation.
   (b) Alternating wet and dry seasons.
2. Their restriction in altitude is only apparent. Their present lines of altitude merely mark ancient or existing basin floors or plains.
3. They are derived from mineralized solutions brought to the surface by capillarity, and are essentially replacements (either mechanical or metasomatic) of soil or of rock decomposed *in situ*, or of both.
4. In the humid regions of India the tendency of change in laterites is towards hydration and not towards dehydration.

[1] Geol. Mag., Dec. IV, Vol. X (1903), p. 65.

The foregoing replacement hypothesis would appear to supply a fairly reasonable explanation for all the eccentricities of laterite. When it was first developed by the writer, it was thought to be entirely novel, but investigation of the literature of the subject has shown that several writers have suggested the alternation of wet and dry seasons as a predisposing cause [1]; while Hislop [2] says that "the ferruginous matter coming up from among the metalliferous strata, might, by the agency of water, have impregnated every decaying rock on the surface, which, with the subsequent infiltration of rain, would then present the appearance of laterite, as we now find it"!

IV.—Notes on the Operculate Madreporaria Rugosa from Yass, New South Wales.

By A. J. Shearsby.

(PLATE XXVI.)

THE town of Yass, N.S.W., is situated on the Southern Railway about 190 miles from Sydney. It is the centre of one of the most picturesque districts to be met with on the journey from Sydney to Melbourne. The surrounding country is a veritable geological and palæontological paradise for the collector, who may depend upon turning up some new and interesting specimens every trip he takes to the district. The town itself is built on the Upper Silurian rocks, which about two miles distant, at a bend in the Yass River known as Hatton's Corner, offer to the palæontologist one of the most prolific collecting-grounds in Australia. Amongst the first to investigate these rocks were the Rev. W. B. Clarke [3] and Mr. C. Jenkins,[4] whose work was followed by a survey in 1882 by the Mines Department.[5] Further good work was done by Mr. John Mitchell [6] whilst stationed in the district; but even at this late hour there is a large amount of interesting work awaiting completion.

About ten miles to the south and south-west of the town are found the vast accumulations of Middle Devonian deposits, which are separated from the Upper Silurian rocks by a thick bed of lavas and tuffs which I believe to be the result of volcanic action during the Lower Devonian period.[7]

[1] Broughton, Journ. As. Soc. Bombay, vol. v (1857), p. 639; Lapparent, Traité de Géologie, p. 1611.

[2] Journ. As. Soc. Bombay, vol. v (1857), p. 63.

[3] W. B. Clarke: "Remarks on the Sedimentary Formations of N.S.W.," 4th edition, 1878.

[4] C. Jenkins, "Geology of Yass Plains": Proc. Linn. Soc. N.S.W., vol. iii, pt. 1 (1878), p. 26.

[5] T. W. E. David, "Report on the Fossiliferous Beds, Yass": Ann. Rep. Dept. Mines N.S.W., 1882 (1883), p. 148.

[6] J. Mitchell, "Notes on the Geology of Bowning": Proc. Linn. Soc. N.S.W. (2), vol. i, pt. 4 (1887), p. 1193. "The Geological Sequence of the Bowning Beds, N.S.W.": Report Austral. Assoc. Adv. Science, vol. i, 1888 (1889), p. 291.

[7] A. J. Shearsby, "On the Occurrence of a Bed of Fossiliferous Tuff, etc.": Proc. Linn. Soc. N.S.W., 1905, p. 275.

During a recent collecting tour around Yass, I was fortunate enough to find a large number of specimens of the genus *Rhizophyllum*, amongst which were a new species which I am describing as *R. robustum*, and several specimens of *R. interpunctatum*, De Kon., possessing the opercula *in sitû*. *R. robustum* makes the fourth species of this genus which has been described from the Upper Silurian of the Yass district; and from fragments I have in my collection I am of the opinion that there are several others which await determination.

The following is a description of the new species :—

Genus RHIZOPHYLLUM, Lindström.

RHIZOPHYLLUM ROBUSTUM, sp. nov. (Pl. XXVI, Figs. 1–6.)

Corallum simple, pyramidal, short, widely expanded above, acutely pointed below, lateral angles rounded, section semicircular, plano-convex. Dorsal surface convex; ventral surface flat, both horizontally and vertically. Calice semicircular, moderately deep; dorsal margin sharp and thin, slightly arched above the level of the ventral margin; ventral margin thick, horizontal, with well-marked central fossula. Several thin projecting septa are noticeable on the ventral margin.

A thick corrugated epitheca covers the corallum; that on the ventral side being partly replaced by minute rosettes of Beekite. A portion of the ventral surface is broken away, and shows to a depth of about a quarter of an inch the weathered vesicular internal structure of the corallum. These vesicles have their convex surfaces facing inwards and upwards.

No traces of anchoring stolons are visible on the specimen, the Beekite rosettes near the lateral angles naturally tending to confuse, if not altogether obliterate, these processes. A small portion, probably about a quarter of an inch, of the apex is missing, but otherwise the specimen is well preserved.

The specimen exhibits a most interesting illustration of rejuvenescence by calicinal gemmation; about half of the calice of the corallum being occupied by the upper portion of a young form, which exhibits in a marked degree the same characteristics as the parent form, with the addition of a sub-central depression in the calice. (Pl. XXVI, Fig. 4.)

The measurements of *R. robustum* are as follows:—Parent corallum, length of dorsal surface $1\frac{1}{8}$ inches, length of ventral surface 1 inch.

Note.—Both of these measurements may be increased by an additional quarter of an inch, for, as mentioned previously, portion of the apex is missing.

Parent corallum, greatest diameter of calice $1\frac{1}{8}$ ins., least $\frac{5}{8}$ in. The measurements of the calice of the young form are :—Greatest diameter $\frac{11}{16}$ in., least $\frac{3}{8}$ in., depth $\frac{3}{16}$ in.

R. robustum differs from *R. interpunctatum*, De Kon., by its much greater size and particularly the manner in which the dorsal margin rises above the level of the ventral, causing the angle made between the operculum when closed to be obtuse; while in *R. interpunctatum* the angle is acute on account of the dorsal surface being much shorter than the ventral; and also the ventral surface of *R. robustum* is flat both horizontally and longitudinally; on the other hand, in *R. interpunctatum* the ventral surface is convex longitudinally.

It is also easily distinguished from *R. australe*, Eth. fil., by its greater size and more deltoid shape and because the ventral surface of *R. australe* is convex in longitudinal section.

It is distinct also from *R. enorme*,[1] Eth. fil., being much smaller in size, more deltoid in shape, and the dorsal surface possessing a higher degree of convexity. The vesicles in *R. robustum* are also much smaller.

It differs from *R. yassense*,[2] Shearsby, in which form the apical angle is obtuse and the upper portion of the ventral surface is convex, being turned in towards the calice.

I have not yet been successful in my endeavours to find an operculum of this species.

Locality and horizon.—Impure limestone on the Wargeila road about half a mile west of Yass Junction Railway Station; Upper Silurian.

Collection.—A. J. Shearsby.

In the accompanying Plate XXVI, illustrating this paper, I have given lateral views of the three other described species found at Yass. The convexity of the ventral surfaces (*v*) of *R. australe* (Fig. 8) and *R. interpunctatum* (Fig. 15) is here well shown in comparison with the flat ventral surface of *R. robustum.* The acute angle between the operculum and ventral surface of *R. interpunctatum* is also clearly illustrated.

Fig. 7 is an outline of a median perpendicular section of *R. yassense*, wherein is depicted the inturned ventral margin of that species.

Operculum, exothecal processes, and calicinal gemmation of *R. interpunctatum*, De Kon. (Figs. 12, 12*a*).

In his description of this species Mr. R. Etheridge, jun.,[3] mentions that the operculum was unknown, and states that the total apparent absence of exothecal structure in *R. interpunctatum* showed a departure towards *Calceola*, in which genus there is no trace of them. I have succeeded in collecting a very large number of this species of *Rhizophyllum*, and several of the specimens have the operculum *in sitû*; in addition to these a few detached opercula have rewarded my search.

Figs. 9 and 11 (Plate XXVI) show a corallum with the operculum closed. Figs. 17 and 18 illustrate a fine and almost complete specimen showing the corallum with its operculum widely opened.

The operculum is semicircular and thick, concavo-convex. The upper or outside surface is convex, and is sculptured with concentric bands or lines of growth. The under or inner surface is concave, with a stout median ridge starting from the straight hinge-line, and projecting only about half-way across the surface. Near the hinge where the ridge is stoutest is a small, deep, pit-like, triangular depression, into which the counter septum fits when the operculum

[1] Rec. Geol. Surv. N.S.W., vol. vii (1903), p. 232.
[2] Proc. Linn. Soc. N.S.W., pt. iv (1904), p. 869.
[3] Rec. Aust. Museum, vol. i (1891), p. 203.

is in its place. In several specimens in my collection the insertion of the counter septum in this depression when the operculum is closed is well shown. Besides possessing the stout median ridge, the under surface shows traces of lateral septal ridges. Fig. 12 shows these faintly, but Fig. 12*a* exhibits the granular radiating nature of the ridges more distinctly.

Fig. 18 is a lateral view of a corallum with operculum *in sitû* and widely opened. In this figure will be noticed the thickness of the operculum at the hinge-line, and the projecting nature of the median ridge.

Exothecal processes.—Although some scores of these interesting corals have passed through my hands, I have found in only a couple of instances traces of rootlets or anchoring stolons. In both of these the extreme apex of the ventral surface bear two or three very small knobs or protuberances. These being so delicate is no doubt one of the reasons why a complete specimen with rootlets is so rare. Another reason is the apices of the majority of the corals found are missing. One small species of *Rhizophyllum* which I presented to the Australian Museum some time ago exhibits the exothecal processes very clearly, showing as it does at the lateral angles four little knobs, two on each side of the apex. Fig. 16 is a specimen of *R. interpunctatum* from Hatton's Corner, which, besides showing a budding form, has two protuberances on the middle of the ventral surface which may be the remains of rootlets. This is the only specimen I have found which shows them in this position, so I am figuring it for future reference.

Calicinal gemmation.—Many of the specimens which I have collected at Hatton's Corner show very distinct calicinal gemmation. In all of these the young form has completely filled the calice of the parent corallum. Examples of two of these are figured in Pl. XXVI, Figs. 13 to 16. The latter one is of special interest on account of exhibiting, as mentioned above, what appear to be remains of the exothecal processes or anchoring stolons.

Locality and horizon.—Hatton's Corner, Yass; Upper Silurian.

Collection.—A. J. Shearsby.

Further note on the Exothecal Processes of *Rhizophyllum*.

Previous to sending away the foregoing paper I made a minute and lengthy search in places where I knew these corals abounded in order to obtain more complete information as to the occurrence of rootlets on both species; but in spite of over a hundred specimens passing through my hands I was unsuccessful.

It was only about a week after the paper was sent away that I visited a bed of impure coral limestone at Derrengullen Creek, a few hundred yards above the crossing-place of the Yass-Wargeila road, and found amongst numerous other Corals and Brachiopods some fine specimens of *R. robustum*, *R. interpunctatum*, and *R. australe*, Eth. fil. In my description of *R. robustum* I stated that no traces of anchoring stolons or rootlets were visible, the Beekite rosettes tending to destroy any trace of them. One of my specimens from

Derrengullen Creek, however, exhibits the remains of eight stout rootlets (Pl. XXVI, Fig. 19). There were probably more than this number on the complete coral, as the apex is missing, and specimens collected at this locality which have the apex show remains of at least six on this part of the coral.

Of these rootlets some are scattered over the ventral surface, but most of them are situated along the lateral angles. They are hollow and cylindrical, and in some cases branching, and range from mere filaments to as much as a millimetre in thickness. The specimen figured presents another example of calicinal gemmation, the young coral in this case completely filling the calice of the parent form, and exhibiting also an instance of abnormal growth, one side of the coral having grown much faster than the other.

The remaining figures illustrate some fine examples of rootlets on *R. interpunctatum* and *R. australe* from the same locality. In my previous paper I stated that I had only found a couple of specimens showing the exothecal processes, and these consisted of small protuberances at the apex, the remains of probably very small and delicate processes. I figure one (Fig. 16) showing two little knobs about the middle of the ventral surface, which I said might be the remains of rootlets. I am now able to say that my surmise was correct, as I have several examples of this species, which, besides having a liberal allowance of rootlets along the lateral angles, possess extra ones at or near the middle of the ventral surface. Figs. 20–22 are specimens of *R. interpunctatum* which exhibit very clearly the tubular anchoring stolons projecting from the lateral angles. Fig. 21 shows three strong lateral rootlets and the remains of one near the middle of the ventral surface. Fig. 20 is an interesting specimen showing a small parent coral from which has budded a much larger form. This younger coral shows three strong rootlets and one more delicate growing from the lateral angle.

Figs. 23 and 24 are specimens of *R. australe* which exhibit both lateral and median rootlets, Fig. 23 also possessing one on the dorsal surface.

Nearly all my previous specimens of *Rhizophyllum* were obtained in the shale beds at Hatton's Corner, Yass, and in spite of the large number collected there, only two showed faint traces of rootlets. On the other hand, every specimen, with few exceptions, obtained recently during an afternoon's search at this new locality showed remains of well-preserved rootlets in many instances.

It would seem, then, that at Hatton's Corner they had been subjected to violence of some kind before being finally deposited in the shale bed. The violence probably consisted of being rolled to and fro by the action of the waves in the vicinity of the coral reefs which abounded there at that period. The worn and rounded pieces of other corals occurring at Hatton's Corner, in places giving the shales an amygdaloidal appearance, should, I think, help to confirm this opinion.

The occurrence of the delicate rootlets on *Rhizophyllum* in an almost perfect state at Derrengullen Creek, together with some beautifully preserved small undescribed species of ***Tryplasma*** and ***Cyathophyllum,*** which also possess remains of delicate anchoring stolons, points to the existence of quieter waters, probably in the shape of a lagoon or harbour free from the violence of heavy seas.

EXPLANATION OF PLATE XXVI.

FIGS. 1–18: Upper Silurian operculate corals from Hatton's Corner, Yass, N.S.W.:

FIG. *Rhizophyllum robustum*, Shearsby.

1. Dorsal view.
2. Ventral view, showing fossula, septa, and vesicular tissue.
3. Lateral view.
4. Calice, showing fossula and calicinal bud.
5. Apical view.
6. Part of ventral surface, showing vesicular tissue. × 2.

Rhizophyllum yassense, Shearsby.

7. Outline of vertical median section.

Rhizophyllum australe, Eth. fil.

8. Lateral view.

Rhizophyllum interpunctatum, De Kon.

9. Lateral view with operculum *in situ.*
10. Apical view.
11. Dorsal view with operculum *in situ.*
12. Operculum, inner surface showing median ridge with pit-like depression.

12*a*. Operculum, inner surface showing median ridge and radiating granular lateral ridges.

13. Ventral view of specimen with calicinal bud.
14. Lateral ,, ,,
15. Dorsal ,, ,,
16. Another specimen, ventral view showing calicinal bud, and remains of two exothecal processes (?).
17. Dorsal view of an almost complete specimen with operculum *in situ* and widely opened, showing median ridge and radiating lateral ridges of operculum, and the counter septum and septa of the ventral wall.
18. Lateral view of same specimen, showing projecting nature of median ridge of the operculum.

d = dorsal surface. *v* = ventral surface.

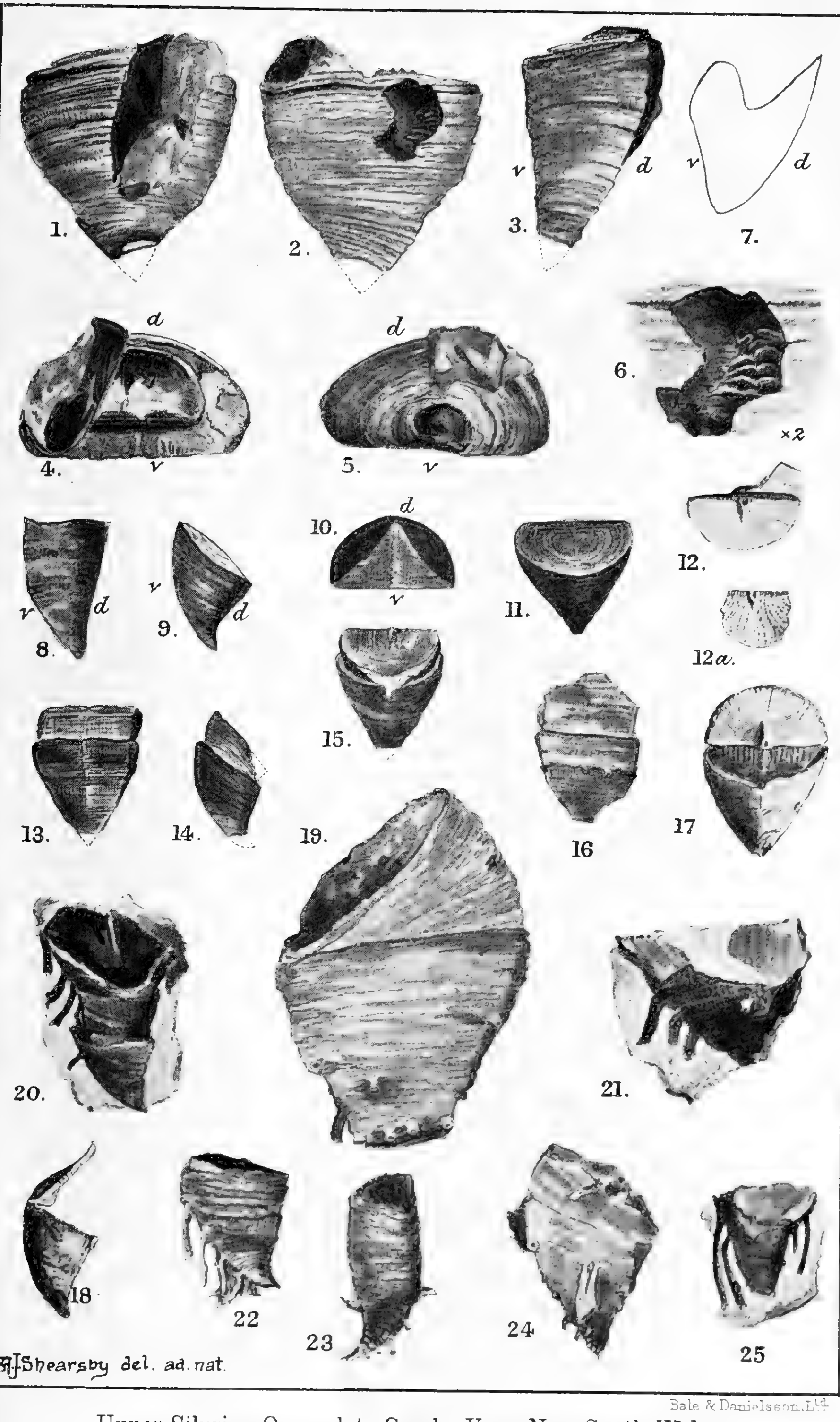
Note.—Fig. 6 is twice natural size; all the other figures are drawn natural size.

FIGS. 19–25: Upper Silurian operculate corals showing exothecal processes, from Derrengullen Creek, Yass, N.S.W.:—

FIG.

19. *Rhizophyllum robustum*, Shearsby. Ventral view showing remains of rootlets, and abnormal growth of calicinal bud.
20. *R. interpunctatum*, De Kon. Dorsal view of budding form, showing one rootlet on the small parent form and four on the bud. The bud also shows a strong counter septum.
21. *R. interpunctatum.* Ventral view showing three strong rootlets at the lateral angle and one near the middle of the ventral surface.
22. *R. interpunctatum.* Lateral view showing rootlets.
23. *R. australe*, Eth. fil. Lateral view with lateral and median rootlets on the ventral surface, and also one on the dorsal surface.
24. *R. australe.* Ventral view with lateral and median processes, and one near the middle of the ventral margin.
25. *R. interpunctatum* (?). Dorsal view of specimen showing four rootlets.

Note.—Figs. 19–25 are slightly magnified.



Upper Silurian Operculate Corals, Yass, New South Wales.

V.—On Concretionary Nodules with Plant-Remains found in the Old Bed of the Yarra at S. Melbourne; and their Resemblance to the Calcareous Nodules known as 'Coal-Balls.'

By Frederick Chapman, A.L.S., etc.,
Palæontologist to the National Museum, Melbourne.

ALTHOUGH many of the nodular bodies met with in sedimentary rocks which were formerly held to be concretions or simple aggregations of mineral matter have since been found to be due to the work of minute animals or plants, there is yet a more numerous class of true concretions which were undoubtedly formed by chemical reaction in the surrounding water and sediments; the resulting precipitation being often deposited upon nuclei of organic origin, as fish, woody fragments, or shells. Occasionally these nodules were of subsequent formation to the deposit in which they occur. In nodules which include organic remains, the segregation was accelerated by the partial decay of the included organic fragments.

To the latter class belong some interesting examples of spheroidal concretions lately brought under my notice by a keen observer, Mr. F. Spry, of Melbourne. In June, 1900, sewerage excavations were being carried on in S. Melbourne, and at Power Street, near Grant Street, 16 feet below the surface, the concretionary nodules were found which form the subject of this paper. The workmen here struck the bed of one of the old channels of the Yarra estuary. At the time of the formation of this deposit (probably late Pleistocene) the mouth of the Yarra was situated three or more miles to the eastward of the present river mouth, the Saltwater and Yarra Rivers having had separate outlets, instead of, as now, the former joining the latter before entering Hobson's Bay. The earlier course of the Yarra to the sea was thus shortened by about six miles. The estuary was evidently much farther back in late Pleistocene times; but since then the shore-line has been gradually encroaching on Hobson's Bay, owing to the vast quantities of silt carried down by the Yarra and Saltwater Rivers, and also by the drifting of the shore-sand from the eastward, which has been continuously supplied by the disintegration of the Tertiary cliffs from Brighton to Beaumaris. This process of filling up has more than kept pace with the subsidence of the area of the Yarra Delta, as indicated by the level of the old river channel, which is now found at five feet below low-water at S. Melbourne. Since the actual subsidence of this area, however, there has been what is perhaps best termed a negative movement of the shore-line, resulting in a six-foot raised beach, preserved at various parts around Port Phillip Bay.

The details as to the conditions under which the clay nodules were found have been kindly supplied me by Mr. Spry, who considers that the channel, to which reference has been made, was not the main bed of the river, but a neighbouring backwater, occasionally subjected to tidal influences.

On the sides of the valley sloping to the old river channel at S. Melbourne, several flattened nodules, circular in outline, were found embedded in silt, and in close proximity to the clay bottom. The angle of slope of the sides of the channel at this spot was about 2° (1 in 30). Externally, these nodules have the appearance of flattened balls of clay, mixed throughout with small fragments of dark-brown lignitoid plant-remains and fragments of charred wood.[1] On splitting open some of the nodules, which easily separate, sometimes along the median (equatorial) plane, or in parallel cakes, there is revealed a moderately thick layer, almost entirely composed of matted fragments of woody and foliaceous material, around and amongst which the clay, permeated with a large amount of carbonate

Fig. 1.

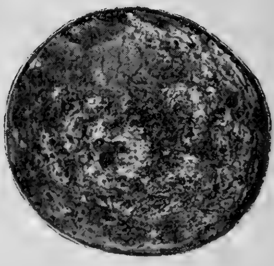


Fig. 2.

Fig. 1.—Cleaved surface of nodule from the old bed of the Yarra at S. Melbourne, showing included fragments of wood. (One-half the diameter of original.)

Fig. 2.—Convex outer surface of the same nodule, showing small fragments of charred wood. (Reduced one-half.)

of lime, seems to have accumulated. The calcareous nature of these nodules is shown by the strong effervescence on treatment with H Cl.

A little of the outer crust of the nodule was taken for examination under the microscope, when it was seen to consist of quartz-grains, fine calcareous and argillaceous particles, brown woody tissue, and valves of the marine diatom *Actinocyclus*.

The residue of the powder from the nodule, after treatment with H Cl, showed it to consist largely of a fine angular quartz sand, the grains of which have a diameter varying generally between ·1 mm.

[1] Mr. Spry has also shown me portions of branches of gum-trees, one of which has been charred by fire. These he found at the bottom of a sewer manhole at the corner of McGowan and Power Streets, at 14 feet from the surface and about 4 to 6 feet below the present low-water mark. Prehistoric bush-fires must have been of frequent occurrence, and may be ascribed to the action of lightning. At the time of writing this note there is a paragraph in the *Argus*, February 14th, 1906, reporting several bush-fires having been started by lightning at Chetwynd and Kadnook in Western Victoria. An interesting feature connected with the above occurrence of drifted wood was a bank of marine shells 7 inches thick, left behind the logs by the retreating tide. See also the reference to charred wood in coal-seam nodules by A. C. Seward ("Fossil Plants," vol. i, p. 88).

and ·018 mm. Some tourmaline and zircon crystals were also present, probably derived from the acid igneous dykes of the neighbourhood, and also remains of diatoms.

These nodules differ in appearance from the irregular concretions found in the estuarine swamps near Melbourne, in having an almost circular outline, as if artificially rounded (so much so that the workmen considered them to be 'faked'). From the occurrence of the nodules on the sides of the old river channel, and seated in depressions, we may reasonably assume that they received their form in 'kettles' or 'potholes' in the clay bottom of the river bed, within reach of tidal influence.

It was whilst examining the calcareous nodules from the old Yarra channel that the writer was impressed with the close resemblance they bore to the 'coal-balls' of the Coal-measures in England. The coal-seams of the Yorkshire and Lancashire Coalfields contain calcareous nodules which include portions of Coal-measure plants in a very perfect state of preservation. These nodules vary in size, but are usually a few inches in diameter, and more or less flattened. They are spoken of as 'coal-balls,' although that term has also been applied to the rounded nodules of pure coal having a concentric structure, which are met with in the coal-seams of England, France, New South Wales, and elsewhere. The former class of 'coal-balls,' however, are highly calcareous, being composed of about 70 per cent. of carbonate of lime and magnesia, and 30 per cent. of oxide of iron, sulphide of iron, etc.[1] A great interest attaches to these calcareous 'coal-balls' on account of their having furnished the palæobotanists Binney, Williamson, Scott, and others with some of the best preserved Coal-measure plants upon which they based their valuable observations.

The general form of the nodules from the Coal-measures is a flattened sphere; and in this respect, amongst others, they resemble the nodules from the Yarra. That the shape of the 'coal-balls' is due to segregation of carbonate of lime from the overlying beds deposited radially and concentrically is open to serious objection, since the nodules include pieces of *Lepidodendron* stems, Calamitean roots, and other woody remains, which, by their rod-like shape in the conglomerated mass of sticks and stems, would tend to interfere with an incipient crystallization or segregation acting from a central point. This idea of segregation *in sitû* is, however, the generally accepted one, and was clearly stated by Professor T. Rupert Jones in his Presidential Address to Section C, British Association Meeting at Cardiff in 1891,[2] in the following words:—"The 'coal-balls' of Oldham, in Lancashire, and the bullions at South Owram, in Yorkshire, are calcareous-carbonaceous nodules in coal, having been formed by the infiltration of water carrying carbonate of lime from the shells in an overlying shale

[1] See Cash & Hick: Proc. Yorkshire Geol. and Polytech. Soc., vol. vii (1878–1881), p. 73. Also Seward: "Fossil Plants," vol. i (1898), p. 85.

[2] Report, 1892, p. 13. See also D. H. Scott: "Studies in Fossil Botany," 1900, p. 11.

down into the bed of woody fragments and other bits of dead plants. The carbonate of lime there segregated from the mass to certain centres, and preserved, in round nodules, the vegetable structures, before they were quite decomposed, more or less distinct, as they had fallen on the forest floor."

Considering the perfect preservation of most of the stems, leaves, and other plant-remains found in the nodules from the Coal-measures, it seems evident to me that they were sealed up at an early stage in the formation of the deposit. The calcareous matter was most likely supplied by small shells, such as Goniatites,[1] caught up in the tangled mass of vegetable remains, which, on being dissolved by the organic acids generated from the decaying bodies of small organisms likely to be present, quickly redeposited around the woody fragments, and, as in the case of the nodules from the Yarra, the balls finally received their rounded contour from the swirling action of eddies and currents.

On breaking open one of the nodules from the Yarra, the resemblance to a fractured 'coal-ball' is very striking, the plane of fracture often showing a matted mass of twigs and woody fragments, together with seeds and some of the more durable leaves. In the light of the data used in the above comparison it is therefore certainly worth a further enquiry into the tenability of the theory of the 'coal-balls' of England being formed *in sitû*; and especially in view of the evidence already known, which goes to prove an allochthonous origin for much of the coal-deposits of various ages in different parts of the world.

VI.—A New Palæoniscid Fish from the Base of the Pendleside Series near Holywell, Flint.

By Dr. R. H. Traquair, F.R.S., F.G.S.

THE remains of a Palæoniscid fish from the Lower Carboniferous rocks of Flintshire, submitted to me by Mr. J. T. Stobbs, are unfortunately not sufficiently perfect to afford material for a complete diagnosis. The specimen shows the impressions of the outer surface of both mandibular rami and of the left maxilla, and beyond this we have only a mass of dislocated scales—the general form of the fish, the position of the fins, and the condition of the fin-rays being entirely lost.

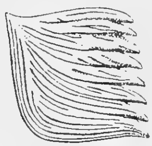
The mandible is three-quarters of an inch in length, slender and tapering, the external sculpture, according to the impression left, consisting of fine close ridges, which, in feather fashion, diverge upwards and forwards and downwards and forwards from a line running longitudinally along the middle of the surface, thus forming

[1] Whilst writing these notes I have received a valuable and suggestive paper by M. H. Douvillé, "Les 'Coal-balls' du Yorkshire," from the Bull. Soc. Géol. France, sér. IV, vol. v, pp. 154–156, pl. vi, in which that author records the association of large numbers of Goniatites (*Gastrioceras*), *Nautilus*, *Orthoceras*, *Aviculopecten*, and other marine shells, with the coal-balls and their vegetable contents.

a series of backwardly directed acute angles. The maxilla is of the usual palæoniscid form, the suborbital process being long and slender, and the expanded postorbital portion ornamented, according to the impression, with fine ridges, which mostly run parallel with the posterior and superior borders.

Among the scales may be distinguished some which are nearly equilateral and only slightly oblique—these belonged to the flank; others, longer than high, were ventral in position; while others again, smaller in size and more oblique in contour, appertained to the tail. The flank scales are about $\frac{1}{10}$ inch in height, and have nearly the same breadth; the overlapped area is scarcely perceptible; the free surface is marked with fine striæ, which run mostly parallel with the upper and lower margins, a very few of the lowest ones turning up in front so as to run parallel with the anterior margin, while again a number of deeper indentations divide the posterior margin into six to eight strong and sharp denticulations. The ventral scales, being lower in contour, have fewer denticulations on

Fig. 1.



$\frac{10}{1}$

Fig. 2.

$\frac{10}{1}$

Fig. 1.—Flank scale of *Elonichthys denticulatus*, Traquair, sp. nov.
Fig. 2.—Ventral scale of same species.
Lower Carboniferous Rocks (Pendleside Series): near Holywell, Flintshire.
Both figures magnified ten diameters.

the hinder border, these numbering from three to five. As to the caudal scales, though it is evident that they remained highly ornate up to the extremity, it is not clear how far posteriorly the denticulated character persisted.

The configuration of the mandible and maxilla clearly proves that the place of the present fish is in the family Palæoniscidæ, but owing to the complete absence of fins or fin-rays the evidence as to the genus is not conclusive. According to the form and sculpture of the scales, and the configuration of the jaws, the fish might appertain either to *Rhadinichthys* or to *Elonichthys*. Perhaps the scales have the greatest resemblance in sculpture to those of *Elonichthys Egertoni* (Egert.), but the denticulations of the posterior margin are proportionally coarser. Any way the association, on these scales, of fine striæ with comparatively coarse denticulations of the hinder margin, is a feature which leads me to believe that the species is new to science. I therefore propose to name it *Elonichthys denticulatus.*

NOTICES OF MEMOIRS.

I.—Memoirs of the Geological Survey.

THE following Memoirs, in addition to those already noticed, have been issued during the present year :—

(1) The Geology of the Scilly Isles. By George Barrow, F.G.S., with petrological contributions by J. S. Flett, M.A., D.Sc. 8vo; pp. 37, with 7 plates. (Price 1*s.*)

In this memoir a particular description is given of the Granite and associated rocks which form the Isles of Scilly.

Attention is also directed to the various superficial deposits of Raised Beach and Blown Sand, and to the occurrence of Glacial Drift. The evidence of recent movements in the area is discussed, and remarks are made on the industries and on the water supply.

The memoir is accompanied by a colour-printed geological map (Sheets 357 and 360), and it contains six plates depicting the scenery. The map is the first issued of the area on the one-inch scale; the price is 1*s.* 6*d.*

(2) The Geology of the Country near Sidmouth and Lyme Regis. By H. B. Woodward, F.R.S., W. A. E. Ussher, F.G.S., with contributions by A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. 96, with a plate and 39 text-figures. (Price 1*s.*)

In this memoir there is a description of the strata exhibited in the fine cliff-sections from the New Red Sandstone and Marl of Sidmouth to the Rhætic Beds and Lias of Axmouth and Lyme Regis, together with an account of the overlying Gault, Upper Greensand, and Chalk. Inland the country around Honiton and Axminster is described. Figures are given of some of the common Lias fossils found in this richly fossiliferous region. The plateau and valley deposits, the famous Landslip of Bindon, and the economic products of the area receive due attention.

The memoir is accompanied by a colour-printed map (Sheets 326 and 340), price 1*s.* 6*d.*

(3) The Geology of the Country around Macclesfield, Congleton, Crewe, and Middlewich. By T. I. Pocock, M.A., with contributions by G. Barrow, W. Gibson, B.Sc., C. B. Wedd, B.A., and J. A. Howe, B.Sc., and notes on fossils by E. T. Newton, F.R.S. 8vo; pp. 138, with 2 plates and 8 text-figures. (Price 2*s.* 6*d.*)

This memoir is descriptive of parts of Cheshire and Staffordshire, including the northern end of the Potteries Coalfield, and portions of the coalfield and salt-bearing districts of Cheshire. We note that the term Pendleside Series is adopted for the strata between the Carboniferous Limestone and Millstone Grit.

The area, consisting mainly of Carboniferous and New Red rocks, is extensively covered with drift; and a detailed account is given of these superficial deposits, together with notes on the shells from the high-level gravels of Macclesfield.

The memoir is accompanied by a colour-printed map (Sheet 110), price 1*s.* 6*d.*

(4) The Water Supply of Suffolk from Underground Sources, with Records of Sinkings and Borings. By W. Whitaker, B.A., F.R.S., with contributions by H. F. Parsons, M.D., H. R. Mill, D.Sc., and J. C. Thresh, D.Sc. 8vo; pp. 177, with map. (1906. Price 3*s.* 6*d.*)

In this memoir Mr. Whitaker gives a general outline of the water-bearing strata, and summarizes some points of special geological interest in connection with the numerous records of borings. Notable among these records is that of a boring at Glemsford, which proved a thickness of 470 feet of Glacial Drift, much to the perplexity of the well-borer, and of special interest to the geologist as being the greatest recorded thickness of Glacial Drift in Britain. Full details are given of the Stutton boring, which was carried down to a depth of 1,525 feet, reaching Palæozoic rocks beneath the Gault. The records deal mostly with wells or borings for water, and analyses of water are appended. Dr. Mill contributes a map and statistics relating to the rainfall.

(5) Water Supply of the East Riding of Yorkshire, from Underground Sources, with Records of Sinkings and Borings. By C. Fox-Strangways, F.G.S., with contributions by H. R. Mill, D.Sc. 8vo; pp. 181, with map and 3 illustrations. (Price 3*s.*)

This memoir contains an outline of the geology of the East Riding and of portions of the Vales of York and Pickering, with especial reference to the water-bearing strata. It contains records of all known sinkings and borings in the area, together with analyses of waters, and a bibliography. There is also a section on the rainfall with a colour-printed map, by Dr. Mill.

(6) Soils and Sub-Soils from a Sanitary Point of View. With especial reference to London and its Neighbourhood. By Horace B. Woodward, F.R.S. 8vo; pp. 58, with 18 illustrations and colour-printed map. Second edition. (Price 1*s.* 6*d.*)

The object of this work has been to supply information regarding sites for houses and other questions involving the applications of geology to sanitary science; and it includes notes on sewage-farms and cemeteries. In this second edition the chapter treating of water-supply and drainage has been enlarged, with especial reference to the residential areas within easy reach of the Metropolis. A new colour-printed map on the scale of an inch to four miles is given in the memoir. It includes Guildford, Sevenoaks, Chelmsford, and Rickmansworth.

II.—The Tenth Meeting of the International Geological Congress, held in the City of México, September, 1906. [Being the Abstract of a Report prepared and communicated by Bernard Hobson, M.Sc. Vict., F.G.S., a Memb. Int. Geol. Congress.]

The tenth triennial meeting of the International Geological Congress was held this year in the city of México. The Mexican Government acted with the greatest liberality towards the members of the Congress, while the inhabitants of the country did their utmost to make their visitors feel that Mexico was not behind any other country in its hospitality to strangers. Excursions to places of geological interest were set on foot, and an excellent guidebook, containing the most recent information relating to the districts to be visited, was provided. The excursions included visits to Vera Cruz, the volcanoes of Jorullo and Colima, Mitla Monterrey, San Luis Potosi, the isthmus of Tehuantepec, etc.

The Congress was opened in the School of Mines on September 6th by the President of the Republic, General Porfirio Diaz.

The first paper presented was a memoir entitled "Die Trochilisken," by M. Karpinski. These are fossils of problematic origin, limited to the Devonian. Mr. Heilprin read a paper on "The concurrence and interrelation of Volcanic and Seismic Phenomena," in which he advanced the opinion that earthquakes considered to be of tectonic origin may really be due to volcanic agency sometimes remote from the seat of the disturbances. In the discussion which followed Professor A. C. Lawson, of Berkeley, California, dissented from this view.

Dr. Renz's paper, "Ueber das ältere Mesozoicum Griechenlands," showed the importance of the marine Trias of Alpine facies in Greece, and pointed to the identity with the Trias of some marmorized limestones hitherto regarded as Cretaceous.

On September 7th a party of the members, under the guidance of the Secretary, Mr. E. Ordóñez, inspected the olivine-basalt lava stream at Coyoacan, six miles S.S.W. of México. The lava issued from the volcano of Xitli, and it covers 60 square kilometres, being 30 kilometres long and 5 kilometres in maximum width (E. Ordóñez in Bol. del Inst. Geol. de México, No. 2, 1895).

At the meeting on the 8th September Professor F. D. Adams, of Montreal, described the Geological Map of North America prepared at the expense of the Geological Survey of the United States, the material having been supplied by the Geological Surveys of Mexico, the United States, and Canada. The nomenclature adopted is that of the American Survey. In the discussion following the reading of this paper the nomenclature was in some points called in question by the Canadian geologists present.

Professor Edgeworth David, of Sydney, then read a paper on "Changes of Geological Climates," with special reference to Cambrian and Permo-Carboniferous glaciation in Australia and India.

The climatic evolution of the earth from the Palæozoic to the present epoch was the subject of a paper by Professor Frech, of Breslau, who maintained that this evolution has always progressed in correlation with changes in the proportion of carbon dioxide and aqueous vapour in the atmosphere. A discussion upon this paper took place at the afternoon session. Professor Stefanescu, of Bucharest, described a new species of *Dinotherium,* viz. *D. gigantissimum* (Stef.), which he discovered in 1888 at Manzati, in Roumania. This is the first complete skeleton found up to the present time.

An excursion, in which 190 members of the Congress took part, was made on the following day (9th September), under the auspices of the Mexican Geological Society, to Cuernavaca, 74 miles south of the city of México. Fine views were obtained *en route,* including a distant one of the snow-capped Popocatapetl.

On the 10th September the discussion on the condition of climates in geological time was renewed and concluded, and on the 11th a large number of members joined in an excursion to San Juan Teotihuacan, the sacred city of the ancient Toltecs, situated 29 miles north-east of México. Here they inspected two pyramids dedicated to the Sun and Moon, the former 216 and the latter 151 feet in height.

The meeting of the 12th September was occupied by the reading and discussion of a paper by Mr. Joh. Königsberger, entitled "Ueber den Verlauf der Geoisothermen in Bergen und seine Beeinflussung durch Schichtstellung, Wasserläufe, und chemische Processe." It was followed by papers on the latest eruption of Vesuvius by Mr. Sabatini and Dr. Tempest Anderson, and in the evening of that day the members of the Congress were entertained at a banquet at the palace of His Excellency the President.

An excursion to the silver-mines of Pachuca was carried out on the 13th September.

On the 14th September Professor A. C. Lawson presented his paper on the earthquake of San Francisco, which provoked an interesting discussion. Professor Frech pointed out the analogy between the Californian earthquakes and those preceding them in Europe, notably that of Dobratsch, in Carinthia. He drew attention to the fact that the earthquake of Dobratsch followed, equally with that of California, a certain tectonic line which was conspicuous both in the mountain formation and in the course of the valleys. He also pointed out the remarkable fact that in neither country was there any true volcanic action.

A paper, which must have proved interesting to the glacialists, was read by Professor A. P. Coleman, of Toronto, on "Interglacial Periods in Canada."

"A Meteorite Crater of Arizona" was the subject of a communication by Professor H. L. Fairchild, of Philadelphia, and in the afternoon of the same day Professor Edgeworth David read his paper on the occurrence of diamond in matrix at Oakey Creek, Inverel, New South Wales.

Mr. H. F. Reid, of Baltimore, then communicated an extract from the report of the International Committee on glaciers, and the

General Secretary that of the Committee on Co-operation in Geological Investigations.

Mr. Sjögren, of Stockholm, gave an invitation for the eleventh meeting of the Congress to take place at Stockholm, at the instance of Messrs. Törnebohm and J. G. Anderson, President and Secretary of the Swedish Committee. This invitation was gladly accepted, and, after some congratulatory remarks by the President and others, the Congress was declared closed.

REVIEWS.

I.—Geology of Armenia.

A Treatise on the Geology of Armenia. By Felix Oswald, B.A., D.Sc. Thesis accepted by the University of London for the Degree of Doctor of Science. In two parts: I. Geological results of a journey by the author through Turkish Armenia. II. The Geological Record of Armenia. 8vo; pp. ix, 516, maps, plates, and sections. London (printed at Dulwich by the author, and published by the author at Iona, Beeston, Notts), October, 1906. Price one guinea, net, 100 copies only printed.

THIS is a remarkable book in more ways than one. It is no small feat to write a book on the geology of Armenia, which embodies all that has gone before, plus a vast amount of original research; but when the traveller and author deliberately sits down to set up his own manuscript, draw, print, and colour his own maps and sections, and turn out the five hundred and odd pages of a complete book, with the sole exception of the binding, it demands more than passing attention.

Mr. (now Dr.) Oswald accompanied Mr. H. F. B. Lynch on his second journey through Turkish Armenia in 1898. Mr. Lynch's volumes appeared in 1901, and the delay in publication of Dr. Oswald's book is due to the fact that he prepared many of the maps, plans, and other illustrations for his friend's work, before finding the necessary leisure to prepare his own. He acknowledges help received from Dr. T. G. Bonney, Mr. R. B. Newton, Mr. G. C. Crick, Col. F. R. Maunsell, and Col. G. S. Elliot, and these names, together with the Bibliography (pp. 487–500) and the general treatise on Armenian geology, show that the work has been sweeping and comprehensive in character.

The country dealt with lies between the Caspian and Black Seas, including to the south the Euphrates and Tigris rivers and the lakes Van and Urmi. The author's route, told in successive chapters each geologically treated, was as follows:—Constantinople to Trebizond, Trebizond to the Vavuk Pass, to Erzerum, to Khinis, to Tutakh, to Akhlat, thence to the Tauric Heights, the Nimrud Volcano, Akhlat to Sipan, to Khamur, to the Bingöl Cliffs, Bingöl Volcano, Erzerum to Trebizond. The observations made during this journey occupy thirteen chapters, and the remaining ten chapters treat of the general geology of Armenia system by system. The volume closes with a note by Dr. Bonney on rocks collected by Mr. Lynch in 1893, a bibliography, and voluminous index. On the value of the two last items we need not enlarge.

In an introductory chapter Dr. Oswald discusses the orography of the Asiatic continent, and calls attention to the Armenian plateau as the natural bridge between Central Asia and Southern Europe, illustrating his remarks with maps. He regards the chief eras of mountain folding in Armenia as belonging to the Lower Permian, ante-Tithonian, and post-Oligocene periods, and at each time the pressure came from the south (the Arabian tableland), while the northern limit to all this folding was formed by the great granitic 'horst' of the Meschic Mountains. The lines of fracture are carefully explained in the text and on the maps, and the author points out that the position of the numerous volcanos of Armenia is by no means fortuitous, but on the contrary they have invariably arisen along these lines, while those volcanos which occur at points of intersection are proportionately larger. Gently folded Miocene limestones are characteristic of the plateau, but never occur in the border ranges; on the other hand, while metamorphic schists are characteristic of the Taurus, they occur only quite exceptionally in the plateau region. The depressions along the lines of fracture became filled by lake-deposits during Pliocene and Pleistocene times, and lavas and tuffs of contemporary volcanos became interbedded with the later deposits, and assisted in levelling the pre-existing inequalities of the ground.

Special attention has been paid to the petrology, and numerous long footnotes describe in detail the rocks met with by the author in his journey. The book is remarkably free from misprints, is full of topographical detail, and is the first attempt which has been made to write a systematic geological history of an interesting portion of the world. One can only regret that Dr. Oswald has (owing to the extreme difficulties under which his volume has been produced) printed but one hundred copies, for it is quite evident that his book must remain for a considerable period the chief work of reference on the geology of Armenia. C. D. S.

II.—Geological Map of the Colony of the Cape of Good Hope. Sheet I. Published by the Geological Commission, 1906. Geology: by A. W. Rogers, E. H. L. Schwarz, and A. L. Du Toit.

The Geological Commission of Cape Colony has now been at work for over ten years. During this period it has issued valuable Annual Reports with small scale maps illustrating the areas surveyed. The present map, then, can be regarded as the outcome of years of arduous field-work, undertaken by the Director, Mr. A. W. Rogers, with the assistance of Messrs. E. H. L. Schwarz and A. L. Du Toit. The manner in which this survey has always been carried on has led us to expect that the final map would be a standard. There can be no doubt that Sheet I represents the results of long-continued and brilliant geological investigation.

The present map, which is on the scale of about 3·7 miles to the inch, includes Cape Town and its well-known suburbs; the towns of Robertson, Ladygrey, Caledon; and the coastline from a little north of Cape Town to within ten miles of Cape Agulhas. The farms are named and their boundaries represented. Heights are unfortunately few and far between—a serious omission on a map on which the mountain ranges are only indicated by a name written along their general trend.

The geological formations represented by colour extend from the Malmesbury Series to the Uitenhage Series, the superficial deposits being uncoloured. The intrusive rocks are shown by two colours, one for the dolerites and diabases and another for the quartz porphyries and granites intrusive into the Malmesbury Series. The colours throughout are clear and distinctive, and bring out the structure at a glance.

The alterations from maps published previous to the work of the Commission include the representation of a series of grits, arkose, and conglomerates—French Hoek Beds—probably newer than the Malmesbury Series and certainly older than the Table Mountain Sandstone. The Witteberg Series are separated and coloured distinctively from the Table Mountain Sandstone. This clearly brings out the structure of the folded regions. A considerable area of the Dwyka Series and Ecca Series is shown on the downthrow side of the Worcester-Robertson Fault. The Enon Conglomerate is definitely correlated with the Uitenhage Series.

It is nowadays demanded of a Geological Survey that it should be of economic value. In questions of water supply from underground sources, irrigation works, and agriculture, the present map is patently of service. It is not, however, so generally known that the systematic geological survey of Cape Colony has yielded results of fundamental importance in determining the geological succession of the neighbouring, and, from a mining point of view, more favoured colonies. In this respect it is not altogether gratifying to learn that the work of the Cape Geological Surveyors is more keenly watched and more highly appreciated abroad than in this country.

While engineers will naturally make use of these maps, no geologist, claiming to be cosmopolitan in his aims, can neglect the structure so clearly illustrated in the geology of Cape Colony.

The map is unpriced.

III.—A New Geological Map of North America.

AT the meeting of the Tenth International Geological Congress in the city of Mexico, on September 6th, copies of a new geological map of North America were distributed to the members present. It is accompanied by a descriptive text written by Mr. J. G. Aguilera, "Aperçu sur la géologie du Mexique pour servir à l'explication de la Carte géologique de l'Amérique du

Nord." The map itself is entitled "Congrès Géologique International. Dixième Session, 1906. José G. Aguilera, Président. Ezequiel Ordóñez, Secrétaire général. Carte Géologique de l'Amérique du Nord. Dressée d'après les sources officielles des Etats Unis, du Canada, de la République du Mexique, de la Commission du Chemin de Fer Intercontinental, etc. Henry Gannett, Géographe. Bailey Willis, Géologue. Echelle 1 : 5,000,000, 1906." (Scale = 78·9 miles to one inch.)

The map embraces the whole of North America, and includes Alaska, the Parry Islands, Greenland, Iceland, Canada, United States, Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, the West Indies, and part of Colombia and Venezuela. By an extraordinary oversight the island of Cozumel off Yucatan is omitted. Twenty-five distinctive colours are employed, the subdivisions being Effusive Rocks, Intrusive Rocks, Pre-Cambrian, Eo-Algonkian, Neo-Algonkian, Metamorphic Palæozoic, Palæozoic, Cambro-Ordovician, Ordovician, Silurian, Devonian, Carboniferous, Mississippian, Pennsylvanian, Permian, Trias, Jurassic and Triassic, Lower Cretaceous, Upper Cretaceous, Laramie and allied formations, Eocene, Neocene, Miocene, Pliocene and Quaternary, Quaternary. The Quaternary is only shown in localities where it completely covers the subjacent formations.

As one would naturally expect, there are blank areas in parts of Alaska, North-West Canada, Idaho, Nevada, Utah, Arizona, California, New Mexico, Texas, Lower California, and the States of Guerrero, Oaxaca, and Vera Cruz, and parts of Honduras, Costa Rica, Nicaragua, and Panama.

The map is beautifully printed, and consists of four sheets, each $28\frac{3}{4}$ inches (73 cm.) by $37\frac{1}{4}$ inches ($94\frac{1}{2}$ cm.), measured over the engraved work.

The comparative scantiness of place-names is a slight drawback in a very handsome and useful map.

The colour index is in French and Spanish.

This map is the result of a resolution proposed by the late Professor I. C. Russell at the Ottawa meeting of the Geological Society of America, to the effect that it was desirable to prepare a geological map of North America for the International Congress at the city of Mexico. A committee was appointed, consisting of Professor I. C. Russell (chairman), Professor F. D. Adams, Sr. José G. Aguilera, Mr. C. W. Hayes, and Mr. Bailey Willis. Mr. Bailey Willis was officially charged with the work of compiling the map.

The accompanying pamphlet by Mr. Aguilera consists of a title-page and 22 pages of text (size of page 11 inches by $7\frac{3}{4}$ inches), and gives a useful sketch of the geology of Mexico. Fuller details will be found in the "Sinopsis de geología Mexicana," Bulletins 4, 5, and 6 of the Inst. Geol. de México, 1897, of which an abstract appeared in *Science Progress* (New Series), vol. 1, 1897, pp. 609–615. A pamphlet by Mr. Bailey Willis entitled "Carte géologique de l'Amérique du Nord" (and in English, "Geological Map of North

America") also accompanies the map, and consists of a title-page and 12 pages (11 inches by 7¾ inches). It consists chiefly of historical introduction and notes on classification and colouring of the Geologic Series. BERNARD HOBSON.

IV.—GEOLOGICAL SURVEY OF CANADA. A. P. LOW, B.Sc., Deputy Head and Director. PALÆOZOIC FOSSILS. Vol. iii, part 4 (and last). By J. F. WHITEAVES, LL.D., F.G.S., F.R.S.C. pp. 243–352, with pls. xxiii–xlii. (Ottawa, September, 1906.)

THIS memoir contains four distinct papers, numbered in continuation of those contained in the previous parts, viz.: (5) The fossils of the Silurian (Upper Silurian) rocks of Keewatin, Manitoba, the north-eastern shore of Lake Winnepegosis, and the lower Saskatchewan River. (6) The Canadian species of *Plectoceras* and *Barrandeoceras*. (7) Illustrations of seven species of fossils from the Cambrian, Cambro-Silurian, and Devonian rocks of Canada. (8) Revised list of the fossils of the Guelph Formation of Ontario.

5. The Keewatin fossils comprise two series. The first, collected at Rainy Island and 17 to 30 miles below it, consist of few and fragmentary specimens which were originally referred provisionally to the Devonian. The second series, obtained in 1901 from similar rocks on the Ekwan River and other localities in the province, furnished unmistakable evidence of the true age of the rocks, which proved to be Silurian. The following classes are represented in these collections, which contain twenty-three species from the Ekwan River, described in Ann. Rep., vol. xiv, pt. F, 1904, but illustrated in this memoir for the first time:—Spongiæ, Anthozoa, Hydrozoa, Echinodermata, Polyzoa, Brachiopoda, Mollusca, Crustacea (Ostracoda, Trilobita).

The fossils from Manitoba (Stonewall and Davis Point, Lake Manitoba) comprise a few species of Corals, Brachiopods, and Molluscs; those from Davis Point, Lake Manitoba, three species of Corals and a doubtful Stromatoporoid. From the north-east shore of Lake Winnepegosis, and also from the Lower Saskatchewan, species representative of the Anthozoa, Brachiopoda, Mollusca, and Crustacea were obtained.

6. This section contains critical comments upon the following species of *Plectoceras* and *Barrandeoceras*; the original descriptions of both genera and species being given in full:—*Plectoceras Jason*, Billings (sp.); *P. Halli*, Foord (sp.); *P.* (?) *undatum*, Conrad (sp.); *Barrandeoceras natator*, Billings (sp.); *B. Minganense*, Hyatt; *B. subcostulatum*, Whiteaves; *B. vagrans*, Billings (sp.).

7. These species have been described, at various times, in the *Canadian Record of Science* or in the *Ottawa Naturalist*, but none of them have been either described or figured in the publications of the Geological Survey, and four have not previously been figured anywhere. They are as follows:—*Anomalocaris Canadensis*, Whiteaves, from the Cambrian rocks of British Columbia, a species

of doubtful affinities; *Cyrtoceras Quebecensis*, Whiteaves, from the Levis Formation of Quebec; *Steganoblastus Ottawaensis*, Whiteaves, *Matheria brevis*, Whiteaves, and *Spyroceras Beauportense*, Whiteaves, from the Trenton Limestone of Quebec and Ontario.

8. This list chiefly concerns the nomenclature of the species, which has been brought up to date, but it also includes changes made in the identification of the species based on the reconsideration of their supposed affinities in the light of new or more ample material. Dr. Whiteaves adds important observations on some of the species from his own rich stores of knowledge, and Dr. E. O. Ulrich also contributes valuable criticisms on some of the species that were submitted to him. The groups dealt with belong to the Anthozoa, Hydromedusæ, Brachiopoda, and Mollusca.

An appendix containing errata to parts 1–3 of the volume, and an index to the generic and specific names in the whole volume, complete the work. A. H. F.

V.—Geological Survey: Western Australia. Bulletin No. 22: The Auriferous Deposits and Mines of Menzies, North Coolgardie Goldfield. By Harry P. Woodward, Assistant Government Geologist. 8vo; pp. 1–92, with two maps and six plates of sections. (Perth, W.A., 1906.)

THIS excellent report upon the important gold-mining district of Menzies forms part of a series treating of different mining centres of the State.

The geological work is based upon Mr. W. D. Campbell's topographical map prepared in the year 1899. The area embraced by the report covers about 50 square miles, and includes the productive part of the district so far as it has been investigated.

In its salient geological features Menzies consists of a complex of basic rocks with intrusive acidic dykes which were most probably derived from the large granitic mass forming the higher ground in the vicinity of Springfield, near the eastern border of the map. A covering of superficial deposits has rendered geological mapping difficult, but the different rock masses have been delineated as accurately as the scale of the field plans would admit of.

The basic crystalline rocks are of much importance owing to their intimate connection with the auriferous quartz reefs of the district. They consist mostly of amphibolite and diorite, with their derivatives—serpentine, chlorite, and hornblende schists.

The acidic rocks occupy only a relatively limited area of the surface in the vicinity of Springfield, though their presence to the north and west has been proved in wells and quarries. They consist of gneiss, mica schist, and sericite schist, and, as is the case with the basic rocks, the schistose character seems to be lost at a variable depth below the surface. A portion of the field is traversed by numerous acidic dykes, generally represented by sericite schists and allied rocks, with transitions to porphyritic granite.

The quartz reefs, which are confined to the greenstones, are of various types and of somewhat different characters. Most of the gold from Menzies has been obtained from segregation reefs, which have an irregularly lenticular form; they constitute a series of small but rich parallel veins. There are also one or two fissure veins, which though poor in their gold contents are promising by reason of their extent and their probable continuity in depth.

Mr. Woodward has made an examination of all the mines to which he could obtain access, and has supplied full descriptions of each in relation to their economic value and to their geological characteristics.

Statistics show that a little more than 400,000 ounces of gold were obtained up to the close of 1905, and it is observed that a considerable quantity is still got out by working miners aided by a State battery.

This report by Mr. H. P. Woodward deserves commendation for the very careful manner in which it has been prepared, and the Chief Geologist is to be congratulated upon having acquired the services of so able a coadjutor in the work of the Survey.

A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The opening meeting of the Session was held on November 7th, 1906. Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the chair.

The following communications were read:—

1. "The Upper Carboniferous Rocks of West Devon and North Cornwall." By E. A. Newell Arber, M.A., F.L.S., F.G.S.

After a reference to the previous work in the area, the author gives a description of the coast-sections, which display a highly disturbed sequence of Upper Carboniferous rocks. Special attention is paid to two lithological types — the carbonaceous rocks, which contain inconstant and impersistent beds of the impure, smutty coal, known locally as 'culm'; these beds have yielded plant-remains; and the calcareous rocks, partly of marine and partly of fresh-water origin, consisting of well-marked, impersistent bands of impure limestone, and conglomeratic beds of calcareous nodules embedded in shales. One of the limestone bands, the Mouthmill Limestone, is marine, and contains an abundant fauna; while in others the only fossils are *Calamites Suckowi* and *Alethopteris lonchitica*. The calcareous nodules, which are not ferruginous, occur in thin shale-beds, 2 to 3 feet thick; they commonly contain a marine fauna, with Goniatites, Lamellibranchs, and fish-remains. The fossil flora and the horizon of the beds are next discussed, lists of plants being given from various localities; and the conclusion is reached that the rocks belong to the Middle Coal-measures, and that there is no evidence of Upper Coal-measures. Conglomerates of water-worn pebbles are also present, the pebbles being derived plant-petrifications, possibly of earlier age than the sandstones and shales in which they occur. Two distinct and unmingled faunas are present in the rocks: one consists of fresh-water Lamellibranchs, and the other of marine fishes, Cephalopods, and Lamellibranchs; and the evidence as to horizon obtained from them agrees with that yielded by the plant-remains. The paper concludes with a bibliography.

2. "The Titaniferous Basalts of the Western Mediterranean." By Dr. Henry S. Washington, For. Corr. Geol. Soc.

In 1905 the author visited the volcanic districts of Catalonia, Sardinia, Pantelleria, and Linosa. He recognizes the existence in this region of a hitherto unrecognized petrographic province, in which the basalts contain a remarkably high percentage of titanium. The rocks are of Tertiary age. Labradorite, augite, and olivine are the essential minerals, with titaniferous magnetite and apatite, and in some cases subordinate nepheline. The rocks vary from compact to highly vesicular; they are not conspicuously porphyritic, though small phenocrysts of augite and olivine, and occasionally felspar, are sometimes present. Olivine nodules occur in some cases. The textures are those common in basalts, and ophitic relations are almost wanting. A series of analyses is given; the silica varies from 44 to 52 per cent., the alumina from 12 to 19, and the titanium-oxide from 2 to 5. The last oxide appears to be chiefly contained in titaniferous magnetite. Phosphoric pentoxide is distinctly abundant, and appears to vary, as the titanium does, with the amount of iron-oxides. Soda is dominant over potash in every instance. The augites are almost, if not quite, colourless. The classification of the rocks according to the quantitative system is discussed, and the majority of the basalts fall into the 'Salfemane' class, the exceptions being some of the Sardinian basalts and that of Graham's Island.

The extent of the region is as yet problematical, and the author points out that along the southern coast of France there are several 'basaltic' volcanoes, and it is possible that these may eventually turn out to be connecting links between the rocks of Sardinia and those of Catalonia, or possibly extrusion southward is indicated by the occurrence of phonolite at Maid Gharian, near Tripoli.

CORRESPONDENCE.

THE SOMABULA DIAMOND FIELD.

Sir,—Some months ago Sir John Willoughby presented to the Museum of Practical Geology a selection of minerals, accompanied by photographs and plans, to illustrate the geology of the Rhodesian diamond fields. These are now on exhibition on the main floor of the Museum. It fell to my lot to determine the minerals, and as the results are not exactly the same as those obtained by Mr. Mennell and given in his paper on the Somabula diamond field in the October number of the Geological Magazine, I take the liberty of sending you a few notes.

The principal discrepancy between our results is that the remarkable variety of enstatite, very hard and sometimes of a red-brown colour, which he describes as common in the deposits, is absent from all the collections which I have seen. Staurolite, on the other hand, which he does not mention, is very abundant. It occurs in worn crystals, black or dark brown, and with crystalline faces not good enough for measurement on the reflecting goniometer. The angles, however, agree well with those of staurolite. A curious fact is that no cross twins, so characteristic of this mineral, were observed among the crystals. Seeing that kyanite is so abundant, the presence of staurolite is exactly what might be expected. Mr. Mennell is not disposed to agree with Professor Gregory that the diamonds may have been derived from pegmatites, but the conclusion to which I was led by an inspection of the minerals of the alluvial deposit was that they could have come only from the margin of a granite and a contact aureole. The whole paragenesis indicates this. Not one of the minerals I have seen resembles those of the Kimberley diamond pipes. JOHN S. FLETT.

THE TRIMINGHAM CHALK.

SIR,—It seems to me also desirable to make a few comments on Mr. Brydone's letter in your November number. I did not "affect to regard" his note about his use of the magnetic for the true north "as addressed to myself personally." The communication, though it also expressed Mr. Hill's views, was written by myself to save time and trouble. Our remark was not intended as a criticism of anybody, but to explain why we had not altered the terms which we began to employ fourteen years ago, when our attention was concentrated more on the hypothesis advanced in the Geological Survey Memoir than on verbal details. We took those terms from the general direction of the coast, as shown on the Ordnance Survey Map, and I maintain that our practice, the statements in my note (except that the misprint, Weymouth for Weybourne, escaped correction), and my use of the word 'trend' are correct. The "trend of a coast" is not "ever varying from point to point and as you take it at the base or top of the cliff," but it expresses, according to Nares, Johnson, Webster, and others, the general direction, especially where there is a bending, of a coast, mountain chain, etc.

I never asserted the arch in my sketch to be identical with that to which Mr. Brydone referred in his papers. I said "the isolation of the more notable bluff is now complete," and gave a description of what then remained. My sketch and the photograph published by Mr. Hudleston in your November number exhibit the later stages of the work begun in October, 1905. My purpose in stating that a certain mass of chalk was a separate boulder was to imply, not that Mr. Brydone had denied this, but that the fact, under all the circumstances, diminished rather than increased the probability of a neighbouring mass being a seastack.

In regard to the line (*g*) in my sketch (the basement bed, according to Mr. Brydone, of the grey chalk) and my missing it on the opposite side, I can only plead the difficulty of seeing what one believes to be non-existent, but must confess that I did not understand him to mean that the *O. lunata* chalk had such a curiously irregular surface as he assigns to it in his last letter; that, however, in my opinion, only increases the difficulties in his hypothesis of an intra-Cretaceous unconformity. As this hypothesis appeared to me (as it still does) a fundamental one, and the other evidence insufficient to overcome its inherent improbability, I considered myself justified in limiting my criticism to the questions which lay within my more special field of work, and am now content to await further developments as the sea continues its inroads.

T. G. Bonney.

9, Scroope Terrace, Cambridge.

THICKNESS OF LAND-ICE.

Sir,—I have just sufficient acquaintance with your reviewer of Chamberlin & Salisbury's Text-book, vol. i, to be able to discuss what was in his mind in penning the sentence to which Professor Schwarz takes exception in your November number, though I shall not venture to defend his gratuitous interjection of a reference to Professor Schwarz's views on the occasion in question.

Professor Schwarz claims that certain physicists have proved by calculation that ice cannot attain a greater thickness on the earth's surface than 1,400 to 1,600 feet, and with implicit faith in this calculation he seeks to reconcile the result with the geological evidence. The reviewer, however, probably lacking sufficient knowledge of physics to criticize the calculation, and being also doubtful whether the result is one on which all physicists are agreed, has fallen back upon the available geographical and geological evidence, and on this evidence alone has felt no hesitation in rejecting the postulated limits. He has, no doubt, considered that the Greenland ice-sheet, as described by Peary, must at its maximum far exceed the thickness allowed by these physicists; and he probably also still believes that the Antarctic ice in the valleys of the interior surpasses this limit, in spite of the ingenious argument of Professor Schwarz as to the progressive deepening of such valleys.

Then, as regards bygone glaciation, the reviewer perhaps remembered the glacial phenomena in British Columbia, where there is every indication that ice-sheets have filled pre-existing valleys to a much greater depth than 2,000 feet; and he may have recalled the conditions in the north-eastern portion of the United States, where the uplift of boulders in the Adirondacks, if due, as usually believed, to land-ice, must imply a thickness of ice on the Canadian lowland far exceeding the supposed limit.

Or without going so far afield, he may have had in mind the conditions of glaciation in the Isle of Man, where the highest summit, over 2,000 feet above present sea-level, has been striated transversely to the direction of the hill-range by ice which must have risen considerably above the summit, while there is strong evidence that the same ice-sheet filled up the adjacent basin, now occupied by the Irish Sea, which was certainly in existence before the glaciation. And indeed, since I know that this reviewer accepts the 'land-ice theory' for our glacial drifts he would find no dearth of instances where the geological evidence is incompatible with the restriction supported by Professor Schwarz.

Furthermore, I have reason to believe that the reviewer gathered from at least one physicist that the calculation in question would not be trustworthy under the conditions of a moving ice-sheet. In short, this reviewer and I are at one in concluding that the evidence for the past and present existence of ice of greater thickness than 1,600 feet is so strong that the physicists who wish to apply this limitation may be advised, in their own interest, to revise their calculations. G. W. LAMPLUGH.

NOTTINGHAM.
November 7th, 1906.

THE KEISLEY LIMESTONE.

SIR,—While welcoming Dr. Marr's paper on the Keisley limestone, in your November issue, as a most important addition to our knowledge of that rock, I should like to point out a slight inaccuracy repeated from his and Nicholson's previous paper on the Cross Fell inlier—a mistake discovered several years ago while accompanying Professor P. F. Kendall's field class in Westmorland.

Dr. Marr says (quoting from the previous paper)—"at a point where a tributary stream (Rundale Beck) enters Swindale from the east," etc. This should be *Small Burn*, and not Rundale Beck.

His description of the *Staurocephalus* limestone applies to the beds below the junction of Small Burn and Swindale Beck, while around the junction of Rundale (or Great Rundale) Beck and Swindale Beck, about 220 yards further south, the Stockdale shales are developed, into which a lamprophyre dyke is intruded, as shown in the section on the map accompanying the paper on the Cross Fell inlier.

The streams are correctly named in the description of this area in the Survey Memoir on "The Geology of Appleby, Ullswater, and Haweswater" (pp. 36 and 41).

The names of the streams are taken from the 6-inch Ordnance Map, and I take this opportunity of pointing out the mistake, so that strangers to the district may not be misled by the wrong naming of the stream, if they should ever wish to make a closer acquaintance with this interesting bed in the field. E. J. EDWARDS.

12, NORWOOD TERRACE, LEEDS.
November 8th, 1906.

THE LOOSE VALLEY, ETC., NEAR MAIDSTONE.

Valleys of subsidence initiated by Swallow-holes.

Sir,—My attention has for some time been called to the formation of valleys from what seems to me a new point of view, and both at and near Malling the evidence for this seems as clear as one can expect in these cases.

This evidence seems to point that these valleys, all of which are in the same formation, viz. the Hythe Beds, and I would also include some valleys in the Chalk, have been initiated by swallow-holes, and that these have been in their primary stage *formed from below*, by the uprise of the water up lines of weakness under hydrostatic pressure.

Many of these swallow-holes still exist parallel with the course of the valley, but high and dry, and many of these are known by local names as Jacob's Hole, Baldwin's Hole, etc. Some still contain water, and are situated *at the heads* of some of the side valleys and are fed by springs.

It appears also that much more has been done by way of erosion by the invisible underground stream than by the visible one, and the shape of the valley sides, very steep in places, indicates subsidence consequent on the giving way of the valley under the weight above, rather than by subaerial action alone, though this of course has contributed.

In the case of Loose Valley we have instances of the loss of the stream for over a quarter and half a mile respectively, not an unusual occurrence in limestone areas, but here accompanied by what, as far as I know, is a most unusual feature, viz., that the loss of the valley accompanies the loss of the stream, and that where this occurs the valley ceases practically to exist, and is bridged over. Another governing factor seems to be the varying proportion of the Rag to the soft Hassock, as where the valley ceases there the Hassock is very thin and there the quarries occur, naturally at the place where the Rag is thicker.

Another interesting feature is the fact that there are various water-levels in this valley, and one case is that of a spring pond at a much higher level than the river and running over into it, a phase in the former state of that valley when this pond was a deep swallow-hole. Again, too, there occur many natural pools along the course of the river, and where these occur the valley assumes a crater-shaped form as if these pools also had once been deep swallow-holes, now worn away. That the loss of the river and of the valley must have escaped notice when the geological map was made, is shown by the fact that at the part where the last issue of the river takes place at the foot of the rise which there terminates the valley, a fault has been mapped, cutting off the Atherfield Clay, which it appears merely passes under that rise.

But I think I have said enough to show that both the Loose and the Malling Valleys deserve attention from all those interested in valley formation. F. J. Bennett.

West Malling.
October 3rd, 1906.

THE ZONES OF THE LOWER CHALK.

SIR, — In the November number, p. 507, Mr. Jukes-Browne comments on my "curious method of estimating the affinities of a fauna."[1] The faunas compared are those of—

A. The Chalk above the Burwell Rock of Cambridgeshire and Suffolk, containing 51 species, 33 of these being common to the Burwell Rock.

B. The Burwell Rock of Cambridgeshire, with 87 species.

C. The Chalk Marl of Cambridgeshire, with 25 species, of which 23 occur in the Burwell Rock.

The "more rational" course advocated by Mr. Jukes-Browne is to ascertain whether A or C contains the greater number of species common to B, irrespective of the fact that fauna A is twice as large as fauna C.

By his method, since all three faunas are closely related, the larger of the two faunas A and C is bound to appear the more closely related to B. Therefore I prefer to compare the percentage of forms in A common to B (67 per cent.) with the percentage of forms in C common to B (92 per cent.).

With Mr. Jukes-Browne's statement that taking a larger area, including Bedford and Hertford, the fauna of the Totternhoe Stone, excluding reptiles, "comprises 96 species, of which only 23 range downward into the Chalk Marl of the counties mentioned," I cannot agree. His own General Memoir records 31 such forms; and I have already recorded *Nautilus elegans* in addition to all these. The Chalk Marl of these counties contains 35 species, of which 32 are common to the 'Totternhoe Stone,' i.e. 91 per cent., a figure in close agreement with the percentage quoted for the smaller area. In support of my contention that the zone of *Ammonites varians* should include the Totternhoe Stone, I give the subjoined chart, p. 575. Upon this I have plotted most of the species in the Burwell Rock of Cambridgeshire which are not recorded from the Chalk Marl of that county. The species chosen occur in the Lower Chalk of Folkestone and also at some intermediate locality.

Forms above the line **A B C** have not been recorded below the 'Totternhoe Stone' of the region indicated.

Forms below the line **A B C** are not recorded above the Chalk Marl (unless marked *).

Forms actually upon the line **A B C** occur in the 'Totternhoe Stone' and also in the Chalk Marl.

Thus the line **A B C** represents the base of the 'Totternhoe Stone.'

The straight line **A D** represents the top of the 'Totternhoe Stone,' and also, as I maintain, the top of the zone of *Ammonites varians*.

Thus we see that the fauna which occurs above the base of the 'Totternhoe Stone' in the north, is within the Chalk Marl of the south, and that the transition is gradual.

But, on the other hand, the line **A D** separates two different faunas.

[1] See my Article "Zones of the Lower Chalk," GEOL. MAG., Sept. 1906, p. 412.

Below it there is always the *Ammonites varians* fauna, containing: *Pecten elongatus, Discoidea subuculus, Nautilus deslongchampsianus, Nautilus elegans, Turrilites, Baculites,* and *Actinocamax lanceolatus.*

Above it is the *Holaster* Chalk with *Cidaris Bowerbanki, Echinocyphus difficilis, Holaster trecensis, Discoidea cylindrica* (hemispherical form), *Ptychodus decurrens.*

Fossils of the Totternhoe Stone.

Cambridgeshire.	Bedfordshire and Hertfordshire.	Oxfordshire, Buckinghamshire, and Berkshire.	Folkestone.
D Chalk containing *Cidaris Bowerbanki, Ptychodus decurrens, Holaster trecensis, Echinocyphus difficilis,* and *Discoidea cylindrica* (hemispherical form).			A
Oxyrhina Mantelli.	*O. Mantelli.*	...	*O. Mantelli.*
Protosphyræna ferox.[1]	*P. ferox.*	...	*P. ferox.*
Notidanus microdon.	...	...	*N. microdon.*
Corax falcatus.	...	...	*C. falcatus.*
Ammonites cenomanensis.	*A. cenomanensis.*	...	*A. cenomanensis.*
Actinocamax lanceolatus.	*Act. lanceolatus.*	...	*Act. lanceolatus.*
Pecten Beaveri.	*P. Beaveri.*	*P. Beaveri.*	**P. Beaveri.*
Pecten elongatus.	*P. elongatus.*	*P. elongatus.*	*P. elongatus.*
Pholodomya decussata.	*Ph. decussata.*	*Ph. decussata.*	*Ph. decussata.*
Inoceramus striatus.	...	*I. striatus.*	*I. striatus.*
Ammonites navicularis.	*A. navicularis.*	*A. navicularis.*	*A. navicularis.*
Hemiaster Morrisi.	*H. Morrisi?*	*H. Morrisi.*	**H. Morrisi.*
Solarium.	...	*Solarium.*	*Solarium.*
Nautilus deslongchampsianus.	...	B *N. deslongchampsianus.*	*N. deslongchampsianus*
Turrilites costatus.	...	*T. costatus.*	*T. costatus.*
Turrilites Scheuchzerianus.	*T. Scheuchzerianus.*	*T. Scheuchzerianus.*	*T. Scheuchzerianus.*
Ammonites rhotomagensis.	*A. rhotomagensis.*	**A. rhotomagensis.*	**A. rhotomagensis.*
Pleurotomaria.	*Pleurotomaria.*	**Pleurotomaria.*	*Pleurotomaria.*
Neithea quinquecostata.	*N. quinquecostata.*	**N. quinquecostata.*	*N. quinquecostata.*
Lima aspera.	*L. aspera.*	**L. aspera.*	*L. aspera.*
Ammonites Coupei.	*A. Coupei.*	*A. Coupei.*	*A. Coupei.*
Palæga Carteri.	*P. Carteri.*	*P. Carteri.*	*P. Carteri.*
Aporrhais.	*Aporrhais.*	*Aporrhais.*	*Aporrhais.*
Scaphites æqualis.	*S. æqualis.*	*S. æqualis.*	*S. æqualis.*
Ammonites varians.	*A. varians.*	**A. varians.*	*A. varians.*
Nautilus elegans.	**N. elegans.*	*N. elegans.*	*N. elegans.*
Discoidea subuculus.	...	*D. subuculus.*	*D. subuculus.*
Rhynchonella Martini.	*R. Martini.*	*R. Martini.*	*R. Martini.*
Ammonites Mantelli.	*A. Mantelli.*	*A. Mantelli.*	*A. Mantelli.*
Rhynchonella grasiana.	**R. grasiana.*	**R. grasiana.*	**R. grasiana.*
Turrilites tuberculatus.	...	*T. tuberculatus.*	*T. tuberculatus.*
Lima globosa.	**L. globosa.*	**L. globosa.*	*L. globosa.*
Inoceramus latus.	**I. latus.*	*I. latus.*	...
C And 14 others.	Etc.	Etc.	Etc.

Fossils of the Chalk Marl.

In conclusion, I may say that the Discoideas from the *Holaster trecensis* beds of Cambridgeshire seem to be distinguishable from those in the zone of *A. varians* (including the Burwell Rock), but I am not yet sure of being able to separate them from the large forms in that zone in the south.

[1] Not listed in the General Memoir, but fairly common at Burwell.

On the other hand, *Cidaris Bowerbanki* is a characteristic and easily recognisable fossil in the Chalk above the zone of *A. varians* as understood by me. It has only been recorded in the lower zone near Lewes, and does not occur in the 'Totternhoe Stone.' As an index, it seems much more suitable and definite than any of those species suggested by Mr. Jukes-Browne.

I still maintain, however, that it is more practicable to use the "Two Holasters," which are commoner fossils; and it does not seem unreasonable to use in partnership two contemporary species of different habitat to indicate beds deposited under variable conditions at the same time. Mr. Jukes-Browne has shown at some length that my brief summary of the occurrences of *Holaster subglobosus* contains some inaccuracies. This I am willing to admit; but the necessary corrections do not affect the main conclusion—that it requires the *two* Holasters to define the whole zone.

T. O. Bosworth.

St. John's College,
Cambridge.

OBITUARY

FREDERICK JUSTEN, F.L.S.

Born February 29, 1832. Died November 20, 1906.

It is with deep regret that we record the death, on Tuesday, 20th November, of our dear and valued friend, Mr. Frederick Justen, F.L.S., the publisher of this journal.

Mr. Justen was born at Bonn on the 29th February, 1832, and came to England as a German Assistant to the firm of Messrs. Dulau & Co., 37, Soho Square, W., in 1851.

Upon the decease of the late Mr. Twentyman, the then acting partner, Mr. Justen became the sole proprietor of the firm, and for many years devoted his energies to supplying the requirements of the British Museum and the Libraries of the various scientific societies of London and the provinces with foreign publications.

It was his strong sympathy with the aims and objects of the Geological and Palæontographical Societies, the Geologists' Association, and other kindred institutions, that prompted him, in 1895—irrespective of any pecuniary considerations whatever—to undertake the publication of the Geological Magazine, in the success of which he always took the deepest interest.

It is not too much to affirm that the onward progress of the Geological Magazine in the last 12 years has been mainly due to the public-spirited support given to it by Mr. Frederick Justen, and no one of all our friends and supporters rejoiced more than he did, when, in February last, the 500th monthly number of this journal was issued from 37, Soho Square.

Notwithstanding the great personal loss which the death of Mr. Justen has caused to us, we are happy to state that the business relations with the firm of Messrs. Dulau and Company will be continued in the same cordial manner as heretofore. H. W.

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