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JANUARY—DECEMBER, 1904.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCCLXXV TO CCCCLXXXVI.

EDITED BY

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ORIGINAL ARTICLES.

I.—A Retrospect of Geology in the last Forty Years.

(Part I.)

THE completion of the 40th volume of the Geological Magazine, and the commencement of its Fifth Decade under the Editorship of one who has been responsibly associated with the undertaking since 1864, and has been Editor-in-chief since July, 1865, furnishes a fit opportunity for a retrospect.

In the opening pages of this Magazine Professor Rupert Jones dealt with "The Past and Present Aspects of Geology." He remarked on the tendency to encroach upon the theory of Uniformity, upon the right "to call in the agency of forces which, though not seen in operation in nature, may be evoked in the laboratory." He further referred to "recent discussions respecting the origin of granite, the mode of formation of river-valleys, the excavation of lake-basins, the doctrine of 'homotaxis,' and the origin of species." At that time, owing to the teachings of Huxley, there was more scepticism than there is now as to the exact truth of "the contemporaneity of strata which contain the same or similar fossils, and which are geographically far apart."

All these and many other subjects at home and abroad have been discussed in our pages, the aim (as stated in the January Number, 1866, p. 1) having been "to enlarge the opportunities of preserving the results" of the labours of the ever-increasing number of geologists, and "to supplement, as far as possible, the authoritative and old-established Journal of the Geological Society."

Throughout this long period the material at our disposal has been abundant, and the importance of the greater part of it has been acknowledged: indeed, we may claim to have published many an essay that is now regarded as a classic; while among them we may count perhaps a few of the 'Rejected Addresses' that a too conservative element in former Councils of the Geological Society thought right to discountenance.

Looking back over the forty volumes, our pride and satisfaction are not unalloyed with a reasonable amount of humility, such as everyone naturally feels with a work that has been accomplished.

Some articles, indeed, might with benefit have been curtailed, a few might perhaps have been omitted without detriment to science, while here and there asperities in correspondence might have been softened or removed with evident advantage.

Our First Decade was characterized by many articles and much discussion on various forms of Denudation, in which Scrope, John Ruskin, Jukes, Colonel George Greenwood, O. Fisher, D. Mackintosh, Hull, Whitaker, Green, Kinahan, Topley, and others took part. Escarpments and valleys, lakes, and the relative importance of sea *versus* rivers came again and again to the front, the last-named subject being dealt with in a masterly way by Whitaker in his classic essay on Subaërial Denudation. The origin of the Chesil Beach and the adjacent features was considered, and even the ancient valley system of Pre-Triassic times in the Bristol area and Charnwood Forest, which has quite lately been a subject of interesting observations, was briefly discussed by G. Maw.

Glacial geology and the causes of changes of climate occupied the attention of S. V. Wood, jun., James Geikie, James Croll, W. Boyd Dawkins, and D. Mackintosh; and Geological Time was also brought before our readers.

The study of Igneous rocks with microscopic aid came into prominence. Interest was stirred up by P. H. Lawrence's translation of B. von Cotta's work, "Rocks Classified and Described." David Forbes and Samuel Allport dwelt on the importance of the study and gave an impulse to research. Forbes and Sterry Hunt entered into controversy on certain questions of chemical geology.

The recognition of 'Eozoon' as a foraminifer was in these early days largely accepted. It was held to have built up in reef-like masses the limestones since altered into marbles in the great Laurentian gneiss of Canada. Eozoonal structure was also seen in the green and white marble of Connemara.

Sir Roderick Murchison wrote on the Laurentian rocks of Britain, Bavaria, and Bohemia; and cores of the ancient gneiss (now grouped as Archæan) were recognized by H. B. Holl at Malvern and by others elsewhere.

Hicks, aided at first by Salter, commenced his brilliant researches among the Lower Palæozoic rocks of Wales, and the results of some of these, together with the now classic paper of T. Belt on the Lingula Flags, are included in the volumes. Hughes dealt with the break between the Upper and Lower Silurian rocks of the Lake District, in a paper which (if we are rightly informed) found little favour in the eyes of Murchison.

Other topics received treatment; J. Ruskin wrote on Banded and Brecciated Concretions, S. P. Woodward on Banded Flints, John Morris on the Oolites and Lower Cretaceous rocks, and Meyer on Cretaceous rocks, while G. Maw described interesting pockets of white clay, etc., in the Carboniferous Limestone of North Wales, Derbyshire, and North Staffordshire.

In the Second Decade the desirability of having a detailed record of geological and palæontological literature was brought prominently before the Editor. A small Committee met in his study during the winter of 1873–74, and as a result brief abstracts of geological papers were for a time contributed with some regularity to the Geological Magazine. The Committee consisted of Henry Woodward, Prof. Williamson, F. W. Rudler, L. C. Miall, W. Topley, W. Whitaker, G. A. Lebour, W. Carruthers, and H. B. Woodward. It soon became obvious that the Geological Magazine was not large enough to embody all the abstracts that were forthcoming. This led on to the establishment of the "Geological Record" under the editorship of Whitaker, and for a few years an excellent and carefully edited annual volume was published, with the aid of a grant from the British Association. Difficulties, however, arose, and that work was ultimately abandoned when the "Record" was brought up to 1884.

In this Decade Pleistocene geology again occupies a prominent position in the Magazine, and Sir Henry Howorth appears on the scene with essays on the Mammoth in Siberia and its extinction, and on the evidences which he pictured of a great Post-Glacial Flood. The Loess is discussed by Baron von Richthofen, Howorth, and Nehring. Ice-work in Newfoundland is described by J. Milne, and special attention is called to the action of coast-ice. R. D. Darbishire discourses on the drifts at high levels at Macclesfield; and the Recent and Pleistocene geology of Cornwall was treated of in essays by W. A. E. Ussher.

The subjects of Climate, Continents, Mountains, and Escarpments are again discussed; and W. Flight discourses on the History of Meteorites. Judd deals with the study of Volcanoes, and in an article on the origin of Lake Balaton, in Hungary, he so far questions the glacial origin of certain lakes as to rouse a storm of opposition from Ramsay, J. Geikie, and others. J. Milne turns from the subject of Glaciers to Volcanoes, and finally to Earth Movements.

Among the older rocks, and especially in the structure of the Scottish mountains, a great advance is made: in the classic paper by Lapworth on the Secret of the Highlands, and in papers by Hudleston on Assynt, and Hicks on parts of Ross-shire.

The older Palæozoic rocks are dealt with by Hicks and Lapworth, and the Devonian by Champernowne.

The relations of Permian and Bunter are freely discussed; while the palæontology of the Yorkshire Oolites forms the subject of another classic paper by Hudleston.

In Petrology we have the important essay by Teall on the Cheviot Andesites and Porphyrites; while of general papers, that on the geology of Spitzbergen, by A. E. Nordenskiöld, and the "Travelling Notes" of J. Milne, across Europe and Asia, are specially noteworthy.

In the Third Decade the subject of Metamorphism is largely dealt with, the effects both of contact with intrusive masses and of earth stresses being discussed. Serpentine in particular comes in for treatment. Teall deals with the origin of Banded Gneisses and with the metamorphism of the Lizard Gabbros—a subject into which Bonney and McMahon enter in discussion. The schists of

Bolt Head are dealt with by A. R. Hunt, and he is not suffered by Bonney to go free from criticism.

Eozoon again comes up, Sir J. W. Dawson making one more appeal in favour of its organic origin.

Callaway deals with Archæan. The 'Monian' system of J. F. Blake is also discussed, and Hughes writes on the Cambrian of North Wales.

Notable are the articles by Lapworth on the Close of the Highland controversy, on the Cambrian rocks of Nuneaton, and on the Olenellus Fauna in Britain. He likewise defines his Ordovician System, and writes on the Ballantrae rocks. Nicholson and Marr deal with the Lower Palæozoic rocks of the Lake District.

The Culm-measures of Devonshire, Coal in the south-east of England, the Trias, the Neocomian, and the Bagshot Beds come in for a good deal of attention.

A. Harker, as well as T. H. Holland, appears on the scene, and they, together with G. A. J. Cole, describe various igneous rocks; while Judd writes on the lavas of Krakatoa, and Teall on the Cheviot quartz-felsites and augite-granites.

The mineralogical constitution of calcareous organisms forms the subject of an important paper by V. Cornish and P. F. Kendall. Pisolite is dealt with by Wethered; explosive slickensides by Strahan; Earthquakes, the creeping of soil-cap, and the stone-rivers of the Falkland Islands by Davison; Dust and Soils by C. Reid; while W. M. Hutchings writes on Slates and fire-clays. Landscape Marble, the flexibility of rocks, faults, jointing, and cleavage also receive consideration. Howorth continues to write on the Mammoth and the Glacial Drift; others deal with the Caves of North Wales, and with Moel Tryfaen, while Geological Time, the permanence of Continents, and geological nomenclature attract several writers.

In the Fourth Decade the life-zones of Carboniferous and Cretaceous rocks are specially dealt with, while those of earlier and later date come in for a certain amount of discussion. The zones of the Carboniferous system had been neglected, but Marr, Garwood, and Wheelton Hind come to the rescue, and it is well known that Traquair and Kidston are also keenly interested in the subject. The admirable work of A. W. Rowe on the Chalk zones is reviewed, and Jukes-Browne discusses the possibility of making 'chronological maps,' which no one has yet attempted except on a small scale or in a general way.

The nomenclature of Igneous rocks is discussed by H. Stanley Jevons, and the new American classification is criticized without favour. The order of consolidation of minerals in igneous masses receives attention from Sollas, while Harker describes the sequence of igneous rocks in Skye. Greenly gives accounts of various Anglesey rocks; Bonney and Miss Raisin deal with rocks from Kimberley in Cape Colony, Teall with Nepheline-syenite from north-west Scotland, McMahon with the granite of the Himalayas, and A. R. Hunt with that of Dartmoor. J. Parkinson and H. J. Seymour describe sundry igneous rocks. Hutchings discourses on the Great Whin Sill, on clays, shales, and slates, and on contact metamorphism, T. H. Holland on Laterite, W. F. Hume on the Black Earth of Russia, and A. P. Pavlow on Sandstone dikes.

Miss Ogilvie (Mrs. Gordon) gives some results of her researches on the Dolomites of the Tyrol. Marr treats of the Skiddaw Slates, C. A. Matley of the Arenig rocks, while W. Gibson deals with the Palæozoic rocks of South Africa.

The fossils discovered by Hicks in what were regarded as the unfossiliferous Morte Slates receive attention, and Howard Fox records new localities for fossils in the Devonian of Cornwall. Wheelton Hind discourses on the Yoredale Series, and W. Gunn on the Lower Carboniferous rocks of northern England and Scotland.

The age of the Wealden, whether Jurassic or Cretaceous, comes under discussion. The Chloritic Marl and Warminster Greensand are dealt with by Meyer and Jukes-Browne, and interesting notes are given of the Cretaceous fossils from the Drift of Aberdeen. An important paper on the structure of Creechbarrow, in Dorset, is contributed by Hudleston, who shows that this remarkably prominent hill owes its preservation to the occurrence of an Eocene or possibly Oligocene limestone.

The origin of erratic blocks in the Drift of Yorkshire leads to an amusing correspondence between Howorth and Harker, in part relating to the supposed carrying of stones by the Vikings. Many pages of the Magazine are occupied by Howorth in essays on the Surface Geology of North Europe, on the Scandinavian Ice-sheet, on recent changes of level, and on the Glacial Drifts of Eastern England, the power of water *versus* ice being dwelt upon; while Dugald Bell writes on the question of submergence during the Great Ice Age. R. M. Deeley and G. Fletcher deal with the Structure of Glacier Ice, and Mr. E. P. Culverwell contributes an important article on the Theory of the Ice Age.

The glacial phenomena and denudation of the Skye mountains are dealt with by Harker, who has spent many field-seasons in this grand region. Howorth, writing on the Earliest Traces of Man, rouses up some discussion on Kent's Cavern and Buckland, while Mr. S. H. Warren contributes a suggestive paper on the relative age of Stone Implements, and the Rev. R. A. Bullen deals with Eoliths. Scharff describes the caves of county Sligo. The subject of Dene-holes comes in for discussion.

An interesting essay is contributed by H. W. Pearson on Oscillations of Sea-level, and Holst deals with Oscillations of land during the Glacial period in Scandinavia. In connection with this subject Hull's paper on the Submerged Platform of Western Europe roused up discussion by J. W. Spencer and Jukes-Browne, and led to an important essay by Hudleston on the Eastern Margin of the North Atlantic Basin.

The determination of the pre-Glacial age of the raised beach in Gower by R. H. Tiddeman finds interesting support elsewhere in the similar sequence of deposits off Cork Harbour, quite lately described by H. B. Muff and W. B. Wright.

River development attracts much attention, and S. S. Buckman leaves his Ammonites and his 'Hemera' to take part in the discussion. The subject was introduced in a paper on Bala Lake and river system by Philip Lake, and Callaway contributes articles on the general question, while W. M. Davis writes on the peneplain of the Scottish Highlands and discusses the meanders of rivers.

The ancient glacier-dammed lakes of the Cheviots are described by Kendall and Muff, while Bonney writes on moraines and mud-streams in the Alps. Parkinson discusses the origin of certain Canadian Lake-basins. Rock-basins, indeed, come in for considerable notice.

Watts deals with the ancient rocks of Charnwood Forest and their physiography, and Mellard Reade continues to discourse on mountains.

Among general papers those by Cowper Reed on the Geology of Waterford, and by Beadnell, Barron, and Hume on Egypt, may be mentioned.

Our old friend Rupert Jones gives a full History of Sarsens.

The subject of Geological Photographs is brought prominently into notice by Watts, and a number of excellent examples are reproduced. Judd gives an interesting history of the earlier British geological maps.

Finally, much attention is again given to Geological Time, the question having been considered by Joly in reference to the circulation of salt. Sir A. Geikie deals generally with the subject in his address to the British Association.

Turning to the topics that are occupying much attention at the present day, we find that the chief discussions are on subjects somewhat similar to those mentioned by Professor Rupert Jones in the first number of the Magazine. The origin of the crystalline schists, the genesis of rivers and the formation of their valleys, the excavation of lake-basins, the correlation of strata by means of special assemblages or zones of fossils, and the evolution of species are subjects which engage continued attention and upon which much has yet to be learnt.

Throughout the history of the Magazine, now one topic, now another has become dominant for a time. The relative importance of marine and subaërial denudation, the origin and development of rivers, the formation of crush-conglomerates, and the subject of dynamic metamorphism are instances. But if these subjects have again and again been brought forward, it is because someone gives the key to what was previously an enigma, and many are ready to use it; or another has gained a position from which a clearer view of a subject has been gained. From every fresh summit our ideas of the expanse of unacquired knowledge are constantly enlarged—a statement which is well known to apply to every branch of learning—and this being the case there is a constant demand for careful, earnest observers and workers, and there should be a constant demand for the Geological Magazine.

(*To be continued.*)

Cupressinoxylon hookeri, sp. nov.,
a large silicified tree from Tasmania, preserved in the Geological Department, British Museum (Natural History).

II.—*Cupressinoxylon hookeri*, sp. nov., a large Silicified Tree from Tasmania.

By E. A. Newell Arber, M.A., F.L.S., F.G.S., Trinity College, Cambridge University Demonstrator in Palæobotany.

(PLATE I.)

ONE of the most striking objects exhibited in the Gallery of Fossil Plant remains in the Geological Department of the British Museum (Natural History) is a large trunk of a Coniferous tree from Tasmania, of which a photograph is reproduced on Plate I. This specimen[1] is one of the largest in the gallery, being nearly nine feet in height, and three feet in diameter. The woody tissues are in excellent preservation, the specimen being silicified, and in part opalized.

The history of this tree is an interesting one. It was discovered, apparently early in the last century, on the estate of a Mr. Richard Barker at Macquarie Plains, New Norfolk, Tasmania. When found, the tree was embedded in an upright position in a basaltic lava. Although silicified wood is of common occurrence in that neighbourhood, the large size of the trunk—the specimen being then at least three feet longer than at present—appears to have created general interest. Among others, Sir Joseph (then Mr.) Hooker, while on a voyage of discovery in the Southern seas in H.M.S. "Erebus," visited the locality to examine this fossil. Sir Joseph Hooker[2] contributed a most interesting description of the specimen to the first volume of the Tasmanian Journal of Natural Science, published in 1842, from which the following quotation is taken:—"One of the most remarkable circumstances connected both with the Geology and Botany of Tasmania, is the occurrence of vast quantities of silicified wood, either exposed on the plains, or imbedded in rocks both of igneous and aqueous formations. Those of the former, in particular, are the most striking, from their singular beauty, and the very perfect manner in which the structure of the living wood is retained. Soon after my arrival in this Colony, magnificent specimens of a fossil tree were shown me, dug out of a volcanic rock, and which, as far as my memory serves me, were unequalled even in what I had seen of the rich collection of Brown."[3]

A few years later the tree was brought to England and exhibited in the Tasmanian Court of the Great Exhibition of 1851.[4] At the close of the Exhibition it was presented to the British Museum by the Tasmanian Commissioners, but owing to the large size of the

[1] Registered number, V. 332. A smaller specimen (V. 9,606) of a similar tree from the same locality is exhibited side by side with that described here.

[2] Hooker: Tasmanian Journ. Nat. Sci., vol. i (1842), p. 24.

[3] Robert Brown (1773–1858), first Keeper of Botany at the British Museum, gathered together a large collection of petrified woods from different parts of the world. Most of these specimens are now incorporated with the plant collections in the Geological Department of the British Museum.

[4] Official Catalogue, Great Exhibition of the Works of Industry of all Nations, 1851, vol. ii, p. 999 (No. 348).

specimen and the crowded nature of the Natural History exhibits, then at Bloomsbury, it was not possible to exhibit it until their removal to the more suitable and spacious quarters at South Kensington had been completed.

From the geological standpoint, this tree is especially interesting in the manner of its occurrence. The Basalts of the Macquarie Plains are of Tertiary age, but there seems to be some difference of opinion as to whether they belong to the earlier [1] or later [2] period. McLachlan's [3] description of this specimen states that the tree "was imbedded in lava, and distinctly surrounded by two flows of scoria."

The association of plant remains with volcanic outpourings, especially with the more basic tuffs and lavas, is by no means of rare occurrence. Excellent illustrations may be found in the rocks of this country. In the Tertiary leaf-beds of Mull,[4] well-preserved impressions of leaves, similar to *Platanus* and other recent genera, occur in gravels closely associated with sheets of basaltic lava. Calcified stems and other fragments of plants of the greatest botanical importance have been discovered in beds of volcanic ash in the Lower Carboniferous rocks of Petticur, near Burntisland, and at Laggan Bay in the island of Arran.[5] Silicified stems in association with basalts and other igneous rocks are known from many parts of the world, especially from South America, where their occurrence has been described by Darwin.[6]

The vertical position in which the tree was found is emphasized by Hooker and by McLachlan. It would be of some interest to know whether this trunk once formed part of a forest which, at some period or other, was overwhelmed by showers of ashes and lava-flows. On this point there is, however, little information. McLachlan suggests that the vertical position is more or less accidental, and states that the base of the tree was embedded in sand.

The tree, as it stands now, is decorticated, only the woody tissues being seen. The outer portion is opalized and fairly hard, but the more internal tissues crumble away to a fine white powder at the slightest touch. This powder consists of the isolated woody fibres of the stem. Sir Joseph Hooker has so graphically described the condition and structure of the specimen that I cannot do better than quote his remarks.[7] "The bark (?) is of a different colour and more consolidated than the interior, resembling the most beautiful agate. The woody part reminded me of the lignite, so common in Lough Neagh, in the north of Ireland. . . . . The most remarkable circumstance, however, connected with this fossilized tree, is the manner in which the outer layers of wood, when exposed by the

[1] Johnston: "Geology of Tasmania," 1888, pp. 215 (table) and 294.
[2] Stephens: Papers and Proc. Roy. Soc. Tasmania for 1897, p. 54 (1898).
[3] See note 4, previous page.
[4] Starkie Gardner: Q.J.G.S., vol. xliii (1887), p. 270.
[5] Wünsch, Trans. Geol. Soc. Glasgow, vol. ii (1865), p. 97; and Bryce, "The Geology of Arran," 4th ed. (1872), p. 123.
[6] Darwin: "Geological Observations," 2nd ed. (1876), p. 394, etc.
[7] Hooker: ibid., p. 25.

removal of the bark, separate into the ultimate fibres of which it is composed, forming an amianthus-like mass on the ventricle of the stump in one place, and covering the ground with a white powder, commonly called here native pounce. The examination of a single concentric layer from this part shows that it may be detached from the contiguous layers of the preceding and following years' growth; there being no silicious matter infiltrated into the intervening spaces. A portion of each layer is found to have a second cleavage, not concentric with it, but in the direction of its radius, or of a line drawn from the centre to the bark of the tree. Such a cleavage is to be expected from the fact, that it is in the direction of the medullary rays that traverse every where the woody tissue. Each of these laminæ is of extreme tenuity, of indeterminate length, and of the breadth of the layers of wood; and is formed of a single series of parallel woody fibres, crossed here and there by the cellular tissue of the medullary rays, which do not generally interfere with their regularity. These plates, again, are separable into single minute fibres, which are elongated tubes of pleurenchyma or woody tissue, tapering at either end into conical terminations of indefinite length. They lie together in such close approximation that the microscope does not detect an interstice, though the least force separates them."

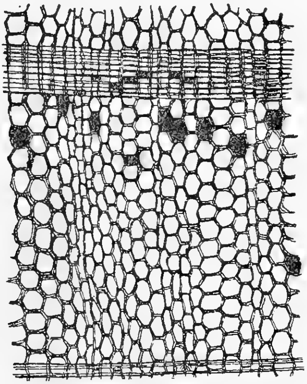


Fig. 1

FIG. 1.—*Cupressinoxylon hookeri*, sp. nov. Transverse section, × 100.

Sir Joseph Hooker concluded that the tree was undoubtedly Coniferous, as could be ascertained by a microscopic examination of the isolated fibres, without the preparation of sections. It may be interesting in these days, when microscopic sections are a constant necessity to those who are working on the subject of fossil plants, and readily obtained at a cost of a few shillings, to quote a further sentence of Sir Joseph Hooker's description, as illustrating the progress in this respect during the last sixty years. He says, "Such slices have hitherto only been prepared by the most skilful lapidary, and at great cost."[1]

Sections of the harder parts of the tree have recently been made with the object of determining, if possible, the group of Coniferæ to which this specimen belongs. The preservation is exceedingly beautiful, the pits on the walls of the woody elements being well preserved.

The conclusion arrived at from an examination of these sections is that the woody tissues of the tree possess a structure of the type known as *Cupressinoxylon*, Goepp. As this species has not, apparently, been named hitherto, I propose to call it *Cupressinoxylon hookeri*, in honour of the great Botanist whose description of this specimen formed one of his earliest scientific contributions.

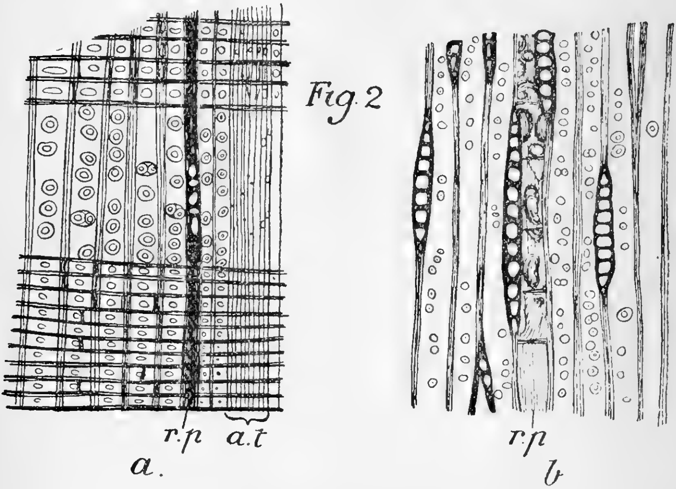


Fig. 2.—*Cupressinoxylon hookeri*, sp. nov.

(*a*) Radial longitudinal section showing the medullary rays with simple pits, and spring tracheides with bordered pits. *r.p.* resin parenchyma; *a.t.* tracheides of autumn wood. ×200 (slightly restored).

(*b*) Tangential longitudinal section. *r.p.* resin parenchyma. ×200.

It has been long known that it is not possible to refer coniferous woods, by a study of the anatomy of stems, whether recent or fossil, to genera based on the natural affinities of such plants. This was first clearly pointed out by Goeppert[2] in his treatises on the structure of living and fossil Coniferæ published in 1841 and 1850. Several recent genera belonging to such widely different families as Cupressaceæ, Abietaceæ, and Taxoidiaceæ, possess a woody structure

[1] Hooker: ibid., p. 26.

[2] Goeppert: "De Coniferarum, structura anatomica," Breslau, 1841; and "Monograph der fossilen Coniferen," Leiden, 1850.

closely similar to that of the Tasmanian tree, and such woods are usually included in the form-genus *Cupressinoxylon*.[1]

In *Cupressinoxylon* the annular rings are well marked. The bordered pits of the tracheides are separate, usually uniseriate; when biseriate the pits are opposite one another. Resin canals are absent, but resin parenchyma is abundant.

Cupressinoxylon hookeri, sp. nov., may be recognized by the following characters. A tree more than 12 feet high, and 3 feet in diameter. Only the woody tissues are known. Annular rings distinct; the 'autumn tracheides' being markedly narrower than the 'spring' elements. Rings narrow, varying somewhat in size, but averaging about ·7 mm. in width. 'Summer wood' containing about 15 elements on an average in the ray. 'Autumn wood' with 4 to 9 or more elements; dense. Tracheides of considerable length, with uniseriate bordered pits on the radial walls, and often also on the tangential walls. The pits on the latter are sometimes smaller than those on the radial walls. Occasionally the pits are biseriate, and then the two pits are always opposite. Medullary rays numerous, composed of similar elements, uniseriate or occasionally biseriate, 3 to 14 or more cells in height. The medullary rays communicate with the tracheides, usually by a small simple pit on the radial walls. Occasionally in large medullary ray cells more than one pit occurs. Resin parenchyma, consisting of continuous rows of thin-walled cells, frequent, especially in the younger elements of the 'spring wood' and in the 'autumn wood.' Usually only one resin cell in each ray of the annular ring.

This type of woody stem is known from rocks of Jurassic age onwards, and is especially abundant in the Tertiary period. Perhaps the species which is known in most detail is that described very thoroughly a few years ago by Mr. Barber[2] from the Lower Greensand of Shanklin in the Isle of Wight, under the name of *Cupressinoxylon vectense*. Numerous species have also been described by Knowlton from the Potomac series (Neocomian) of North America, and many others are known from the Tertiary rocks of Europe, North America, and elsewhere. Conifers possessing this type of woody structure are abundantly represented in Australasia at the present time by such genera as *Podocarpus* and *Dacrydium*, both of which occur in Tasmania.

I wish to express my indebtedness to Dr. Smith Woodward, F.R.S., Keeper of the Geological Department, for permission to describe this interesting fossil, and for having sections prepared for the examination of its structure. I am also indebted to Dr. Henry Woodward, F.R.S., for having suggested to me an inquiry into the history and nature of the specimen described here.

[1] The grouping together of coniferous woods by their anatomical characters is fully dealt with by Schenk in Zittel's "Traité de Paléontologie," pt. ii, Paléophytologie, 1891, p. 838.

[2] Barber: "Annals of Botany," vol. xii (1898), p. 329.

III.—Remarkable Examples of Atmospheric Erosion of Rocks in Corsica.

By F. F. Tuckett, F.R.G.S.

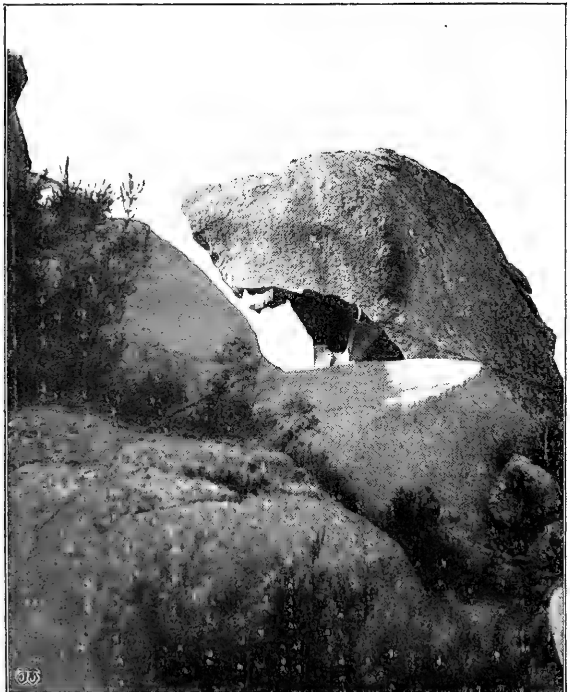
(PLATE II.)

In the course of repeated visits to Corsica I have been much struck by the extraordinary erosion, not only of cliffs, but even more so of detached masses or boulders, from near sea-level to heights of 5,000 to 6,000 feet; and, having taken some photographs last January of specimens of the kind last referred to, I sent them to my friend Professor Bonney, who informed me that he had never met with any instances of erosion of such a peculiar and unusual character, and asked whether I could furnish him with a fragment of the rock.

Unfortunately, owing to the inaccessibility of two of the objects photographed, and my hesitation to break away any of the third ("Tête de Chien"), I was only able to send him a piece obtained from a cliff by the roadside at some distance, which had been scooped out by erosion into overhanging eaves and other curious forms; and his report on this, after having a microscopic section prepared from it, was as follows:—

"The specimen is about 4½ in. long, 2 in. wide, and 1 in. in maximum thickness, weathered on both sides and on the blunter edge, apparently having been broken from a thin, flake-like projection such as would form the edge of one of the peculiar cavities in the photograph. The weathered surface is irregular, lumpy, and inclining to be flaky, of a dull dark-brown colour in the less prominent parts, elsewhere a pale brownish-green. The rock itself, quite close to the exterior, is a rather pale greenish-grey colour, somewhat mottled with small whiter and one or two darker patches, showing elsewhere a fibrous structure.

"Microscopic examination of a slice cut from one end, transverse to the length of the flake, proves the rock to consist largely of microlithic minerals, and to have been greatly affected by pressure—probably almost crushed. It exhibits two or three small grains of rhombic pyroxene, probably bastite; a number of small grains of augite, probably residual; a large quantity of rather minute actinolite, and perhaps a few flakes of a greenish to white mica. Some small grains, however, of a colourless, slightly flaky mineral, like bastite, but with oblique extinction, are certainly secondary, occurring somewhat after the manner of albite in certain crushed Alpine schists. Brown iron oxide is present only as an occasional staining or in granules, and sphene (possibly) in the latter condition. The rock has undergone so much secondary change that its original condition has been obliterated. I think it most probably has been a pyroxenite, with a little enstatite and possibly a few grains of olivine, allied to, but hardly to be classified with, the peridotites. It reminds me a little of some of the augite-serpentines of the Valais Alps, but in it actinolite practically takes the place of the mineral serpentine."



1. Hollow eroded dome, "Tête de Chien" (8–10 feet long).

2. Hollow eroded dome, in stream near Porto.

"Le Calanche," near Piana, west coast of Corsica.

I may add that the first specimen I saw during an ascent of Monte Rotondo was a huge boulder, or *bloc perché*, perhaps 12 to 15 feet in diameter, at a height of 5,000 to 6,000 feet on a narrow spur of the peak, the interior of which reminded me of an ant's nest in an old oak beam, and so completely was it honeycombed that I was able to penetrate into the heart of the mass, where I was practically invisible to my companion.

Can any geologist suggest a cause for this extraordinary and, both in altitude and area, widely distributed erosion? It can hardly be decomposition, for, in the specimen described above, the rock seems in good condition just beneath the outer surface, and, at any rate in some instances, the situation appears to make the action of sand very improbable. Neither Professor Bonney nor I have seen anything in the Alps at all comparable to it, nor remember to have read a description of its occurrence in other places.

Note.—Since writing the foregoing my attention has been drawn, through the kindness of the Editor and of Dr. C. I. Forsyth Major, F.Z.S., to a passage at pp. 127–128 of "La Corse," by M. Ardouin-Dumazet, forming the 14th series of a "Voyage en France." This writer very accurately and pictorially describes the extraordinary weathering or erosion of the 'Red Granite,' or granitoid rocks of the Calanche, but only briefly alludes to the hollowed out, bomb-like forms specially referred to by me, if indeed they may be recognized in the phrase "La forme la plus générale de ces bizarreries est un évidement en forme de niches." He also speaks of "Des silhouettes d'animaux fantastiques."

As already stated, the rock from which my specimen was taken, instead of on the spot as it ought to have been, was at some distance to the south-west of the limited region of the Calanche, and, though much eroded or undercut, was probably of a different geological character from the sometimes almost spherical, bomb-like blocks such as that in the stream near Porto. I am inclined to think that the Calanche themselves are a rose or brick-coloured granite, as the writer just quoted and Joanne's "Guide en Corse" state them to be.

EXPLANATION OF PLATE II.

Fig. 1.—Eroded dome, "Tête de Chien" (8 to 10 feet long), "Le Calanche," near Piana, west coast of Corsica.

Fig. 2.—Eroded boulder in stream near Porto, west coast of Corsica.

IV.—Note on the Keratophyres of the Breidden and Berwyn Hills.

By H. Stanley Jevons, M.A., F.G.S., Lecturer in Mineralogy and Demonstrator in Geology in the University of Sydney.

It may be of interest to note the occurrence of a somewhat rare and interesting rock, named *keratophyre*, at two easily accessible localities in a district where it has been hitherto unknown—at Moel-y-Golfa, in the Breidden Hills, and in the Berwyn Hills.

The Breidden Hills.

Moel-y-Golfa was visited by me in 1899, and I collected a few specimens, which, however, remained unexamined until a few days ago when I needed one for teaching purposes.[1] On examination of a thin section the plagioclase proved to be *albite*, idiomorphic and tabular in form, set in a matrix of chloritic decomposition products, doubtless the remains of pyroxene. The ratio of albite to pyroxene must have been about two or three to one. This composition is sufficient to place the rock in the keratophyre group,[2] but confirmation was obtained by comparison with a slide of the well-known keratophyre of Hüttenrode, in the Harz, the rocks proving almost identical both in structure and composition. The determination of the felspar was made by Becke's bright line method, which proved its refractive index to be everywhere slightly lower than that of balsam.

The igneous rocks of the Breidden Hills have been ably described by Professor W. W. Watts,[3] but I am not aware of any later reference to them. He believed the rocks of Moel-y-Golfa to be mostly lavas, and their plagioclases to be probably labradorite, and therefore named them andesites. His failure to recognise albite is to be attributed solely to the want of the refinements of petrographical investigation which exist to-day, Becke's bright line method having been known only since 1893.

The intrusive rocks of the Breiddens, described by Professor Watts as the 'Newer Series' of igneous rocks, and named by him diabases, may prove to be keratophyres when their felspars are closely examined. I have unfortunately no specimens available. The specific gravities quoted by Professor Watts are of little use as a guide owing to the decomposed condition of the rocks. Should they turn out to be dolerites (diabases), we should have another example of the interesting association of keratophyres with dolerites noted by Rosenbusch.[4]

The Berwyn Hills.

Since 1897 I have been from time to time engaged in investigating the igneous rocks of the Berwyn Hills, which lie to the south of the Dee Valley, between Corwen and Llandrillo. The igneous mass occupying the highest stratigraphical position is a series of quartz-keratophyre (soda-rhyolite) tuffs, with a lava of the same composition at its base. The fact that sections across the tuffs a mile or less apart invariably show different successions of quartz-keratophyre tuffs, the latter being distinguished from one another by colour and slight corresponding differences in composition, points to a large number of centres of eruption as their source. One of these lay near Blaen Llynor, as shown by the agglomerate to be seen in the bed of that stream.

The four great sills marked 'greenstone' on the Geological Survey Map of the district, together with their associated dykes

[1] The two specimens available are labelled:—568, Crags N. of Ty-bryn Farm, N. of Moel-y-Golfa summit; 572*a*, S. of road between "Plough and Harrow" and Trewern Farm, S. of Moel-y-Golfa.

[2] See definition, Rosenbusch, "Elemente der Gesteinslehre," 2nd ed., 1901, p. 287.

[3] Q.J.G.S., vol. xli (1885), p. 532.

[4] "Elem. d. Gesteinslehre," 1901, p. 288.

to be seen on the cliff above Llyn Llync-caws, were found to have the composition of a keratophyre;[1] that is to say, they are essentially composed of *albite* and *diopside.* The proportion of diopside to albite was found to vary somewhat, and to be generally greater than in the case of the keratophyre of the Breiddens. Other minerals rarely make up as much as 10 per cent. of the rock. The texture is never porphyritic, and is generally that characteristic of the dolerites (diabases), from which these keratophyres are only to be distinguished by the refractive index or extinction angles of their felspars. As I believe this to be the first description of keratophyre as an intrusive rock, I may state that in this case there can be no question as to its intrusive character. The slates are distinctly metamorphosed above and below each sheet, the spotted slate so well exposed above having been mistaken for tuffs in 1850 by officers of the Geological Survey. The crag on Carnedd-y-Ci shows the hanging wall rent and penetrated by minute tongues of the igneous rock, and fragments of the sedimentary rock have been floated off into the magma.

No dolerites of the keratophyre facies (i.e. containing diopside) occur in the Berwyn district so far as I have been able to discover. The only basic rock in the neighbourhood is an olivine-dolerite with titaniferous augite forming a dyke trending north-west and south-east in Nant Llwyn Gwern, near Craig Wen. This is erroneously mapped as a triangular patch on the Survey Map, but is simply a coarse-grained dyke, probably to be connected with the Post-Carboniferous dykes of Anglesey and Carnarvonshire.

General.

The superficial resemblance of the intrusive keratophyres here described to the dolerites (diabases) so common in Carnarvonshire may be regarded as a significant fact. The felspars of the latter rocks have in a few instances been determined,[2] and were found to belong generally to the andesine-labradorite series. Albite has not been recorded. I would suggest that an interesting field of research lies open to some one more favourably situated than myself in determining the felspars of a large number of the Welsh pre-Carboniferous dolerite intrusions. Should albite be proved present in Carnarvonshire, we should have the association of keratophyres and dolerites confirmed, and it would be interesting to discover whether there was a passage between the two rocks, and, if so, whether horizontally or vertically. On the other hand, should albite be absent in Carnarvonshire, the existence of a series of rocks all of the same facies, basic in the north-west but acid in the south-east, would have to be explained.

A complete petrographical description of the rocks mentioned in this note is in hand, and will be published in another place as soon

[1] Thin sections of some 60 specimens taken from various parts of these masses have been examined.

[2] Harker: Q.J.G.S., vol. xliv (1888), p. 449; and "Bala Volcanic Series of Carnarvonshire," p. 81, Cambridge, 1889.

as the pressure of other duties permits. I would like to add that my work in the Berwyn Hills was assisted by a grant from the Government Grant Committee of the Royal Society.

Appendix.

Confirmation of the determination of the felspars in the keratophyre of Moel-y-Golfa was obtained by uncovering a portion of one of the slides and immersing the thoroughly cleaned edge of the section in ethylene bromide ($\mu = 1{\cdot}5355$, by the Fuess Refractometer, Model II). The felspar showed γ a little above μ of the liquid, α distinctly below. The extinction angles on sections perpendicular to 010 of twins on the albite and carlsbad laws also confirmed albite, the measurements on four sections being:—[20 : 22] [18 : 21]; [17 : 16] [17 : 21]; [9½ : 9½] [13 : 16]; [5 : 6] [3 : 3]. The determination of the felspar of the Berwyn keratophyre was also confirmed by refractive index measurements, and extinction angles on cleavage chips as well as on symmetrical sections twinned on the albite and carlsbad laws.

Brief descriptions of Becke's bright line method of determining small differences of refractive index, and of Michel Levy's method of determining the plagioclase felspars by the extinction angles on sections perpendicular to 010 of crystals twinned on both albite and carlsbad laws, will be found in the Appendix to Iddings' Translation of Rosenbusch's "Microscopical Physiography of the Rock-making Minerals," 4th ed., New York, 1900.

V.—Contributions to the Geology of Ceylon:

II. Silicification of Crystalline Limestones.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineral Survey of Ceylon.

The occurrence of small quantities of chert and opal, usually in or near exposures of crystalline limestone, but very often in fragments or boulders not quite *in sitû*, is not unusual in Ceylon. For some time the origin of these siliceous rocks remained obscure; observations made within the present year (1903), however, enable me to give a more detailed account of their mode of occurrence. I have had the advantage of my colleague Mr. James Parsons' company in examining many of the exposures, and have been able to discuss with him the problems raised.

A band of chert occurs *in sitû* on the path descending from the ambalam just ¼ mile W.N.W. of Uduwela trigonometrical station (about 3 miles south-east of Kandy), and about 4 to 5 yards below the fourth of the six bands of limestone which are crossed in descending the hill.[1] The width of the band of chert is about 5 feet; it includes a number of varieties, all with good conchoidal fracture. These are: homogeneous green opal; homogeneous brown chert

[1] The locality can be identified on the map, Q.J.G.S., vol. lviii (1902), pl. xiii, but the position of the bands of limestone is not correctly indicated there.

(these two with very smooth fracture); brown mottled chert, with phlogopite, spinel, and graphite; green chert, with abundant mica and graphite, and less frequent spinel; and whitish decomposed chert, with the same accessory minerals in addition to blue apatite.

Specimens of limestone with identical accessory minerals occur quite near. On its north side, the chert band appears to pass into decomposed limestone which shows green spots suggestive of partial silicification. It was not quite certain that these apparent transition types occurred *in sitû*. There were, however, many specimens which could only with difficulty be definitely named as chert or limestone. A thinner band of brown chert occurs on the path a little below the main band.

Partially silicified crystalline limestone. × 22.
C, carbonate (dolomite); M, mica; S, spinel; remainder, opaline silica.

Five thin sections of these cherts were prepared. One of the green opal (1056) shows merely a green, structureless, homogeneous, isotropic rock. The brown chert (1052) consists of chalcedonic silica, in characteristic spherulitic aggregates; there is a colourless transparent base in which are scattered very numerous tiny ferruginous aggregates which give the brown colour to the whole rock. Certain cracks are filled with characteristic chalcedonic infiltrations. Rounded spots containing fewer of the ferruginous specks, and appearing rather dark between crossed nicols, call to mind the appearance presented by structureless radiolarian casts; the presence of radiolaria is, however, quite out of the question. The greenish micaceous chert (1055) consists of opaline and chalcedonic silica in roughly equal proportions, enclosing numerous individuals of well-preserved phlogopite and a flake of graphite. In another, very similar specimen (1054) the mica is much hydrated, and silica has been deposited between the laminæ, which are swollen and displaced. In the mottled chert (1053) chalcedonic chert is much more abundant than chalcedony, and the accessory minerals include graphite and abundant and characteristic spinel, colourless in the thin section but pink in the hand specimen. In none of these slides are any remains of carbonates to be found.

Some specimens collected from blocks resting on crystalline limestone, but not quite *in sitû*, on Upper Rajawela estate (about 11 miles from Kandy on the Teldeniya road), about a third of a mile E.S.E. of Rajawela trigonometrical station, were also sliced. Of these one (1074) evidently consisted of partially silicified limestone; the section showed disintegrated and corroded crystals of dolomite embedded in an isotropic siliceous matrix, in which an abundance of hydrated phlogopite and a few grains of spinel are also found.

The silica has penetrated along the cleavage cracks of the carbonates, with every appearance of corrosion. The dolomite individuals are thus broken up into irregular fragments, often more or less rhombohedral, and these graduate into the smallest specks which remain scattered in the siliceous base, sometimes indicating by their disposition the rough outline of the original carbonate.

Another specimen (1073) from this locality consisted entirely of brown chert and resembled No. 1053.

The amount of chert present in any locality is always small, and quite insignificant in comparison with the total amount of crystalline limestone present; nor can the occurrences of chert be followed for any distance. They are also met with in other parts of Ceylon, e.g. in the Uva Province, although their connection with crystalline limestone is not always traceable; but there is no direct evidence of their occurrence as a replacement of any other rock.

From the foregoing observations I conclude that these opaline cherts result from the alteration of crystalline limestone, the carbonates being dissolved and replaced by opaline or chalcedonic silica, or a combination of the two. Very possibly the pure siliceous rocks, free from accessory minerals, do not so directly replace the limestone, but are siliceous deposits similar to the chalcedony deposited in cracks in the other cherts, which must already have had time to harden and develop cracks, previous to the introduction of a further supply of silica. The silicification is probably the result of the presence of heated waters containing silica in solution introduced after the consolidation of the crystalline limestone in its present form. In other words we have here a metasomatic transformation. A number of hot springs are known to occur in Ceylon, e.g., at Badulla, Alupota, Bubule, and Bibile, in the Uva Province [1]; and near Koggala, Magam Pattu, in the Southern Province.[2] The occurrence of these springs lends support to the probability of such alterations having taken place.

It is of interest to notice the bearing of these observations on the origin of cherts in general [3]; we are here dealing with cherts which are certainly of inorganic origin. The mica, spinel, and graphite met with in the chert are proof that the original rock was a crystalline

[1] Uva Manual, by H. White, Colombo, 1903, p. 82.
[2] Ceylon Administration Reports, 1902, Survey Department, p. B. 30.
[3] For a discussion of this question, see C. A. Raisin, Proc. Geol. Assoc., xviii (1903), pp. 71–82.

limestone quite similar to those still met with in large quantity; no source of abundant silica can be found in these rocks, so that we are driven to conclude that it has been introduced from without. It is simplest to suppose that the silica was introduced in solution in the waters of hot springs. It may have been deposited at first in the colloid form and subsequently have become chalcedonic in parts; or the two forms of silica may have been deposited more or less simultaneously. It seems likely, however, that, at least to some extent, there has been a transformation from opal to chalcedony.

In conclusion, the cherts described represent a secondary condition of a rock originally different, viz. crystalline limestone; the silica has been introduced from without, and is of inorganic origin; the silica has been chemically deposited, chiefly in the colloid form, and replaces the carbonates which have been removed in solution.

VI.—On the Recent Tufaceous Deposit of Totland Bay, Isle of Wight.

By A. Santer Kennard and S. Hazzledine Warren, F.G.S.

On the top of the cliff between Headon Hill and Widdick Chine, in Totland Bay, there is a Recent tufaceous deposit containing land and fresh-water shells. It extends along the cliff for nearly 350 yards in a north-easterly direction from the base of Headon Hill, and is about 60 feet above the sea-level.

It was first described by Mr. Joshua Trimmer,[1] and subsequently by Professor Edward Forbes[2] and Mr. H. W. Bristow.[3] In the more recent memoir on the Isle of Wight[4] the earlier descriptions are quoted, but the section is described as being then almost entirely overgrown.

The deposit is described as being of very variable character, as the following details will show. At the base of Headon Hill Mr. Trimmer states that it presented the following section:—

		feet.
e.	Warp-drift: brown sandy loam without lamination, containing fragments of flint and Tertiary limestone. Filling furrows in the bed below	1 to 3
a–c.	Alternations of cream-coloured marl, calcareous tufa, and sand and clay blackened by organic matter; the calcareous tufa being in beds 6 inches to 2 feet thick, and the sand and clay forming bands of 2 to 6 inches in thickness	12 or more

This author also states that Professor Edward Forbes obtained shells of the genus *Unio* in a layer of flint gravel which occurs in places beneath the tufaceous deposit. Possibly this should be *Anodonta* rather than *Unio*, but no fresh specimens have been found to settle the point. Not far from the termination of the deposit

[1] Quart. Journ. Geol. Soc., 1854, vol. x, p. 53.
[2] "On the Tertiary Fluvio-Marine Formation of the Isle of Wight"; Mem. Geol. Survey, 1856, p. 8.
[3] Ibid., p. 105.
[4] "The Geology of the Isle of Wight," by Messrs. H. W. Bristow, Clement Reid, and Aubrey Strahan: Mem. Geol. Survey, 1889, p. 229.

(that is, as seen in the cliff section), in a north-easterly direction, or away from Headon Hill, Mr. Trimmer gives the section as follows:—

		ft.	ins.
e.	Warp-drift of brown loam	5	0
c.	Cream-coloured marl, with calcareous concretions, and a few thin black seams coloured by vegetable matter; land-shells	2	6
b.	Sand blackened by organic matter; calcareous concretions and land-shells ... ... 4 inches to	1	0
a.	Calcareous tufa; land-shells ... ... 10 inches to	2	0

In describing the calcareous concretions, Mr. Trimmer states that some are cylindrical and others sub-globular. The former have often a cavity through the middle, which is occasionally filled with decayed vegetable matter; thus showing them to have accumulated round the twigs and stems of plants, as their form suggests. He also considers that many of the sub-globular concretions may have had land-shells for their nuclei. This author records: ***Helix* [= *Helicigona*] *arbustorum*** or ***nemoralis***; ***Helix* [= *Hygromia*] *hispida***; ***Cyclostoma elegans* [= *Pomatias reflexus*]**.

Professor Edward Forbes confirms Mr. Trimmer's account, and gives the following section, though without stating its exact position in the cliff section:—

		ft.	ins.
e.	Loam, with scattered Helices, fragments of flints ... ... *Helix* [= *Helicigona*] *arbustorum* or *nemoralis*, *Cyclostoma elegans* [= *Pomatias reflexus*], abundant.	6	0
d.	Clay-bed more full of shells. *Limnæa palustris*, *Helix* [= *Vallonia*] *pulchella*, *Helix ericetorum* [= *Helicella itala*], *Helix* [= *Hygromia*] *hispida*, *Zua* [= *Cochlicopa*] *lubrica*, *Achatina* [= *Cœcilianella*] *acicula*.		
c.	Bluish carbonaceous marl, shells most plentiful ... ... *Succinea oblonga*, *Cyclas*.	2	0
a–b.	White tufaceous marl, sandy in places, becoming purplish towards base, and somewhat stratified ... ... *Cyclostoma elegans* [= *Pomatias reflexus*], *Clausilia*, *Succinea oblonga*, *Cyclas* or *Pisidium*, *Helix hortensis*, *Helix* [= *Pyramidula*] *rotundata*, *Helix* [= *Vitrea*] *cellaria*.	3	8

Mr. H. W. Bristow describes the deposit generally as consisting of:—

e. Brown loam, of unequal thickness, with scattered angular flints.
d. Brown clay with perished shells.
a–c. Calcareous tufa, 4 to 5 feet thick, sometimes equalling the Limnæan limestone in hardness, finer at the top and coarser below, and with a few black lines caused by decayed vegetable matter.

Since these last-named authors examined the deposit for the memoir of 1856 on "The Tertiary Fluvio-Marine Formation of the Isle of Wight," no further information concerning it appears to have been obtained.

It was largely owing to a remark in a former paper[1] that one of us was led to collect from this deposit. Though the cliff was

[1] A. Santer Kennard and B. B. Woodward, "The Post-Pliocene Non-Marine Mollusca of the South of England": Proc. Geol. Assoc., 1901, vol. xvii, p. 231.

found to be overgrown, but little difficulty was experienced in finding a place where the turf had slipped so as to expose the calcareous tufa beneath. Nothing, however, was seen of any of the beds of clay or sand associated with it. The spot from which the present collection was taken was at a very short distance to the south-west of Widdick Chine, and at about 8 or 10 feet below the top of the cliff. All the shells were obtained from about the same level, within a foot or so, but as no clear section was seen, and the bed collected from may have slipped somewhat from its original level, there is no reason to correlate it with one of the beds of tufa, as described by previous authors, rather than with another.

Seventeen species of mollusca were obtained, viz. :—

Vitrea crystallina (Müll.).
 ,, *nitidula* (Drap.).
 ,, *radiatula* (Alder).
Zonitoides nitidus (Müll.).
Euconulus fulvus (Müll.).
Sphyradium edentulum (Drap.).
Pyramidula rotundata (Müll.).
Helicigona arbustorum (Linné).
Helix nemoralis (Linné).
Helix hortensis (Müll.).
Cochlicopa lubrica (Müll.).
Jaminia muscorum (Linné).
Vertigo substriata (Jeff.).
 ,, *pusilla* (Müll.).
Clausilia bidentata (Ström.).
Carychium minimum (Müll.).
Limnæa truncatula (Müll.).

It will be noticed that only six of these species have been hitherto recorded, whilst several listed species did not occur in the material. Two species, *Vertigo substriata* and *V. pusilla*, are as yet unrecorded living from the Isle of Wight or Hampshire, though they are known to occur in tufaceous deposits in Hampshire. It is noteworthy that the examples of *Helix nemoralis* are without bands, whilst the specimens of *Helix hortensis* possess all the bands. Mr. Clement Reid, F.R.S., has noted that in the tufaceous deposit at Blashenwell a similar state of things occurred.[1] The great variation in these species is well known, and this variation is to be found amongst the fossil examples as well as recent, but with the shells from these two similar deposits there is no variation whatever. It affords an extremely interesting problem for which we can offer no solution.

The deposit lies on an uneven surface of the Potamomya Sands, which underlie the Limnæan limestone and belong to the Upper Headon Beds. Both Professor Edward Forbes and Mr. H. W. Bristow describe it as lacustrine, though land-shells are characteristic and fresh-water forms comparatively scarce, as had previously been noticed by Mr. Joshua Trimmer. Both the molluscan fauna and the nature and position of the deposit itself clearly indicate a damp land-surface, over which oozed the water, highly charged with carbonate of lime, which was thrown out of the Headon Hill limestones by springs. It is noteworthy, in this respect, that Mr. Trimmer describes it as being thickest under Headon Hill, and thinning away, and finally disappearing, in a distance of little more than

[1] C. Reid, "An Early Neolithic Kitchen Midden and Tufaceous Deposit at Blashenwell": Proc. Dorset Nat. Hist. and Ant. Field Club, 1896, vol. xvii, p. 74.

300 yards in a north-easterly direction. The springs to which this tufa owed its origin have been tapped by the recession of the cliffs,[1] so that no calcareous deposit now takes place, or has done since the deposition of the 'Warp-drift.' From the presence of a certain proportion of fresh-water forms, and from the beds of sand and clay which are interstratified with the tufa, there were most probably one or more small streams meandering through the area, with frequently changing course, but there does not appear to be any evidence of lacustrine conditions.

There can be no doubt that the deposit belongs to the Holocene Period, but no evidence has been obtained to enable us to fix its age with any greater precision.

VII.—The Ophite of Biarritz.

By P. W. Stuart-Menteath, Assoc. R. S. Mines.

Four articles in the Biarritz Association Bulletin, and a series in the last publications of the Soc. Géol. de France, discuss the problem of Pyrenean ophite by conjectures regarding the obscure points of greenstone in the shifting sands of the Biarritz coast. When first seeking new facts at Biarritz, I discovered the red marls and gypsum that accompany the ophite to be recurrent in the undisputed Upper Cretaceous of Croix d'Ahetze, and I followed the Biarritz rocks to Zumaya and Loyola in the attempt to trace their relations. Having subsequently proved that the other red clays mapped as Trias are brick clay of post-Glacial origin, contemporary with a tooth of *Elephas primigenius* and anterior to flint implements described as Pliocene, and having vainly demonstrated the continuity of the rocks of the Spanish coast by both maps and fossils, I would invite geologists to profit by the light railways and other advantages which to-day enable the fundamental section of Pyrenean geology to be easily studied in its unmistakable continuation.

Ideal constructions represent the Biarritz rocks as sharply truncated by an *effondrement* of the Atlantic basin. Observation proves that they skirt the coast, form the promontory of Abadia, present three species of Nummulites at Pasages, and, although stripped by the waves beyond Zumaya, recur in patches to far beyond Santander. The confusion resulting from treating as a transverse section the almost longitudinal exposures of Biarritz is an example of not uncommon tectonics.

The fossiliferous red limestones and marls which extend by Abadia and Fontarabia to Zumaya are rich in Ammonites, worked for cement, recognizable by lithologic character, and regularly affected by sharp local plications and dislocations along the thirty miles of coast in question. Marine erosion between Bidart and Abadia produces the only important break. Exactly as at Biarritz, so also at Fontarabia, the fossiliferous Danien summit of the Cretaceous is overlain by Flysch that represents the Lower Eocene and

[1] "The Geology of the Isle of Wight," by Messrs. H. W. Bristow, Clement Reid, and Aubrey Strahan: Mem. Geol. Survey, 1889, p. 229.

insensibly passes to the Nummulitic sandstones of the Biarritz cliffs. But at Fontarabia all formations are inclined at 15°, and the red and green clays that irregularly occur towards the junction of Eocene and Cretaceous are here, as along the whole thirty miles to Zumaya, obviously normal beds of Eocene or Cretaceous, whose vivid coloration and lithologic character explain these supposed intrusions of the Trias. The clearly local character of the sharp plications and dislocations is proved along thirty miles; the incorrectness of assuming the same to be gigantic faults at Biarritz is hence apparent. But many years ago I further urged the fact that the opposed dips and strikes, regularly quoted at Caseville as proof of a gigantic fault, are visibly local and gradually vanish towards the 'fault,'—which fault is moreover inferred logically from the erroneous supposition of Jacquot that its continuation at Fontarabia is indicated by a recurrence of Cretaceous, marked as such on every map except mine of Comptes Rendus Ac. Sc. of June, 1894, and that published in 1900 by the author of the Spanish Geol. Survey map of 1884. The Nummulites found at Pasages were recognized as unquestionable by Munier-Chalmas and other special authorities. As such decisive points are ignored in the entire discussion, and as the geologist who concludes it has classed the Flysch as Cenomanien by fossils at Gotein whose head and tail project on opposite sides of the decomposed limestone rolled pebbles that contain them, I need hardly discuss the siliceous *Orbitolina* which occur in the Flysch conglomerates, both beneath the Danien at Ciboure and above the Danien at Caseville, in rolled pebbles of that Cenomanien limestone whose outcrops to the south bristle with those indestructible organisms. From the central Pyrenees to the Ocean I have found *Hippurites, Plagiopticus,* and other shells of Turonien character in the uppermost beds of the Cenomanien limestone, which is the usual basis of the Flysch. My best collection of Turonien fossils is from the base of the Flysch of Roncesvalles and Oroz, which visibly overlies the Cenomanien limestone. M. Seunes discovered in my Cenomanien both Gault and Lower Aptien, respectively characterized by two names of one shell, found by both Sowerby and Davidson in the Cenomanien, but at first inadvertently christened with a name already monopolized by a Jurassic brachiopod.

South of Zumaya the red Danien and the Senonien of Bidart, largely worked at both places for cement, rest normally, as at Biarritz, on the Turonien Flysch. From beneath this rise irregular bosses of Cenomanien limestone, which, precisely as at Arette, Atheray, and many intermediate places, furnish a black and a flesh-coloured marble abounding in characteristic fossils. The polished slabs which line the sanctuary of Loyola, and are largely employed in the neighbourhood, present innumerable sections of *Radiolites Cantabricus*, Douvillé, *R. foliaceus*, Lamk., and other shells which, here as elsewhere, prove a Cenomanien age. In the recurrence of the Flysch above this limestone between Loyola and Zumarraga, I have counted fourteen intrusions of ophite in eight miles of the road. These intrusions, together with intermediate slices of usually metamorphosed but often freshly marly Flysch, compose a mountain mass nine miles in length and 2,000 to 3,000 feet in height, whose central portion is solid, and is mapped as solid ophite by the Spanish Survey on a transverse diameter of over three miles. The several intrusions strike in the four directions which in 1886 I summarized from a detailed survey of the mineral lodes of the neighbouring Pyrenees. As these lodes are very certainly of Tertiary age, the ophitic intrusions indicate a similar origin. Here only crush and contact breccias are noticeable, and the intrusions are of every variety from typical ophite to typical melaphyre and highly vesicular spilites. The uniquely valuable investigations of Dr. Ogilvie Gordon are especially applicable to this case, which affords ample evidence touching the intrusive character of the Biarritz ophite and its independence of any special formation in spite of constant association with the peculiar *facies* of the Flysch.

East of Biarritz a mass of ophite four miles in diameter, between Anglet and Villefranque, resembles that of Loyola in cutting across the Upper Cretaceous beds, and in the freshly irruptive character which enables both to be largely employed for metalling roads. At the Villefranque salt-work the same Nummulitic species are in contact with the gypsum, salt, and ophite as are in similar contact on the Biarritz coast. At both points the rocks of the Lower Eocene are metamorphosed and dislocated as at other Pyrenean localities. The oldest rocks of the neighbourhood are those containing the abundant Greensand fauna which I discovered and described in 1887 in Bull. Soc. Geol. The subsequent maps and papers of Captain Gorceix (1894), being filled with new and decisive facts, are never quoted by those who best know them. The salt deposits of Villefranque are analogous to those of Cardona, Suria, Pinos, etc., whose obviously Eocene age has been doubted only in consequence of speculations regarding Biarritz.

The ophite of Loyola is connected with the similar mass adjoining Biarritz, not only by the coast rocks, but also by two bands of Upper Cretaceous which, constantly accompanied by numerous ophite intrusions, cut across all the rocks of the western Pyrenees. One runs between Tolosa and Cambo, the other between Tolosa and St. Jean Pied de Port. In indifferent contact with rocks of every age, these bands independently connect the Flysch of Loyola with that of Biarritz, and show the intimate relation of the ophites which I have mapped along their unsuspected course. They habitually skirt the Trias; but the Muschelkalk of that formation, which I have compared by fossils and lithologic character to that of Goslar, is constantly broken into three or four strips separated by ophite outcrops, whereas the Upper Cretaceous exhibits contemporary volcanic conglomerates containing fossiliferous fragments of every age. These conglomerates abound in the Cambo district, and are thence traceable to Biarritz, as habitual constituents of the Upper Cretaceous Flysch. In both the ophitic outcrops of Mouligna and Caseville the ophite is only visible as isolated blocks and fragments in the metamorphosed horizon between the Danien and the Middle Eocene. Attempts to explain these outcrops as intrusions of Trias from below, or as carted caps from above, are equally opposed to the entire analogies of the neighbouring Pyrenees and to all serious observation of the ophites from the Pyrenees to Portugal, Italy, and Switzerland. They are hence instructive as explaining the paradoxes which their identical authors have each and all asserted regarding other districts of both the Alps and Pyrenees. I should add that the Spanish Survey maps, although fully recognizing my earlier observations, require considerable modification through those made since 1884, as their able authors would be the first to acknowledge.

VIII.—The Toarcian of Bredon Hill: A Reply to Prof. Hull.[1]

By S. S. Buckman, F.G.S.

In criticising my paper Professor Hull "regrets very much to have found it necessary to make these remarks." I regret it too, because he only raises issues which have been discussed, and, I hoped, settled years ago. But I fear that Professor Hull has not given attention to modern Jurassic literature. He says that Midford Sands is "a name unknown to geologists in general." Whereas, as the Editor points out, Professor Phillips was the author who amused himself with inventing this fanciful name, to adopt my critic's language. And in the 1879 edition of Sheet 44, at the foot of which appears the name E. Hull, there is on the margin this legend, "G 4, Midford Sand."

With similar neglect of literature the Professor states that "the much-debated question" about the sands "*was* settled [in favour of the Lias] by Dr. Wright in 1856, and was accepted by the Geological Survey." Yet in the Survey memoirs, "The Jurassic Rocks of Britain," vols. iii, iv, 1893–94, the Midford Sands are grouped with the Lower Oolitic series. Sir A. Geikie says in his "Textbook of Geology," 3rd ed., p. 898: "The upper stage [of the Lias] is composed of clays and shales . . . . surmounted by sandy deposits, which are perhaps best classed with the Inferior Oolite"—the view adopted by most Jurassic geologists.

If my critic had read my paper carefully he would have seen that what I claim to have settled is quite different from what Dr. Wright did. That author considered the sands of the Cotteswolds, of Somerset, and of Dorset, to be all on the same horizon, a later deposit than the Upper Lias Clay, but with Liassic affinities. He had no idea that the sands of one district were actually *earlier in date* than the Upper Lias Clay elsewhere. Evidently, too, the Survey Officers had no idea that what they mapped as G 3 in Dorset was much later than what they called G 4 in Gloucestershire, and was the same horizon as some that was mapped G 5 in Somerset.

It is my discovery that "in different localities the Sands are of different dates" (Q.J.G.S., vol. lix, p. 456). It is my discovery

[1] Geol. Mag., Dec. IV, Vol. X, No. XII, p. 541.

exactly what Ammonite faunas are found in the sands of Somerset and Dorset, about which nothing precise was known a few years ago. It is my discovery that the Sands and Cephalopod Bed contain some half-dozen distinct Ammonite faunas, which maintain always the same sequence, now proved widely on the Continent. By this sequence I can date the different sands with precision, as I have done in p. 456 op. cit. This is largely against Wright's "discovery." He claimed all the sands as Lias. I am able, taking the arbitrary line which Wright himself accepted, to show that certain of "these various sands" are Lias, and others Oolite. I can claim to have settled the much-debated question, because I have been able to give the facts—the faunal sequence.

Professor Hull asks where I "got hold of the idea" about the comparative thickness of the Upper Lias at Wotton and Bredon. Not from Survey publications, he is positive. I quote from "Geol. Country around Cheltenham" (Mem. Geol. Surv., 1857, pp. 24, 25): "The Upper Lias Shale . . . at Leckhampton Hill . . . is 230 feet [in thickness] . . . At Cleeve Cloud . . . 300 . . . At Bredon Hill . . . 100 feet or more . . . Towards the south . . . it thins gradually away to Wotton-under-Edge, where it is about 10 feet thick." In Sheet 44, Geological Survey, the outcrop of Upper Lias is 300 feet, measured by the contour-map of the Ordnance Survey. H. B. Woodward says: "In Gloucestershire the Upper Lias varies from about 10 feet at Wotton-under-Edge, to about . . . . 380 feet at Bredon Hill."[1]

Professor Hull asserts that he knew "the sands [G 4] of Wotton with the clays below [G 3] were representative in time of the Upper Lias [G 3] of Bredon Hill." If this was his opinion, why did he not record it in his map? If the value of G 3 changes from place to place, it is not consistent mapping. If G 3 means G 3 at some localities, and G 3+G 4 at others, who is able to interpret the map?

A plea put forward during the discussion of my paper tried to justify the changing value of a symbol on the ground that it was the object of the Survey maps to record lithology for the guidance of agriculturalists. This seems to imply that the Survey maps were not intended to be geological documents, but merely charts showing the outcrop of the various clays, sands, or limestones. And if the benefit of agriculturalists was so much considered, why were the Vales of Evesham and Gloucester mapped as Lower Lias Clay, when nearly their whole surface is thickly covered with sands or gravels? What use is such a map to agriculturalists? I said that, for their good, the superficial deposits should have been mapped first. Professor Hull derides this idea: he implies that so much would be blank. He forgets that, in the few places where the solid rocks are not marked by technical 'drift,' from the farmers' and from a strictly scientific point of view the soil and subsoil are superficial deposits, whose varying phases are quite as capable of being mapped as anything else. There need have been no blanks.

[1] "Geology of England and Wales," 2nd ed., p. 276.

Professor Hull resents the suggestion that a map done fifty years ago naturally requires considerable modification. Yet that must be a truism. To admit it, allows one to offer cordial congratulation on the work accomplished. To deny it, is to claim superhuman infallibility, and to receive a rude awakening. For if the Professor had studied modern Jurassic literature he must have seen many cases where the facts show the boundaries on Sheet 44 incorrect—cases like the one just recorded by Mr. Richardson, that what is mapped as Inferior Oolite at Condicote, near Stow, is Great Oolite.[1] Then there are differences in interpretation. Advance in knowledge has shown that boundaries drawn by lithological characters cannot be maintained; that to a greater extent than was formerly anticipated, lithic change does not imply sequent deposits; that clay, sand, and limestone are but regional phases of contemporaneous deposition, not to be indicated, as formerly, by sequent symbols G 3, G 4, G 5, but to be marked by the same symbol with modificatory additions, say Ag., Ar., C. for Argillaceous, Arenaceous, Calcareous.

Professor Hull's remark about *ésprit de corps* is regrettable. When one meets Officials out of office hours, and especially at the rooms of the Geological Society, one expects to meet, not officials, but scientific men, who would not put the Survey first and scientific accuracy second, but who desire, above all else, the advancement of science.

IX.—Note on *Pericyclus fasciculatus*, F. M'Coy, sp.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

In 1844, in his "Synopsis of the Carboniferous Fossils of Ireland," F. M'Coy described and figured the species *Goniatites fasciculatus* (p. 13, pl. ii, fig. 8), a Goniatite referable to the genus *Pericyclus*, Mojsisovics.[2] The type-specimen is preserved in the "Griffith Collection" in the Museum of Science and Art, Dublin, and has been re-figured (as *Pericyclus fasciculatus*) by Dr. A. H. Foord in his "Monograph on the Carboniferous Cephalopoda of Ireland" (pt. iv, 1901, pl. xxxvii, figs. 5*a*, *b*); where its locality is given as Millicent, Clane, county of Kildare.

In the same work M'Coy also describes the species *Nautilus* (*Temnocheilus*) *furcatus* (p. 21, pl. iv, fig. 13). The type-specimen was most probably from Cork, for it was lent to M'Coy by Dr. Haines of that place, and judging from M'Coy's figure it was much distorted and compressed like so many of the fossils from that locality. Its present location is unknown. Dr. Foord states that it is not in the "Griffith Collection" in the Museum of Science and Art, Dublin, in which many of M'Coy's types are contained, but says that "the excellent figure of it in the 'Synopsis' renders it easy of identification." Although this species has been previously referred to Mojsisovics'

[1] Geol. Mag., Dec. IV, Vol. X, No. 471, September, 1903.
[2] Abhandl. d. k.-k. geol. Reichsanst., Wien, vol. x (1882), p. 141.

genus *Pericyclus*,[1] Dr. Foord has shown (*op. cit.*, pt. iv, 1901, pp. 137, 138) that the specimens described as *P. furcatus* are only examples of *P. fasciculatus* that have lost the test; he has therefore united the two species, adopting M'Coy's name *fasciculatus* for two reasons, "(1) because it was the first to be described in the 'Synopsis,' and (2) because it shows the ornaments on the test, whereas the name *furcatus* was applied merely to the cast of the shell."

The following is Dr. Foord's emended description of the species:—

"Shell discoidal, somewhat inflated, umbilicated; greatest thickness at the umbilical margin, where it is two-thirds of the diameter of the shell; height of outer whorl two-fifths of the diameter of the shell. Whorls not fewer than five (exact number not ascertainable); inclusion about one-half; umbilicus somewhat less than one-half of the diameter in width, with subangular margin, deep, partly exposing the inner whorls. Whorl reniform in section, about twice as wide as high, not much indented by the preceding whorl; periphery broadly convex, continuous with the convex sides; inner margin rather wide, well defined, very steep.

"Body-chamber occupying at least one whorl; aperture not seen. Chambers of moderate depth; suture-line as in pl. xxxvii, fig. 6. Test ornamented with strong, rounded, transverse ribs, which generally begin to bifurcate at or near the umbilical margin, the bifurcation in some specimens not taking place till the middle of the side is reached. The ribs form a broad, shallow sinus in crossing the periphery, the sinus sometimes becoming sharply concave in the median line; the intervening concave spaces wider than the ribs. Covering the ribbing and interspaces there are a series of very distinct, sharp, raised lines, disposed irregularly as regards their distance apart; on the ribs about two of the lines occupy the space of 1 mm., but between them the lines are a little more spread out. The tendency of these fine ribs to form bundles is well marked, and made the name 'fasciculatus' given by M'Coy to the specimen bearing the test singularly appropriate."

The reference to the suture-lines is rather misleading, because the figure which Dr. Foord gives is taken from an immature specimen, and shows neither the characteristic pointed lateral lobe nor the existence of a second smaller pointed lobe on the inner area of the whorl. These suture-lines are stated to be those "of a small specimen where the diameter of the shell is about 30 mm.," but it correctly drawn they appear to have been taken from the young stage of a rather large individual, because the lateral lobe is still rounded, whereas in some of the specimens described below this lobe is distinctly pointed at a diameter of less than 30 mm. (See Figs. 2, 3, and 4.) The suture-line of the original of Dr. Foord's pl. xxxvii, figs. 2*a*, *b*, which is in the National Collection [No. C. 5933], is therefore given in the accompanying drawing (Fig. 1). In the figure in the "Catalogue of Fossil Cephalopoda, British Museum," pt. iii, p. 150, fig. 71*c*, the lobe on the inner margin of the whorl should have been represented a little deeper and more acute.

[1] See Cat. Foss. Ceph. British Museum, pt. iii (1897), p. 149.

M'Coy gives only two measurements of his *G. fasciculatus*, viz., diameter one inch six lines [= 38 mm.], and thickness of last whorl eleven lines [= 23·5 mm.], but according to Dr. Foord's figure of the type-specimen the other dimensions are:—radius,[1] 22·5 mm.; width of umbilicus, 11 mm.; and height of last whorl, 17 mm. The dimensions of *furcatus*, examples of which are, he says, generally elliptical, M'Coy states to be as follows:—diameter, two inches seven lines [65·5 mm.]; diameter [or height] of last whorl, thirteen lines [27·5 mm.]; thickness, eleven lines [23·5 mm.].

FIG. 1.—Suture-line of *Pericyclus fasciculatus*. Drawn of the natural size from a specimen in the British Museum [No. C. 5933] from the Carboniferous Limestone, Clane, co. Kildare, Ireland. In this and the following figures the short dotted lines crossing the suture-line indicate the position of the umbilical margin, the short line at each end marking the position of the suture of the shell, or 'line of involution.'

In his Monograph Dr. Foord gives no dimensions of the species, but figures four examples. Of these one (pl. xxxvii, figs. 2*a*, *b*) is the undistorted specimen from Clane belonging to the British Museum and referred to below; another is M'Coy's type of *fasciculatus* (pl. xxxvii, figs. 5*a*, *b*), the dimensions of which are given above; a third is a somewhat distorted example from Midleton, in the county of Cork; whilst the fourth is a smaller specimen from Glenbane East, in the county of Limerick. For the sake of comparison with the English examples recorded below the dimensions of the third and fourth specimens are here given. The measurements of the Midleton specimen are:—diameter, 65 mm.; radius, 40 mm.; width of umbilicus, 21·5 mm.; height of outer whorl, 28·5 mm.; thickness of outer whorl, 35·5 mm.: those of the example from Glenbane being:—diameter, 34 mm.; radius, 20 mm.; width of umbilicus, 10 mm.; height of outer whorl, 14·5 mm.; thickness of outer whorl, 21·5 mm.

In Ireland, according to Dr. Foord (*op. cit.*, pt. iv, 1901, p. 138), the species occurs at Cork, Midleton, Blackrock, in the county of Cork; Glenbane, in the county of Limerick; and Clane, county of Kildare. The species, however, is rare in England; hence the following particulars respecting English examples which have come under the writer's notice may not be without interest. In the list of fossils appended to the Geological Survey memoir on "The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire," 1887, the species is recorded from North Staffordshire (p. 182), the specimen referred to being from Beeston Tor, in North Staffordshire, about 1 mile east of Grindon, and now preserved in the Museum of Practical Geology, Jermyn Street.

Until comparatively recently the British Museum contained only one example of this species [No. C. 5933] having the locality

[1] A line drawn from the centre of the coil to the periphery of the shell.

recorded; this was from the Carboniferous Limestone of Clane, co. Kildare, Ireland, and was presented to the Collection by Dr. A. H. Foord. It was figured (under the name *Pericyclus furcatus*) in the "Catalogue of the Fossil Cephalopoda in the British Museum (Natural History)," pt. iii, p. 150, fig. 71, and has been re-figured (under the name *Pericyclus fasciculatus*) by Dr. Foord in his "Monograph on the Carboniferous Cephalopoda of Ireland," pt. iv (1901), pl. xxxvii, figs. 2*a*, *b*, its suture-line being given in Fig. 1 accompanying this paper. Its dimensions are:—diameter of shell, 51 mm.; radius, 29·5 mm.; width of umbilicus, 17 mm.; height of outer whorl, 20 mm.; thickness of outer whorl, 35 mm.; height of outer whorl above preceding whorl, 17 mm. As nearly as can be ascertained the outer whorl bears 34 ribs. It lacks the test and agrees with M'Coy's type of *furcatus*. Besides this, the National Collection contains two examples [No. C. 5773], 34 and 17·5 mm. in diameter respectively, like M'Coy's type of *fasciculatus*, but unfortunately the locality whence they were obtained has not been recorded.

In 1901, however, a well-preserved but imperfect example from the Carboniferous Limestone of Kniveton, 2 miles north-east of Ashbourne, Derbyshire, was presented to the British Museum [No. C. 7961] by the Rev. F. St. John Thackeray, M.A., F.G.S. It is a natural internal cast, and consists of the inner whorls up to a diameter of about 22 mm. that are entirely septate, and of about one-half of the succeeding whorl, which is about 40 mm. in diameter, and belongs to the body-chamber. At its greatest diameter, 40 mm., the other dimensions appear to have been:—radius, 23 mm.; width of umbilicus, 14 mm.; height of outer whorl, 14 mm.; thickness of outer whorl, 27 mm. There are eighteen or nineteen ribs in the last half-whorl. At a position on the inner whorls where the shell has a radius of 9 mm. the suture-line is displayed on both the peripheral area and the umbilical margin, and somewhat less clearly on the inner area or umbilical zone of the whorl. It is represented in the accompanying figure. Compared with "the suture-lines of a small

Fig. 2.—Suture-line of *Pericyclus fasciculatus*. Drawn of the natural size from a specimen (where radius is 9 mm.) in the British Museum [No. C. 7961] from the Carboniferous Limestone, Kniveton, 2 miles N.E. of Ashbourne, Derbyshire.

specimen where the diameter of the shell is about 30 mm.," given by Dr. Foord (*op. cit.*, pl. xxxvii, fig. 6), we note in the present specimen that where the radius is only about 10 mm. and the diameter therefore not more than about 18 mm., the sides of the external lobe are more nearly parallel, the external saddle is rounder, the lateral lobe is even at this diameter distinctly pointed, whilst a pointed, acutely V-shaped lobe is present on the inner area or umbilical zone of the whorl. No such lobe as the last-mentioned is indicated in Dr. Foord's figure, but it may be that the short line at each end of the suture-line is intended to denote the position of the umbilical margin, and not that of the 'line of involution,' or, as it is generally termed, the 'suture of the shell.'

Besides four specimens from Irish localities—two from Ireland, but locality uncertain; one from Limerick; and one from Kildare—the Museum of Practical Geology contains two English examples, one being the specimen from Beeston Tor, 1 mile east of Grindon, in North Staffordshire, already referred to, and the other from near Matlock, in Derbyshire.[1]

The Beeston Tor specimen [No. 8860] is a small natural internal cast bearing portions of the test in a very eroded condition. Its dimensions are:—diameter of shell, 20 mm.; radius, 12 mm.; width of umbilicus, about 7 mm.; height of outer whorl, 6·5 mm.; thickness of outer whorl, 16 mm.; height of the outer whorl above preceding, (?). There are about 30 ribs in the outer whorl, the last half-whorl bearing 14. The specimen does not appear to be at all crushed, but, as will be seen from its dimensions, it is relatively thicker than any of the other examples. The suture-lines are not shown.

The example from near Matlock [No. 6696] is also a natural internal cast; besides the outer whorl, which is a little imperfect on one side, about a quarter of the penultimate whorl is displayed, the rest of the inner whorls being probably present, though occluded by matrix. Its dimensions are:—diameter of shell, 32 mm.; radius, 18 mm.; width of umbilicus, 12 mm.; height of outer whorl, 12 mm.; thickness of outer whorl, 21 mm.; height of outer whorl above preceding, about 9 mm. There are 34 ribs in the outer whorl. A little less than one-half of the outer whorl is occupied by the body-chamber; several suture-lines are well displayed; the last is represented in the accompanying figure. This specimen is relatively

FIG. 3.—Suture-line of *Pericyclus fasciculatus*. Drawn of the natural size from the last septum of an example (at a radius of 13·5 mm.) in the Museum of Practical Geology [No. 6696] from the Carboniferous Limestone, near Matlock, Derbyshire.

thinner than the Beeston example, for at a radius equal to the greatest radius of that specimen this shell is only 13 mm. thick.

Through the kindness of Dr. Wheelton Hind I have been able to examine two examples in his collection that came from Bradbourne, about 2 miles north of Kniveton, Derbyshire. Both are internal casts. One is a fairly well preserved cast of the outer whorl, with the inner whorls present, although broken on one side and obscured by matrix on the other; it has the following dimensions:—diameter, 34·5 mm.; radius, 20 mm.; width of umbilicus, 16·5 mm.; height of outer whorl, 11·0 mm.; thickness of outer whorl, 21·5 mm.; height of outer whorl above preceding whorl, 9 mm. About five-sixths of the

[1] My best thanks are due to Mr. E. T. Newton, F.R.S., for the facilities given me to examine these fossils.

last whorl is occupied by the body-chamber; the last three suture-lines are clearly visible at the commencement of the outer whorl (see accompanying figure). Towards the anterior end of the body-chamber one side of the shell bears traces of an injury during the

Fig. 4.—Suture-line of *Pericyclus fasciculatus.* Drawn of the natural size from the last septum (at a radius of 13·5 mm.) of an example in the collection of Dr. Wheelton Hind, from the Carboniferous Limestone of Bradbourne, about 2 miles north of Kniveton, Derbyshire.

life of the animal that has interfered somewhat with the regular sculpturing of the shell, but the original number of the ribs crossing the periphery can be ascertained to be 36. As will be seen from the dimensions, this specimen is more widely umbilicated than the example from Kniveton.

The other specimen consists of about one-half of the outer whorl of a rather more finely sculptured example of about the same diameter as the fossil just described, that has been distorted into an elliptical form. It exhibits no septa, and most likely formed part of the body-chamber; the ribbing is a little irregular at the anterior part of the specimen, but in the half-whorl there appear to have been about 22 ribs on the central portion of the peripheral area.

The following table enables the type-specimen of M'Coy, the British Museum example from Clane, and the English examples referred to in the present paper to be more readily compared with one another, the specimens being arranged according to their respective diameters. (i) is the example from Beeston in the Museum of Practical Geology [No. 8860]; (ii), the specimen from near Matlock in the same collection [No. 6696]; (iii), the nearly complete example from Bradbourne in the collection of Dr. Wheelton Hind; (iv), M'Coy's type-specimen of '*G.*' *fasciculatus* in the Museum of Science and Art, Dublin; (v), the specimen from Kniveton in the British Museum Collection [No. C. 7961]; (vi), the example from Clane in the same collection [No. C. 5933]. The measurements are in millimetres.

	i	ii	iii	iv	v	vi
Diameter of shell	20 (100)	32 (100)	34·5 (100)	38 (100)	40 (100)	51 (100)
Radius of shell	12 (60·0)	18 (56·2)	20 (57·9)	22·5 (59·2)	23 (57·5)	29·5 (57·8)
Width of umbilicus	7 (35·0)	12 (37·5)	16·5 (47·8)	11 (28·9)	14 (35·0)	17 (33·3)
Height of outer whorl ...	6·5 (32·5)	12 (37·5)	11 (31·8)	17 (44·7)	14 (35·0)	20 (39·2)
Thickness of outer whorl	16 (80·0)	21 (65·6)	21·5 (62·3)	23·5 (61·8)	27 (67·5)	35 (68·6)
Height of outer whorl above preceding whorl.	?	*c.* 9 (28·1)	9 (26·0)	?	?	17 (33·3)
No. of ribs in outer whorl	*c.* 30	34	36	*c.* 33?	36	34

From the above table of measurements, it will at once be seen, firstly, that the Beeston example is relatively thicker than the others, and secondly, that there is some irregularity in the height of the outer whorl and of the width of the umbilicus in specimens iii and iv. In iii (Dr. Wheelton Hind's specimen from Bradbourne) the umbilicus seems to be relatively wider and the height of the whorl narrower than usual, whereas the reverse is the case in iv (M'Coy's type-specimen of '*G.*' *fasciculatus*). The former does not appear to be distorted, and is therefore a more evolute form than the rest, but in the absence of other similar specimens it is provisionally at least included in M'Coy's species. M'Coy's specimen is distorted, and the irregularity noted may be due to this distortion, for, judging from Dr. Foord's figure of the fossil (pl. xxxvii, fig. 5*a*), the anterior extremity of the outer whorl appears to be abnormally high. It may be mentioned that the examples of the species figured by Dr. Foord differ considerably in their relative dimensions.

The English localities, then, of *Pericyclus fasciculatus*, so far as known to the present writer, are confined to the western part of Derbyshire and the adjoining part of Staffordshire. They are:—(i) near Matlock, Derbyshire; (ii) Kniveton, 2 miles north-east of Ashbourne, Derbyshire; (iii) Bradbourne, about 2 miles north of Kniveton and about 10 miles south-west of Matlock, Derbyshire; and (iv) Beeston Tor, in North Staffordshire, about 1 mile east of Grindon and about 7 miles west of Bradbourne.

NOTICES OF MEMOIRS, ETC.

On the Igneous Rocks of the Berwyns. By T. H. Cope and J. Lomas.[1]

OWING to cross folding a dome-like structure has been impressed on the Berwyns. From the axis which lies about Llanrhaiadr-yn-Mochnant and Craig-y-Glyn the beds dip outwards on every side. The arch of the dome has been denuded, so that we get shales and limestones of Llandeilo age occupying the central area, while slates, grits, and limestone of Bala age form an almost continuous ring of hills on the margins.

Igneous rocks are associated with the sedimentaries. Three bands in the peripheral series can be traced continuously for a distance of thirty miles from the Mountain Limestone beds which overlap the series on the east, through the hills above Corwen and Bala to the Vyrnwy watershed. A fourth band also occurs in this series about Llanarmon.

In the central area other igneous rocks are exposed, generally of a more acid type.

The igneous series have been regarded as contemporaneous volcanic ashes, and recorded as such in the Survey maps. We have failed to find any instance of undoubted contemporaneous action, and regard all the igneous as intrusive. In places they are seen to cut across the sedimentaries at right angles to the strike.

In this paper we only deal with a small part of the peripheral series as displayed about Llansantffraid-Glyn-Ceiriog where the river Ceiriog in cutting a deep gorge across the strike of the beds has exposed magnificent sections.

[1] Abstract of a paper read before the British Association, Southport, Section C Geology), September, 1903.

Sheet No. 1.—The outermost bed is well seen in the quarries at Coed-y-Glyn, on the west side of the valley, and in a small cutting on the hillside on the east side. It is 45 feet thick on the level of the road, but thins out rapidly to the north, as at a short distance away it only measures 28 feet. Baked slates lie in contact on both its upper and lower surfaces.

The rock consists of a felted aggregate of felspar microliths, and is aphanitic in texture. The upper margin for 5 feet and the lower part for 2 feet are amygdaloidal. Near the upper surface the microscope reveals flow-brecciation, broken fragments of the rock lying in a bond of grey translucent chalcedony.

Sheet No. 2.—This band, about 165 feet thick, has been quarried extensively on the face of the steep crags overlooking Pandy, at Cae Deicws, and in the large quarry opposite Coed-y-Glyn. Indurated slates and grits border the sill on both surfaces, and large masses of slate occur as inclusions. A band of white rock of very varying thickness occupies the middle, which under the microscope shows large idiomorphic quartz and orthoclase felspar crystals in a felsitic ground-mass. The margins are intensely sheared, grey in colour, and include a great number of slate and limestone fragments along with angular pieces of the white uncleaved central portion.

Sheet No. 3.—This sheet is well seen in Coed Errwgerrig, and can be traced across the bed of the river to the east side of the valley at Cwm Clwyd. While the main mass resembles Sheet No. 2 in composition, it includes fragments of quartz felsite, felsite breccias, and nodular rhyolites arranged in parallel bands.

It is 190 feet thick, and has caused intense metamorphic action on the grits above and slates below.

Sheet No. 4 is best seen at Hendre Quarry, where it is worked extensively, and locally known as the Glyn 'Granite.'

It is an analcite-diabase, 96 feet thick, of coarse texture in the middle and finer grained towards the margins. The slates in contact are converted into compact spotted slate.

Intrusions of similar age and almost identical character have been described from Counties Donegal, Armagh, Wicklow, and other parts of Ireland, and a close parallelism can be drawn between these rocks and those in the Berwyns. The intrusions of Sheets Nos. 1, 2, and 3 probably date from the interval between the deposition of the Bala series and the overlying slates and grits of Wenlock age. No. 4 may be of a later date.

REVIEWS.

I.—The Palæontographical Society.

THIS Society, founded in 1847 for the publication of monographs on British fossils, has just completed its fifty-seventh volume, for 1903, which is now being issued to subscribers. It is one of the largest and most varied volumes hitherto published by the Society, and is illustrated with no less than 48 plates. It contains instalments of six monographs devoted to Fishes, Mollusca, Trilobites, and Graptolites. The second part of Dr. Smith Woodward's Monograph of Chalk Fishes resembles the first part in being illustrated by explanatory restored sketches in addition to the usual lithographs of fossils. Mr. Woods completes the first volume of his Cretaceous Lamellibranchia; and Dr. Wheelton Hind finishes his Monograph of Carboniferous Lamellibranchiata, apart from a brief Appendix which is to appear in 1904. Dr. A. H. Foord is to be congratulated on finishing his important Monograph of the Carboniferous Cephalopoda of Ireland; and subscribers will express the hope that he may soon supplement it by another volume treating of the similar fossils of Great Britain. Mr. Cowper Reed begins a new Monograph of the Lower Palæozoic Trilobites of Girvan, which are very numerous, though for the most part fragmentary. The Misses Elles and Wood contribute another valuable section of their Monograph of British Graptolites, the descriptive portion this year relating to the family Leptograptidæ. The Annual Report of the Society is now prefixed to the volume, and from it we learn that during the year ended 31st March, 1903, there was a serious reduction in the income. New subscribers are needed to replace many recent losses by death, and we commend the Palæontographical Society's guinea's-worth to the notice of all geologists who are not yet acquainted with it. The Secretary of the Society, from whom all information may be obtained, is Dr. A. Smith Woodward, British Museum (Natural History), South Kensington, London, S.W.

II.—Memoirs of the Geological Survey: England and Wales.

1.—The Geology of the Country near Chichester. (Explanation of Sheet 317.) By Clement Reid, F.R.S., F.G.S., etc.; with contributions by G. W. Lamplugh, F.G.S., and A. J. Jukes-Browne, F.G.S. 8vo; pp. iv and 52, paper cover; price 1*s.* 1903. Colour-printed sheet, No. 317, price 1*s.* 6*d.* (separately sold).

2.—The Geology of the Country around Torquay. (Explanation of Sheet 350.) By W. A. E. Ussher, F.G.S. 8vo; pp. iv and 142; paper cover, price 2*s.* 1903. [The map (New Series, No. 350) was published in 1898; the present memoir is issued as an explanation of that map.]

1.—The publications of the Geological Survey of England and Wales again claim our attention, the first of the present series relating to the country near Chichester. This memoir takes in an area of 216 square miles, all in the county of Sussex, and includes a large tract of the South Downs, which presents a bold escarpment of Chalk stretching from east to west and fronting to the north, overlooking the great Wealden area, a portion only of which is represented on the map (Sheet 317). It embraces the picturesque regions of Midhurst, Petworth, and Pulborough, on the north, and the low-lying fertile tracts of drift-gravel and brickearth on the south. The Chalk Down descends gradually southwards to a low level, and forms a syncline in the hollow of which Lower Eocene strata are preserved. On the south the Downs usually end in a lower bluff which marks the position of an ancient, partly obliterated sea-cliff, and below this is a flat coastal plain which extends continuously to the sea.

One river of importance, the Arun, traverses the country from north to south, and with its tributaries drains about two-thirds of the area. Over the remaining area most of the water escapes by underground courses to the Lavant, or drains into small streams which reach the sea near Bognor, and at Pagham Harbour—where a submarine forest has been observed, and a deposit of *Scrobicularia* clay occurs—since reclaimed.

Within the area lies the ancient town of Chichester, with its cathedral and its seven churches and other ancient relics; Arundel, with its castle (both giving titles to earldoms); with several other towns, and numerous villages. All through this district the population has taken up its abode where water was easily obtainable, no place of importance lying on the Weald Clay or Gault, nor on the high Downs, where water can only be obtained by means of deep wells.

Most of the district is devoted to agriculture and to sheep pasture, but also contains much woodland—beech on the Downs and oak in the Weald.

The Weald Clay forms wet and rather poor land, much of it being laid down in pasture. In former times it was extensively covered with forests (called *hursts*), hence the suffix to the names of many towns, as Pens*hurst*, Staple*hurst*, Mid*hurst*, etc. It was termed 'Oak-tree Clay' by William Smith, although the term was more generally used by Smith for the Kimeridge Clay, but sometimes also for the Gault. The oak was chiefly used in obtaining charcoal for the old iron furnaces once common in the Weald. The ironstone was largely smelted, particularly in the western part of the area (H. B. Woodward's Geology, pp. 363–364). Of course, with the introduction of coal for iron-smelting the very limited production of the highly superior *charcoal-made* Sussex iron ceased as an industry, and neither mines nor manufactures any longer exist within the district.

The once famous 'Petworth' or 'Sussex Marble,'[1] a fresh-water limestone composed almost entirely of two or more species of *Paludina*, *P. sussexiensis* and *P. fluviorum*, appears to be no longer worked. It was extensively used in ecclesiastical buildings, monuments, and altar-pieces in mediæval times. Some of the recumbent figures of Knights Templar in Winchelsea Church are carved out of Petworth marble.

The formations represented on Sheet 317 embrace Recent Alluvial deposits; Pleistocene, Brickearths, Gravels, Flint-rubble, Clay with Flints (overlying the Chalk); Eocene, comprising London Clay, Pebble Beds, and Reading Beds; Upper Cretaceous Series, Upper,

[1] Known also as 'Bethersden Marble' and 'Laughton Stone.'

Middle, and Lower Chalk; Selbornian, Upper Greensand, and Gault; Lower Cretaceous or Lower Greensand, Folkestone Beds, Sandgate Beds, Hythe Beds, Atherfield Clay, and lastly the Weald Clay.

Nothing is yet known about the strata which underlie the Weald Clay; but as far as can be judged from neighbouring areas, a great thickness of Lower Cretaceous and Jurassic rocks would be met with. It is not probable that any minerals worth mining occur within several thousand feet of the surface.

Figures of fossils from the Gault, the Lower Chalk, the Middle and the Upper Chalk are given in the text, together with lists of fossils and sections. Two sections north and south across the area (1) from Easebourne across Heyshott Down (745 feet) and Goodwood Racecourse (542 feet) to Rumboldswyke, and (2) from Broadford Bridge across Kithurst Hill (700 feet) to Highdown Hill (266 feet), form the frontispiece to this little memoir, which is clearly written, but less interesting geologically than one would have expected, considering its well-marked physiography. The colour-printed geological map is extremely well executed and clear.

Referring to some of the steep slopes of the Lower Chalk (p. 22), Mr. Clement Reid observes: "Some parts of the slopes are too steep for cultivation, and are clothed, and seem always to have been clothed, with ancient hanging woods, locally known as 'hangers,' principally of beech, with some undergrowth of holly and hazel. So little of the primæval forest is anywhere left in Sussex, except on the heavy clay lands of the Weald, that it is interesting to find these small outliers still remaining. They contain rare woodland animals and plants, such as one does not find in the forests of the Weald. Among the mollusca both *Helix obvoluta* and *Clausilia Rolphii* are to be found, and among the plants Solomon's seal and Herb-Paris. In one of these woods the zigzag connecting the Roman Stone Street with the lowlands is well seen."

2.—Mr. W. A. E. Ussher, the author of the present Explanatory Memoir, has had the advantage of following in the footsteps of one of our most able and distinguished of early Devonian geologists, R. A. C. Godwin-Austen, whose map appeared in 1840. Another able worker, Dr. Holl, brought out a map in 1868, with some additional details, and he was followed a few years later by Mr. Arthur Champernowne, who commenced a careful survey of the neighbourhood of Totnes. Mr. Horace B. Woodward, at Torquay, and Mr. Ussher, at Paignton, commenced the official re-examination of the district in 1874–75.

Mr. Champernowne, shortly before his death, generously handed over the results of his geological labours to the Survey, and to Mr. Ussher was entrusted the task of embodying these results in the official publications.

The new map (Sheet 350) was published in 1898, and the present memoir is issued as an explanation of that map.

The district is one of exceptional difficulty owing to the want of persistence in well-marked lithological horizons, and to stratigraphical

TABLE OF FORMATIONS, WITH FOREIGN EQUIVALENTS AND LOCALITIES.

PLEISTOCENE.	Alluvium	Of River Dart and tributaries, and of streams with seaward outlets.
	River Terrace Gravels	Dart Valley above Totnes; north of Paignton.
	Submerged Forests	Tor Abbey Sands; the Paignton coast; Blackpool, near Stoke Fleming.
	Head	Traces on Raised Beach platforms at Hope's Nose, Churston Cove, etc., not shown on the map.
	Raised Beaches	Hope's Nose; Thatcher Stone; Churston Cove; near Berry Head; Sharkham Point.
	Cavern Deposits	Kent's Cavern; Windmill Hill Cavern, Brixham; Happaway Cavern; Anstey's Cove, Cavern.
LOWER NEW RED (Permian).	Conglomerate and Breccia, with beds of Rock Sand	Oddicombe Beach; St. Mary Church; west of Torquay; Paignton.
	Clays with sandy beds, Brecciated Clays	Petit Tor; north of Torre Station; Edginswell; north of Compton; etc.
	Sandstone outliers, and in fissures in limestone	Outliers near Waddeton, Brixham, Durl Head; fissures near Churston Cove and Berry Head.
UPPER DEVONIAN.	Cypridinen Schiefer	Red and greenish slates with Entomostraca: Anstey's Cove, Goodrington.
	Büdesheim Schiefer	Red slates and slaty mudstone: Saltern Cove and Ivy Cove.
	Knollen Kalk and Kramelzel	Slates, etc., with calcareous nodules, compact concretionary limestone: Saltern Cove, Ivy Cove, Ilsham.
	Goniatiten Schichten	Irregular liver-coloured shaly limestone: Petit Tor Combe, Anstey's Cove, Ilsham.
MIDDLE DEVONIAN.	*Rhynchonella cuboides* Zone	Pale massive sub-crystalline limestone: Lummaton, Petit Tor, Ilsham, etc. Bedded limestone: Goodrington, Elbury, etc.
	Stringocephalen Kalk	Massive and bedded limestones, mostly coralline: Babbacombe, Torquay, Brixham, Ipplepen, Marldon, Dartington.
	Stringocephalen Schiefer	Slates replacing limestone in Dartington Park, Broadhempston, etc.
	Eifler Kalk	Thin-bedded slaty and shaly limestones: Hope's Nose, Redgate Beach, Daddy Hole, Mudstone Bay, Harbertonford, etc.
	Eifler Schiefer	Fossiliferous, irregular, partly calcareous slates: Berry Park. More even slates: Mudstone Bay anticline, etc.
LOWER DEVONIAN.	Upper Coblenzien: Staddon Grits.	Hard quartzose grits; red, dull green, and grey grits with slates and shales; top beds west of Hope's Nose Raised Beach; main outcrop from north end of Southdown Cliff westward, Warberry Hill, Lincombe Hill, Torquay, Cockington, etc.
	Lower Coblenzien and Taunusien (Siegener Grauwacke). Meadfoot Beds, including Looe Beds.	Dark grey slates, knubbly and irregular, with compact grit beds, and fossiliferous calcareous bands. Dark grey slates with silty films, occasional beds of grit and lenticles of limestone. Beds of Looe and Ringmore type on coast, south of Man Sands, locally red-stained.
	Gedinnien (?): Dartmouth Slates.	Variegated, purple, green, etc., glossy slates, grit shales (quartzo-phyllades), and occasional beds of hard grit; Scabbacombe Head, to south-west corner of map.

complications of a most intricate character, due to folding and faulting. Much detailed work was therefore necessary before even the broader tectonic features could be deciphered.

The three main divisions of the Devonian formation have now been made out and their boundaries ascertained with approximate accuracy, and brought into line with their Continental equivalents.

Seventeen sections in the text serve to illustrate the numerous faults, folds, and contortions which the Devonian series of Torquay have undergone, and graphically express the difficulties in tracing out and mapping this varied and complicated area. The annexed table may serve to show the several subdivisions which are recognised, together with their foreign equivalents and localities (see p. 38).

The author furnishes lists of fossils from Lummaton (pp. 66–68), and refers to the Rev. G. F. Whidborne's monograph on the Devonian Fauna (Pal. Soc. Mon.) for authorities. Summarised, they show: Trilobita 17, Phyllocarida 1, Ostracoda 9, Entomides 2, Cephalopoda 16, Gasteropoda 48, Lamellibranchiata 30, Brachiopoda 72, Discina 1, Crania 1, Bryozoa 14, Echinodermata 10. In chapter vii, under Post-Tertiary and Recent Deposits (p. 13), there is given a summary of cavern deposits, including the historic caves of Kent's Hole, Torquay, and Brixham Cave. Lists of the animals discovered are given, and, under the account of the Raised Beaches, carefully prepared lists of the Mollusca.

There are no economics to deal with in this area beyond Building-stones, Road-metal, and Ornamental Marble works in which slabs of Devonian Coral limestone are chiefly employed, good examples of which may be seen in the Survey Museum and the Geological Gallery of the Natural History Museum in Cromwell Road.

The six-inch maps of this area have been deposited in the Survey Office for reference, and copies may be obtained at cost price.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 18th, 1903.—Sir Archibald Geikie, D. Sc., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "Notes on some Upper Jurassic Ammonites, with special reference to Specimens in the University Museum, Oxford." By Miss Maud Healey. (Communicated by Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S., F.G.S.)

In the course of rearranging the Upper Jurassic fossils in the Oxford University Museum, the attention of the authoress has been called to the large amount of prevailing misconception with regard to Sowerby's species *Ammonites plicatilis* and *Am. biplex*. The type-specimen of *Perisphinctes plicatilis* (Sow.) is refigured and described. It is in the form of a cast, but only an indefinite statement exists as to the locality from which it was derived. It appears to be an Upper Corallian form, and is usually taken as the zone-fossil of that horizon. Sowerby's two figures of *Perisphinctes biplex* represent different specimens, one of which is dismissed from consideration. The other, probably from a Kimmeridge Clay nodule found in the Suffolk Drift, is refigured and described. The authoress considers that it would be wisest to abandon the name altogether, or at least to restrict it to the abnormal specimen to which it was first attached. The original specimen of *Perisphinctes variocostatus* (Buckland) came from the so-called Oxford Clay at Hawnes, 4 miles south of Bedford; but the authoress gives evidence in favour of her belief that it was really derived from the Ampthill Clay. Sowerby's *Ammonites rotundus* is the last species figured, and it is doubtfully identified as a variety of *Olcostephanus Pallasianus* (D'Orb.). It was derived from the Kimmeridge Clay of Chippinghurst, 6½ miles south of Oxford, and is the zone-fossil of the Upper Kimmeridge Clay.

2. "On the occurrence of *Edestus* in the Coal-measures of Britain." By Edwin Tulley Newton, Esq., F.R.S., V.P.G.S.[1]

This genus was originally described from the United States, and was afterwards recognized in beds of similar age in Russia and Australia. The genus was afterwards placed with *Helicoprion* and *Campyloprion* in the family Edestidæ. The specimen described in the present paper was obtained by Mr. J. Pringle from one of the marine bands which occurs between the 'Twist Coal' and the 'Gin Mine Coal,' in the Smallthorn sinking of Messrs. Robert Heath & Son's pits at Nettlebank (North Staffordshire). Several other marine bands, chiefly met with during the sinking of shafts in this coalfield, have been studied by Mr. J. T. Stobbs, who called the attention of the Geological Survey to the exposure from which this specimen was obtained. The specimen is a single segment of a fossil very closely resembling *Edestus minor*, and consists of an elongated basal portion, bearing at one extremity a smoothed, enamelled, and serrated crown. A description of the fossil shows that it is not to be referred to any existing species, and a new name is given to it. While it seems most in accordance with present knowledge to regard the 'spiral saw' of *Helicoprion* as the enrolled, symphysial dentition of an Elasmobranch, possibly allied to the Cestracionts, it does not seem nearly so probable that the forms referred to *Edestus* are of the same nature. In the opinion of the author the latter are more likely to be dorsal defences. The paper concludes with a bibliography of the subject.

II.—Royal Microscopical Society.

At the ordinary meeting on December 16th, 1903, Dr. Henry Woodward, F.R.S., President, in the chair, the following paper was read:—

[1] Communicated by permission of the Director of H.M. Geological Survey.

"On the Structure and Affinities of the genus *Porosphæra*, Steinmann." By Dr. G. J. Hinde, F.R.S. The well-known rounded and thimble-shaped fossils, of common occurrence in the Chalk of this country, which were named and figured as *Millepora? globularis* and *Lunulites urceolata* by the late Professor John Phillips, have been, by different authors, referred alternately to Foraminifera, Siliceous Sponges, and Cyclostomate Polyzoa. In 1878 the first-named species was placed by Dr. Steinmann as the type of a separate genus of the Hydrocorallina, which he named *Porosphæra*, and its structure was stated to resemble that of *Millepora* and *Parkeria*. From an examination of 2,900 specimens collected by Dr. A. W. Rowe and by the author from the different zones of the English Chalk, and of a singularly perfect specimen in flint discovered by Mr. H. Muller, it has been ascertained that the anastomosing fibres of *Porosphæra* are composed of four-rayed spicules which are fused together so as to form a firm, strong skeleton. In the form of the spicules and in their mode of union there is the closest resemblance to those of *Plectroninia*, Hinde, from the Eocene Tertiary of Victoria, Australia, and to the recent *Petrostroma*, Döderlein, from the Japanese Sea, and with these genera *Porosphæra* belongs to the Lithonine group of Calcisponges. The author further discovered fragments of an outer spicular crust or dermal layer on a very few specimens, which consisted of delicate, simple, rod-like, and three-rayed spicules, irregularly agglomerated, but not fused together. It is probable that a similar crust was originally present in all the forms, though it has now to a large extent been removed.

The following species were recognized and described: *P. globularis*, Phill., *P. nuciformis*, von Hagenow, *P. Woodwardi*, Carter, *P. pileolus*, *P. patelliformis*, sp.n., and *P. arrecta*, sp.n. The relative distribution and the range of size of each of these forms in the respective zones of the English Chalk are also given.

III. — Mineralogical Society, November 17th, 1903. — Dr. Hugo Müller, F.R.S., President, in the chair. Mr. R. H. Solly gave a detailed description of various minerals from the Binnenthal, five of which had not been identified with existing species. These five minerals all contain lead, arsenic, and sulphur, but sufficient material for complete analyses has not yet been obtained. Three of them are red transparent minerals having each one perfect cleavage and a similar vermilion streak, but differing crystallographically: one is apparently orthorhombic with (100), (110) = 39° 16′, (010), (011) = 52° 57′, and (001), (101) = 42° 43′; another is oblique with $\beta = 78°$ 46′, (100), (101) = 42° 22′, and (010), (111) = 37° 3′; while the third has a zone at right angles to the perfect cleavage with angles of approximately 30° and 60°. The other two minerals, which could not be identified with any of the other sulpharsenites of lead previously described by the author, are black with metallic lustre. One of these is oblique with $\beta = 81°$ 11′, (100), (101) = 40° 7′, (010), (111) = 55° 26′: it has a perfect cleavage (100), and like Liveingite exhibits no oblique striations on the planes in the zone [100, 001]. The other mineral is also oblique with $\beta = 89° 40'$, (100), (101) = 46° 18′, and (010), (111) = 59° 56′: it has a perfect cleavage (100), and like Rathite exhibits numerous oblique striations on the planes in the zone [100, 001]. On fine brilliant crystals of Sartorite recently obtained by the author he has been able to confirm the oblique symmetry which he had previously announced and to determine accurately the elements $\beta = 88° 31'$, (100), (101) = 54° 45′, (010), (111) = 69° 52½′. Amongst other specimens from the dolomite of the Lengenbach in the Binnenthal, the author exhibited and described peculiar rounded crystals of Galena resembling Seligmannite, Hyalophane crystals twinned according to the Carlsbad law and showing three new forms, a green mica which was determined to be anorthic, Albite and Biotite, minerals which have not been hitherto recorded from the locality, and Barytes in green crystals. Of specimens from the Ofenhorn, the author exhibited some remarkably fine crystals of Anatase, and crystals of Laumontite, a mineral new to the locality.—Mr. L. J. Spencer described crystals of Adamite from Chili, which were remarkable for their strong pleochroism.—Mr. G. F. Herbert Smith discussed the prismatic method of determining indices of refraction. From observations of the angles of incidence and deviation the refractive index and direction of the wave-front in the crystalline medium could be found. By using pairs of faces in the same zone and different angles of incidence a series of refractive indices is obtained, which, when plotted with the direction angle as ordinate, gives in general a double curve. Three of the critical values are the principal indices, the fourth corresponding to the direction parallel to the zone-axis. The angles of polarisation with respect to the zone-axis provide a means of discriminating between the doubtful values. A description was given of an inverted goniometer whereby observations could be made in media other than air.

OBITUARY.

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S.

Born December 3, 1819. Died December 18, 1903.

In the closing days of the old year another veteran geologist has laid aside his hammer and gone to his rest, working up to the very last of his long and active life at his favourite science.

The name of Robert Etheridge is well known to all the older geologists, and, until his retirement from the public service on the 31st December, 1891, he had been a familiar figure for 34 years in the London geological world, 24 of which he was one of the Palæontologists to the Geological Survey and Museum in Jermyn Street, while for ten years he was attached to the British Museum

(Natural History), Cromwell Road, as Assistant Keeper of Geology. To the readers of the Geological Magazine his name must have been very familiar, having appeared on the cover as one of the Assistant Editors since the 1st July, 1865, a period of 39 years.

Mr. Etheridge was a Herefordshire man, having been born at Ross on 3rd December, 1819.

His public career may be said to have commenced with his appointment in 1850 as Curator to the Museum of the Philosophical Society in Bristol, an office which he held with distinction for seven years. During five years of this period he also occupied the post of Lecturer in Botany in the Bristol Medical School, then a highly esteemed centre of medical instruction. He was besides a frequent lecturer on Geology and Palæontology in the Bristol Philosophical Institution. In 1856, when paying a visit to the Earl of Ducie, who is himself an excellent geologist, Mr. Etheridge was introduced to Sir Roderick I. Murchison, then Director General of the Geological Survey of Great Britain, as a promising geologist deserving of a more important post than Bristol could offer him, and in the following year (1st July, 1857) Etheridge, through Murchison's interest, was appointed to the Geological Survey as Assistant Palæontologist under J. W. Salter in the Museum of Practical Geology.

During the 24 years in which he was attached to the Survey, Mr. Etheridge travelled over a very large portion of the United Kingdom in assisting the younger Surveyors in their work in the field by means of his palæontological knowledge. He prepared numerous Palæontological Reports and Lists of Fossils to accompany the Memoirs of the Geological Survey upon various parts of England and Wales; he also wrote a Report on the Palæontology of Jamaica. For fifteen years he gave demonstrations annually in Palæontology to the students of the Royal School of Mines, at that time attached to the Museum of Practical Geology, Jermyn Street. With the assistance of his colleague, Mr. George Sharman, he rearranged the entire Palæontological Collection, and prepared a catalogue of the specimens which was published with a preface by Professor Huxley.

Mr. Etheridge contributed numerous papers to the Geological Society of London, which appeared in the Quarterly Journal of that Society from 1863 to 1889; the most important being his memoir "On the Physical Structure of North Devon," being a defence of the unity of the Devonian system, which had been disputed by Professor J. Beete-Jukes. It occupied 200 closely printed pages of the Journal, with lists of all the known fossils as well as of those personally collected in the field during an examination of the North Devon area, extending over several months.

He prepared a description of the Palæozoic and Mesozoic fossils of Queensland, Australia, 1872, collected by Mr. R. Daintree, F.G.S., and later on, in 1878, of the fossils brought home by the Arctic Expedition under Captain Sir George Nares, R.N., which formed a most important addition to our knowledge of the palæontology of the Polar lands.

When President, Mr. Etheridge delivered two most valuable addresses to the Geological Society of London, that in 1881 "On the Distribution of British Palæozoic Fossils," and in 1882 "On the Distribution of British Jurassic Fossils."

His other papers include descriptions of British Oolitic and Liassic Mollusca (1863); Jurassic Fossils of the Himalayas (1864); the Rhætic beds and sections (1865–66); Geology of the Bristol Coal-Basin (1866); the Stratigraphical position of Irish Labyrinthodonts (1866–67); the Geological position of the Bristol Conglomerate (1870); a new species of Echinoid from North Africa (1872); the Geology of the Watchet Area (1873); a Table of British Fossils, in Lyell (1874); Fossil Plants from Kosloo, Black Sea (1877); some New Tertiary Mollusca from Brazil (1879); on *Lepidotus maximus* (1889).

Probably the most important of Mr. Etheridge's labours has been the preparation of a Catalogue of the Fossils of the British Isles, stratigraphically and zoologically arranged — published by the Clarendon Press, Oxford, 1888 (4to, pp. 468)—of which it is to be regretted that only vol. i, comprising the Palæozoic fossils, has ever appeared, vols. ii and iii being still in manuscript, although completed up to 1888. In this work the author has catalogued 18,000 species of fossils.

Mr. Etheridge was elected a Fellow of the Geological Society of London in 1854, and served on the Council from 1863 to 1868, from 1872 to 1878, and from 1880 to 1883. He was elected President in 1880, and held the office until February, 1882. He received the Award of the Wollaston Fund from the Geological Society in 1871, and the Murchison Medal and Fund in 1880.

Mr. Etheridge was President of Section C (Geology) at the Meeting of the British Association, Southampton, 1882.

He became a Fellow of the Royal Society of Edinburgh in 1855, and of the Royal Society, London, in 1871, and served on the Council of the latter Society in 1884.

In 1890 he was elected an Honorary Fellow of King's College, London.

He has served on the Council of the Palæontographical Society for many years, and was made Treasurer in 1880, an office he retained up to the time of his death.

On the 20th October, 1881, Mr. Etheridge's services were transferred, with the sanction of the Treasury, from the Geological Survey and Museum to the British Museum (Natural History), where, in association with his friend Dr. Henry Woodward, F.R.S., the Keeper of the Department of Geology, he occupied the post of Assistant Keeper for ten years. One of the most interesting pieces of work which Mr. Etheridge accomplished was the preparation of a Stratigraphical Collection to illustrate by sections, maps, and specimens all the British sedimentary rocks. This is exhibited in Gallery XI, and is much valued by students of geology.

Mr. Etheridge was always distinguished by his courtesy and his readiness to impart scientific information to students and the public at large, and he was greatly esteemed as an officer in the Museum, whilst his energy and activity of disposition enabled him to accomplish a very large amount of scientific work daily.

He retired from office at the end of 1891 (under Clause X of the Order in Council of 15th August, 1890). He continued, however, to be employed by the Trustees until the 31st March, 1893, when the Treasury vetoed any further engagement. A year later, on the 26th April, 1894, his old colleagues and friends, to the number of 85, gave him a complimentary dinner at the Imperial Institute, the chair being taken by Sir William Flower, K.C.B., the Director of the Museum of Natural History.

In 1896 he was presented with the first Bolitho gold medal by the Royal Geological Society of Cornwall in recognition of his distinguished services to geology, especially in the Western Counties.

But his retirement from office by no means retarded his scientific work, for he continued independently to pursue his geological and palæontological labours up to the close.

He devoted much of his time during the last twelve years to the duties of Consulting Geologist to the Dover Coal Boring, and patiently and accurately recorded foot by foot every core and sample of material brought to bank by the engineers. Many of these specimens are deposited in the Geological Department, British Museum (Natural History), where he continued to carry on his researches up to the end. He was deeply interested in the Coal Commission, was a well-known authority on the Bristol Coalfield and on that of the Kentish and the Franco-Belgian area, which he had carefully studied. In 1897 he read a paper before the Engineering Conference on "The Kent Coalfield," in which he affirmed his belief in the existence of an extensive and valuable coalfield in the South-East of England or near Dover, and explained its relation to the coalfields of the South-West of England (Bristol and Somerset), and to those of the North of France and Belgium. He made excursions to Belgium, Germany, and Austria, examined the volcanic phenomena of the Auvergne and of the Eifel districts, and wrote a short account of his visit to Central France.

He was an authority upon water-supply, and was frequently associated with the late Mr. Hawksley and his son, Mr. Charles Hawksley, M.I.C.E., and other eminent Civil Engineers, in connection with supplies for Bristol, Plymouth, London, and other large centres of population.

Mr. Etheridge was author of a Report, dated 22nd June, 1857, on Thames Mud and Thames Water, being based upon a microscopic examination of eighteen samples of mud and detrital deposits and two or more samples of water taken from the River Thames; giving a detailed account of each sample, both for the living organisms, the organic matter in a state of decomposition, and the inorganic mineral residuum; issued as Appendix II to Report relating to the Main Drainage of the Metropolis (folio, pp. 61–72). Ordered to be printed by the House of Commons, 3rd August, 1857.

He was also engaged to prepare Maps and Sections, and to give evidence before the "Royal Commission on Coal" (13th March, 1868) in relation to the Somersetshire Coalfield, and especially in reference to the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata. [See Report of the Royal Commission on Coal, vol. i, pp. 419–422 (D. 7–10), folio; 1871.]

He leaves an only son, Mr. Robert Etheridge, jun., who has occupied the post of Curator of the Australian Museum, Sydney, N.S.W., since 1887, and was from 1879 to 1887 an Assistant under Dr. H. Woodward, F.R.S., in the British Natural History Museum, London, and previously on the Geological Survey of Scotland, with Sir A. Geikie, F.R.S. Like his father, Mr. Robert Etheridge, jun., is a distinguished palæontologist and geologist, and commenced his career as one of the staff of the Geological Survey of Victoria, Australia, under the late Dr. A. R. C. Selwyn, F.R.S.

Among his other literary labours it may be mentioned that Mr. Etheridge greatly assisted Dr. J. J. Bigsby, F.R.S., F.G.S., in the preparation of his great works (see author's prefaces to works)—(*a*) "Thesaurus Siluricus," 1868, 4to, pp. 268; (*b*) "Thesaurus Devonico-Carboniferus," 4to, 1878, pp. 450. He edited the third edition of Part i of "Illustrations of the Geology of Yorkshire," 4to, 1875, pp. x and 354, by Professor John Phillips, F.R.S., who died 24th April, 1874. He also assisted Mr. J. W. Lowry to construct his Chart of Characteristic British Tertiary Fossils, stratigraphically arranged; London, E. Stanford, 1866.

Mr. Robert Etheridge was a Corresponding Member of the Imperial Institute of Vienna, an Honorary Member of the Geological Society of Belgium, of the New Zealand Institute, the Royal Geological Society of Cornwall, the Philosophical Societies of Yorkshire and Bristol, the Geologists' Association, the Norwich Geological Society (since defunct), the Cotteswold Naturalists' Field Club, of the Hertfordshire Natural History Society, the Dorset Natural History and Antiquarian Field Club, and the Northamptonshire Natural History Society and Field Club.

A severe cold and an attack of bronchitis terminated his busy and useful life after a brief illness of three days.

List of Titles of Works and Memoirs by Robert Etheridge, F.R.S. L. & E., F.G.S.

1. "Geology; its Relation and Bearing upon Mining." (Lectures, Bristol Mining School.) 8vo; Bristol, 1859.
2. "Descriptions of new species of Mollusca, etc." [*Ceromya gibbosa, Astarte dentilabrum*, and *Pollicipes liassicus*]: Quart. Journ. Geol. Soc., vol. xx (1864), pp. 112–114.
3. "Note on the Jurassic Fossils collected by Captain Godwin-Austen" [in the N.W. Himalayas]: Quart. Journ. Geol. Soc., vol. xx (1864), pp. 387–388.
4. "On the Rhætic or *Avicula contorta* Beds at Garden Cliff, Westbury-upon-Severn, Gloucestershire": Proc. Cotteswold Club, vol. iii (1865), pp. 218–234.
5. "A Catalogue of the Collection of Fossils in the Museum of Practical Geology, Jermyn Street." (Preface by Professor Huxley, pp. i–lxxix.) Catalogue, pp. 1–382. 8vo. 1865.

6. "On the Palæontology of the Caribbean Area," being Appendix V to the Geology of Jamaica, by Jas. G. Sawkins, F.G.S., 1866. 8vo; pp. 306–339. (Published as a Colonial Memoir of the Geological Survey.)
7. "Section of the Rhætic Beds at Aust Cliff"; Proc. Cotteswold Club (1866), pp. 13–18.
8. "On the Physical Structure of the Northern Part of the Bristol Coal-Basin, chiefly having reference to the Iron Ores of the Tortworth Area": Proc. Cotteswold Club (1866), pp. 28–49.
9. "On the Discovery of several new Labyrinthodont Reptiles in the Coal-measures of Ireland": Geol. Mag., Vol. III (1866), pp. 4–5.
10. "On the Stratigraphical Position of *Acanthopholis horridus*, Huxley": Geol. Mag., Vol. IV (1867), pp. 67–69.
11. "On the Physical Structure of North Devon, and on the Palæontological Value of the Devonian Fossils": Quart. Journ. Geol. Soc., vol. xxiii (1867), pp. 251–252, abstract, (full text) 568–698; Phil. Mag., vol. xxxiv (1867), pp. 317–318.
12. "Supposed Permian Beds at Portskewet": Proc. Cotteswold Club, vol. iv (1868), pp. 256–258.
13. "On the Geological Position and Geographical Distribution of the Reptilian or Dolomitic Conglomerate of the Bristol Area": Quart. Journ. Geol. Soc., vol. xxvi (1870), pp. 174–191; Phil. Mag., vol. xi (1870), pp. 136–137.
14. "Description of a new genus (*Rotuloidea*) of Fossil Scutelloid Echinoderm from Saffe, N. Africa": Quart. Journ. Geol. Soc., vol. xxviii (1872), pp. 97–101.
15. "Description of the Palæozoic and Mesozoic Fossils of Queensland": Quart. Journ. Geol. Soc., vol. xxviii (1872), pp. 317–350, pls. xiii–xxviii.
16. "On the Rhætic Beds of Penarth and Lavernock": Trans. Cardiff Nat. Soc., vol. iii (1872), pp. 39–64.
17. "Notes upon the Physical Structure of the Watchet Area, and the Relation of the Secondary Rocks to the Devonian Series of West Somerset": Proc. Cotteswold Club, vol. vi (1873), pp. 35–49.
18. "Table of British Fossils illustrative of the Successive Appearance and Development in Time of the Chief Orders, Classes, or Families of Animals and Plants in Britain": pp. 623–645. Printed as a Supplement to Sir Charles Lyell's Students' Elements of Geology, 2nd ed., 1874; 3rd ed., 1878.
19. Appendix. [Mesozoic fossils found by the Rev. J. E. Cross in N.W. Lincolnshire.] Quart. Journ. Geol. Soc., vol. xxxi (1875), pp. 126–129.
20. "Notes on the Fossil Plants from Kosloo" [Black Sea]: Quart. Journ. Geol. Soc., vol. xxxiii (1877), pp. 532–533.
21. "Palæontology of the Coasts of the Arctic Lands visited by the late British Expedition under Capt. Sir George Nares, K.C.B.": Quart. Journ. Geol. Soc., vol. xxxiv (1878), pp. 568–636, pls. xxv–xxix.
22. "Notes on the Mollusca collected by C. Barrington Brown, Esq., from the Tertiary Deposits of the Solimöes and the Javary Rivers, Brazil": Quart. Journ. Geol. Soc., vol. xxxv (1879), pp. 82–88, pl. vii.
23. Presidential Address to the Geological Society of London, Feb. 18, 1881, "On the Analysis and Distribution of the British Palæozoic Fossils": Quart. Journ. Geol. Soc., vol. xxxvii (1881), Proceedings, pp. 37–235.
24. "On a New Species of *Trigonia* from the Purbeck Beds of the Vale of Wardour": Quart. Journ. Geol. Soc., vol. xxxvii (1881), pp. 246–248.
25. Appendix. [*Nematophycus Hicksii*.] Quart. Journ. Geol. Soc., vol. xxxvii (1881), pp. 490–495.
26. Presidential Address to the Geological Society of London, Feb. 17, 1882, "On the Analysis and Distribution of the British Jurassic Fossils": Quart. Journ. Geol. Soc., vol. xxxviii (1882), Proceedings, pp. 46–236.
27. Presidential Address to the Geological Section of the British Association, Southampton, August 23, 1882.
28. "Stratigraphical Geology and Palæontology" (being a new and revised edition of Phillips's Manual, entirely rewritten). 1885. 8vo; pp. 712, with 33 plates.
29. "Fossils of the British Islands, Stratigraphically and Zoologically arranged": vol. i (1888), Palæozoic Species. 4to; pp. viii and 468.

Vol. ii, Mesozoic, and vol. iii, Cainozoic, completed, but still in manuscript.

30. (With Mr. H. Willett) "On the Dentition of *Lepidotus maximus* (Wagner), as illustrated by specimens from the Kimeridge Clay of Shotover Hill, near Oxford": Quart. Journ. Geol. Soc., vol. xlv (1889), pp. 356–358, pl. xv.
31. Letter on Dr. Wheelton Hind's Carboniferous Lamellibranchiata: Geol. Mag., Dec. IV, Vol. IV (1897), p. 94.
32. "On the Relation between the Dover and Franco-Belgian Coal Basins": Rep. Brit. Assoc. for 1899 (1900), pp. 730–734.

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1. 1858. Geology of parts of Wilts and Gloucestershire (Sheet 34). Lists of Fossils by R. Etheridge.
2. 1859. Geology around Woodstock, Oxon (Sheet 45). List of Fossils by R. Etheridge.
3. 1860. Geology of part of Leicestershire (Sheet 63). List of Fossils by R. Etheridge.
4. 1861. Geology of part of Northampton and Warwick (Sheet 53). List of Fossils by R. Etheridge.
5. 1862. Geology of the Isle of Wight (Sheet 10). List of Fossils by R. Etheridge.
6. 1862. Geology of part of Berks and Hants (Sheet 12). Lists of Fossils by R. Etheridge.
7. 1864. Geology of Banbury, Woodstock, etc. (Sheet 45). Lists of Fossils by R. Etheridge.
8. 1875. Geology of the Burnley Coalfield (Sheets 88, 89, and 92). Table of Fossils by R. Etheridge.
9. 1875. The Geology of the Weald, by W. Topley, F.G.S., etc. Lists of Fossils by R. Etheridge.
10. 1875. The Geology of Rutland, by J. W. Judd, F.G.S. Appendix and Tables of Fossils by R. Etheridge.
11. 1876. Geology of East Somerset, by H. B. Woodward, F.G.S. Lists of Fossils by R. Etheridge.
12. 1876. Geology of the Lake District, by J. C. Ward, F.G.S. Appendix on New Species of Fossils by R. Etheridge.
13. 1877. Superficial Geology of South-West Lancashire, by C. E. De Rance, F.G.S. Lists of Fossils revised by R. Etheridge.
14. 1878. Catalogue of the Cambrian and Silurian Fossils in the Museum of Practical Geology (the "Wyatt-Edgell Collection"). "The specimens have been named by Mr. Etheridge, F.R.S., Palæontologist to the Geological Survey." The Catalogue drawn up by Mr. E. T. Newton, F.G.S.
15. 1880. Geology of the South of Scarborough (Sheet 95). List of Fossils revised by R. Etheridge.
16. 1881. Geology of the Country round Norwich (Sheet 66). Lists of Fossils revised by R. Etheridge.
17. 1881. Geology of the Oolitic and Liassic Rocks, Malton. Lists of Fossils revised by R. Etheridge.
18. 1881. Geology of the Neighbourhood of Cambridge. Palæontological Appendix by R. Etheridge.
19. 1881. Geology of North Wales, by A. C. Ramsay, F.R.S. (second edition). J. W. Salter's Appendix on the Fossils, revised and greatly enlarged by R. Etheridge (pp. 351–567).

Note.—Although, owing to Mr. Etheridge's death having occurred so very near before Christmas, the Publishers were prevented from issuing a portrait of him in this (January) Number, yet his friends will, we feel sure, be glad to be informed that an excellent and, as yet, unpublished photograph of him—quite lately taken by Miss Constance E. Power (daughter of Edward Power, Esq., one of Mr. Etheridge's oldest and most valued friends)—will appear in the February Number of the Geological Magazine.—H. W.

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HORACE B. WOODWARD, F.R.S., &c.

FEBRUARY, 1904.

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Ever yours
R. Etheridge

THE

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ORIGINAL ARTICLES.

I.—A Retrospect of Palæontology in the last Forty Years.[1]

(Part II.)

IN any retrospect of scientific progress there are always special points, 'golden milestones,' along the road by which we travel, which mark unusual stages in our journey. Zittel, in his "History of Geology and Palæontology," fixes the 'heroic period' from 1790 to 1820, when the great masters of our science, Werner, Pallas, Saussure, Hutton, Playfair, William Smith, Leopold von Buch, Alexander von Humboldt, Alex. Brongniart, and Cuvier arose and laid the foundations of Geology.

The more recent development from 1820 to the close of the century may seem like an unbroken line of advance in geology and palæontology; but such is not the case. Special events of scientific interest from time to time, like the arrival of reinforcements, have given us fresh support and encouragement. The establishment of Geological Surveys in this country, in America, and on the Continent added an enormous onward impulse to such investigations, as did also the meetings of the Geological Society of London and its publications. The establishment of the British Association in 1830, and the increasing tendency to teach Natural Science in our great Universities, have stimulated and encouraged a very large number of ardent workers to enter the geological field. Nor must we forget the interest which the writings of Sedgwick, Buckland, Murchison, Lyell, Phillips, Forbes, Ramsay, Geikie, and many others, produced in the minds of students who came under their influence.

But the most powerful and wide-spreading impulse given to geological and palæontological investigations was undoubtedly due to the publication by Charles Darwin of his "Origin of Species," and the revolution caused by the introduction of the doctrine of 'the variation of species,' which the older naturalists had never admitted, having always treated them as permanent and immutable ideas. Only those of us who have lived through the period between 1858 and 1878 can fully realize the vast and radical change in the current

[1] Part I, of "A Retrospect of Geology," appeared in our January number, 1904, pp. 1–6.—Edit. Geol. Mag.

of scientific thought which was brought about in the minds of men by Darwin's teaching. In making a retrospect of the work recorded in this journal from 1864 to the present time, the evolution of geological and palæontological ideas is most marked, and it is no small gratification to feel that the GEOLOGICAL MAGAZINE has been enabled to incorporate in its pages so much valuable material in aid of the progress of both these sciences.

As has been stated in the earlier part of this Retrospect, the GEOLOGICAL MAGAZINE has had the satisfaction of publishing articles from a large number of early and celebrated geologists, many of whom alas are now no longer with us.

FOSSIL PLANTS.—We record with pleasure the name of Professor John Phillips, who, in 1865, described an interesting specimen of fossil wood bored by *Teredo* and enclosed in flint, from the Chalk of Winchester, preserved in the Oxford Museum. Professor E. W. Claypole, of Ohio, described and figured the oldest known tree, *Glyptodendron Eatonense*, from the Upper Silurian, Eaton, Ohio, U.S.A. No fewer than eighteen valuable contributions on Palæobotany (from 1865 to 1885) have been made by our old colleague, William Carruthers, on Carboniferous plants; Mesozoic Cycadean stems and fruits; on the petrified forest near Cairo; and the plants of the Brazilian Coal-beds; nor must we omit to mention his admirable lecture at the Royal Institution "On the Cryptogamic Forests of the Coal Period" (1869, pp. 289–300). Another distinguished botanist, Sir W. T. Thiselton-Dyer, wrote in 1872 on the Coniferæ from Solenhofen, and on fossil wood from the Eocene of Herne Bay and the Isle of Thanet. In 1868 George Maw described some flower-like forms from the leaf-bed of the Lower Bagshot, Studland Bay. Professor H. A. Nicholson recorded the existence of plants in the Skiddaw Slates. Dr. O. Feistmantel contributed notes on the Fossil Flora of Eastern Australia and Tasmania, dealing with those from the Tertiary, Secondary, Carboniferous, and Devonian formations. Walter Keeping described some early plant-remains from the Silurian of Central Wales, in which he endeavoured to discriminate between tracks and markings made by annelids and other animals and those left on these old rocks by seaweeds and other simple plants. Dr. Constantine Baron von Ettingshausen wrote on the Tertiary Floras of Australia and New Zealand, and J. S. Gardner on the Mesozoic Angiosperms and Flowering or Phanerogamous Plants, in which an exhaustive examination is made of the Oolitic, Cretaceous, and Tertiary Plants of the British Isles, as known to the author in 1886. Henry Woodward described some fragmentary Mesozoic plant-remains from South Australia.

In later years A. C. Seward took up the subject of Fossil Botany, described the stems of *Calamites undulatus*, the leaves of *Cyclopteris* from the Coal-measures of Yorkshire, and wrote on the specific variation in *Sigillariæ*; E. A. Newell Arber followed and defined the *Glossopteris* flora, and discoursed on Homœomorphy among Fossil Plants. Plant-remains from British Columbia and from Argentina have also been described.

Foraminifera.—Sir William Logan was the first to announce the discovery (November, 1864, p. 225) of the Foraminifer '*Eozoon*' in the Laurentian rocks of Canada, and Sir J. W. Dawson contributed "new facts" (in 1888), and "evidence for the animal nature of *Eozoon Canadense*" (in 1895). But the inorganic nature of this supposed most ancient fossil seems to be now very generally admitted, although Dr. Carpenter and Sir William Dawson long and valiantly laboured to maintain its integrity as one of the Protozoa.

The Nestor of Palæontology, Professor T. Rupert Jones, wrote on Foraminifera from the Bridlington Crag; *Orbitoides* from Malta and the West Indies; on Jurassic Foraminifera of Switzerland and the Chalk and Chalk Marl of South and South-East of England; in company with Professor W. K. Parker he elucidated those of the Chalk of Gravesend, and listed Eley's Foraminifera from the English Chalk; whilst with C. D. Sherborn he described the Jurassic Microzoa of Wiltshire, etc. Dr. H. B. Brady enumerated and figured *Involutina liassica* from the Lias of England, and 8 species of Tertiary and Carboniferous Foraminifera from Sumatra. He reported upon some 28 species from the 'Chalk' of the New Britain group, of which he observed: "After washing this Chalk it could not possibly be distinguished, by its organic remains, from a washed sample of 'Globigerina-Ooze' dredged in 1,500 to 2,500 fathoms in the South Pacific. May not the rock (he asks) be part of a recent sea-bottom disturbed by volcanic or other agency." He also wrote on those remarkable flask-shaped Foraminifera of the genus *Lagena*, from the Upper Silurian of Malvern. A. Vaughan Jennings described the Orbitoidal Limestone of North Borneo. Professor W. J. Sollas defined two new species of the genus *Webbina* and other Foraminifera from the Cambridge Greensand, and Walter Keeping the zone of *Nummulina elegans* at White Cliff Bay, Isle of Wight. F. Chapman and C. D. Sherborn discoursed on the Foraminifera of the London Clay, and F. Chapman on Hyaline forms from the Gault, also upon *Patellina* and 23 other genera and species from the Tertiaries of Egypt. A. K. Coomáraswámy wrote on the Radiolaria *Spongodiscus* and *Dictyomitra* from the Upper Gondwána series near Madras.

Porifera—Sponges.—Dr. H. B. Holl contributed a carefully written article on Fossil Sponges, in which, after describing their various structures in considerable detail, he strongly advocated their minute microscopic examination and comparison with living forms, and said: "In conclusion, the Sponges appear to have endured through a long range of time, subject only to modifications which scarcely amount to specific distinctions." Dr. G. J. Hinde explained the structure of *Archæocyathus minganensis* from the Palæozoic (Mingen) strata of Canada; Sponge-remains from the Chert and Siliceous Schists of Permo-Carboniferous age of Spitzbergen; wrote on *Stephanella sancta*, a new genus of sponge from the Lower Silurian, Ottawa, Canada; and on *Palæosaccus Dawsoni*, a new Hexactinellid sponge from the Quebec group (Ordovician), Little Mitis, Canada. The discovery of this fossil by Sir William Dawson made known an abundant sponge-fauna in rocks previously considered to be unfossiliferous. Professor Sollas figured and described a Vitreo-hexactinellid sponge from the Cambridge Coprolite-bed, which he named *Eubrochus clausus*. Dr. G. J. Hinde (1886) showed that *Eophyton? explanatum*, Hicks, and *Hyalostelia fasciculus*, described by Dr. Hicks as plants, were really sponges, and he illustrated their microscopic structure.

Graptolites.—Among the authors who have contributed to the study of this group of organisms must be specially mentioned the names of Professor H. Alleyne Nicholson, William Carruthers, John Hopkinson, Professor Chas. Lapworth, Linnarsson, and Holm. Lapworth wrote on the Classification of the Rhabdopora (1873) and on the Scottish Monograptidæ (1876); Hopkinson on *Dicranograptus*, *Dicellograptus*, and on Scottish Graptolites; Carruthers on the systematic position of Graptolites, and a revision of British species. Nicholson described the Graptolitic shales of Dumfriesshire and the Lower Silurian Graptolites of South Scotland, and noticed some associated reproductive bodies. E. T. Newton figured Graptolites from Peru. Dr. G. Holm, of Stockholm, described and figured some most beautiful Swedish Graptolites belonging to *Didymograptus*, *Tetragraptus*, and *Phyllograptus*. T. S. Hall wrote on the Graptolite-bearing rocks of Victoria, Australia; while Dr. O. Hermann contributed an important paper on the Organisation and Economy of Graptolites, and Dr. G. Linnarsson gave their vertical range in Sweden.

Corals.—One of the most valuable papers on Corals was that by Dr. Gustav Lindström (1866) dealing with those remarkable *operculated* forms from the Silurian — *Goniophyllum pyramidale*, *Rhizophyllum Gotlandicum*, and *Hallia calceoloides*, found at Wisby, I. of Gotland, and from our own Wenlock Limestone—closely related to *Calceola sandalina*, Lamk., from the Eifel Devonian, found also at Torquay, Devonshire, and described in 1873 by the Rev. T. R. R. Stebbing. These fossils were formerly placed with the Brachiopoda. Professor H. A. Nicholson contributed eight papers on *Cystiphyllum*, *Hemiphyllum*, *Favosites*, *Cleistopora*, etc., and R. F. Tomes seven essays on the *Madreporaria*. Professor P. Martin Duncan wrote on *Axosmilia longata* from the Inferior Oolite. Dr. G. J. Hinde described some Corals and Polyzoa from Western Australia; Dr. J. W. Gregory on fossil *Madreporaria* and *Millestroma* from Egypt. H. A. Nicholson and Robert Etheridge, jun., figured a small coral, *Cladochonus*, parasitic on the stems of crinoids.

Stromatopora.—Dr. Alexander Brown, working in the Aberdeen University laboratory, made a most important contribution on the structure and affinities of the genus *Solenopora*, and described and figured seven new species.

Starfishes (Asteroidea and Ophiuroidea).—H. Woodward announced a new and very interesting fossil Ophiuroid from the Silurian of Dudley named *Eucladia Johnsoni*; and *Helianthaster filiciformis*, another new species of starfish from the Devonian of South Devon. Dr. P. Hebert Carpenter figured and noticed a group of beautiful bulbous-armed starfishes from the Chalk of Bromley, Kent. A paper was contributed by the late Dr. Wright on a new *Ophiurella nereidea* from Calciferous Grit, near Weymouth. The Rev. J. F. Blake noticed a new Solaster (*S. Murchisoni*) from the Lias, Yorkshire, closely resembling *Solaster moretonis*; and Dr. J. W. Gregory wrote on *Lindstromaster antiqua* and *Palæasterina Bonneyi* from the Ludlow beds of Shropshire, and *Protaster brisingoides* from Victoria, Australia.

CRINOIDEA. — G. E. Roberts communicated a note on the Mountain Limestone of Yorkshire and its Crinoids, and gave an excellent chromo-lithographic plate of *Woodocrinus expansus*, found near Richmond. J. Rofe monographed five genera of Crinoids from the Mountain Limestone of Lancashire and Yorkshire, giving a plate illustrating the structure of these forms; he also noticed the curious swellings on stems of Crinoids due to small investing Corals, known as *Cladochonus*, which he described (1869). Ten years afterwards Nicholson and Etheridge redescribed this coral. Mr. Rofe had a further paper on the minute structure observable in the column of *Pentacrinus*, illustrated by excellent figures, and in yet another paper he described the structure in the stems of *Rhodocrinus*, *Platycrinus*, and *Euryocrinus*. Professor G. de Koninck gives an account of new and remarkable Echinoderms from British Palæozoic rocks, figuring the genera *Palæchinus*, *Placocystites*, and *Haplocrinus*. E. Billings called attention to *Placocystites* = *Ateleocystites Huxleyi*, from Dudley, while H. Woodward added a note and figures of the same, and in 1880 more fully discussed and figured this remarkable Cystidean. J. E. Lee noted the occurrence of *Cupressocrinus* in the Devonian Limestone near Kingsteignton. Dr. F. A. Bather figured *Merocrinus Salopiæ* from the Ordovician of Shropshire, *Hapalocrinus Victoriæ*, a new Silurian Crinoid from Melbourne, Victoria; he added studies in Edrioasteroidea, and gave an account of his search for *Uintacrinus* in England and Westphalia.

ECHINOIDEA.—Professor P. Martin Duncan had a note on *Galerites albogalerus*, Lamk. Dr. J. W. Gregory described *Rhyncopygus Woodi* from the English Pliocene, and some Australian fossil Echinoderms, *Archæodiadema*, a new genus of Liassic Echinoidea, and Egyptian fossil Echinoderms. T. Roberts noticed two abnormal Cretaceous Echinoids from the Lower Chalk of Cambridge.

ANNELIDA. — J. Hopkinson figured *Dexolites gracilis*, a new Silurian Annelid from Moffat; H. A. Nicholson, two new species of Tubicular Annelids; and R. Etheridge, jun., wrote on British Carboniferous Annelida and noticed some 25 species (1880).

CRUSTACEA.—The Crustacea have always occupied a very important position in the pages of the GEOLOGICAL MAGAZINE. Sir J. William Dawson described and figured *Homalonotus Dawsoni* from the Upper Silurian, Pictou, and *Anthrapalæmon Hilliana* from the Carboniferous of South Joggins, Nova Scotia. C. Spence Bate figured *Archæastacus Willemœsii* (which is really equivalent to *Eryon crassichelis*) from the Lias of Lyme Regis. James Carter refers to *Orithopsis Bonneyi* from the Upper Greensand of Charmouth, near Lyme Regis, Dorset; and notices fossil Isopods from the

Upper Greensand of Cambridge. Professor T. T. Groom gave figures and descriptions of a minute Trilobite, *Acanthopleurella Grindrodi*, from the Dictyonema shales (Cambrian) of Malvern. Professor C. E. Beecher sent (1900) a restoration of the great long-legged Eurypterid, *Stylonurus Lacoanus*, from the Devonian of Pennsylvania, U.S. Professor G. A. J. Cole noticed *Belinurus kiltorkensis* from Ireland; and Dr. Anton Fritsch described *Prolimulus Woodwardi* from the Permian 'Gaskohle' of Bohemia. R. Etheridge, jun., noticed a *Turrilepas* from the Upper Silurian of New South Wales, and Professor W. B. Benham figured a gigantic form of Cirripede (*Pollicipes Aucklandicus*) from the Tertiary beds of New Zealand. Wyatt-Edgell described and figured *Lichas patriarchus* from the Llandeilo Flags, also *Asaphus Corndensis* and other species of Trilobites in a second paper (1867). Thomas Belt in two papers illustrated several new Trilobites of the genera *Olenus*, *Agnostus*, and *Conocoryphe*, from the Cambrian of North Wales. Professor Lapworth announced the discovery of the *Olenellus* fauna in the Lower Cambrian rocks of Britain, and described *Olenellus Callavei* from Shropshire. Professor Claypole recorded *Dalmanites* in the Lower Carboniferous of Ohio, U.S. Professor C. D. Walcott and C. E. Beecher sent three papers on the appendages and structure of Trilobites; and W. K. Spencer wrote on the hypostomic eyes of *Bronteus*. S. H. Reynolds figured *Dindymene Hughesiæ* and three other Trilobites, from the Lower Palæozoic of Wharfe, Yorkshire. F. R. Cowper Reed contributed eleven papers on Trilobites from the Cambrian, Silurian, and Carboniferous, including *Oryctocephalus Reynoldsi* from the Cambrian of North America. He noticed a new species of *Cyclus* (*C. Woodwardi*) from the Carboniferous of Settle, Yorkshire. Henry Woodward in six papers described and figured numerous species of Carboniferous and Culm Trilobites from Yorkshire and Devonshire. Two papers are devoted to *Homalonotus*, and six papers to Cambrian and Silurian Trilobites from Australia, Canada, and Britain. Of Brachyuran Decapod Crustaceans Dr. Woodward has monographed *Goniocypoda Edwardsi*, a new genus of shore-crab from the Lower Eocene of Hampshire; several species of crabs from the Upper Cretaceous of Faxe, Denmark, and from the Cretaceous of Vancouver Island, British Columbia; *Prosopon mammillatum*, a true crab from the Great Oolite of Stonesfield. Of Macrouran forms he wrote on *Scyllaridia Belli*, on two species of *Palæmon* from the Eocene of the Isle of Wight, and on *Meyeria Willetti* from the Chalk of Sussex. Dr. Woodward wrote seven papers on *Præatya scabra*, *Eryon antiquus*, *E. Stoddarti*, *Glyphea*, and *Penæus*, and on two species of *Æger*, all from the Lias formation of Dorset and Warwickshire, and on the genus *Anthrapalæmon* from the Coal-measures.

On fossil Isopods H. Woodward added three papers, one on *Palæga Carteri* from the Grey Chalk of Bedfordshire and Folkestone, and *Cyclosphæroma* from the Great Oolite of Northampton and the Purbeck beds of Aylesbury; ten species of the genus *Cyclus* from the Carboniferous Limestone and the Lower Coal-measures are defined in three papers (1870, 1893, and 1894). The Cirripede originally described by H. Woodward (in 1868) as *Pyrgoma cretacea*, from the Chalk of Norwich, proved to be intermediate between the sessile and pedunculated groups. This new form, named *Brachylepas cretacea*, was discovered by Dr. Rowe, and described and figured by H. Woodward in 1901 (p. 145). Two species of *Turrilepas* from the Silurian are enumerated by the same author, one from Canada and one from Dudley. The gastric teeth and shields of Carboniferous, Devonian, and Silurian Phyllopods, especially of the genera *Dithyrocaris* and *Ceratiocaris*, received attention and description in five well-illustrated papers by the same author; while eight papers were devoted to the description and figuring of various genera of MEROSTOMATA, *Eurypterus*, *Stylonurus*, *Hemiaspis*, and *Neolimulus*, the last-named being the earliest king-crab known, coming from the Upper Silurian of Lanarkshire.

ENTOMOSTRACA.—Mr. Sherborn and Mr. Chapman had papers on the Ostracoda of the Gault of Folkestone and the Tithonian of Nesselsdorf. Fourteen papers on Tertiary, Cretaceous, Wealden, Carboniferous, and Silurian Ostracoda from North and South America, South Africa, and Britain, have been contributed by Professor T. Rupert Jones. Four others, in conjunction with J. W. Kirkby and one with Mr. Sherborn, treat of the same subject. Professor Rupert Jones had also five papers on fossil *Estheriæ* from North America, South Africa, and Siberia; and eight papers in conjunction with H. Woodward on fossil PHYLLOPODA from the Palæozoic rocks. Messrs. Brady and Crosskey described in 1871 Post-Tertiary Ostracoda from Canada and New England; and Miss Partridge described *Echinocaris Whidbornei* and *E. Sloliensis* from Devonshire.

INSECTA.—It is pleasant again to record the name of Professor John Phillips (1866), who, under the title of "Oxford Fossils," figured a dragon-fly's wing as *Libellula Westwoodi*, from the Stonesfield Slate, and compared it with the wing of *Æschna Brodiei* from the Lias of Dumbleton. J. W. Kirkby figured some insect-remains (part of wing of a species of *Blatta* and part of wing of an Orthopterous insect related to the Phasmidæ) from the Coal-measures of Durham. A. G. Butler illustrated the wing of a fossil butterfly from the Stonesfield Slate (1873), *Palæontina oolitica*, to which he again referred (in 1874), maintaining its Lepidopterous character against the opinion of S. H. Scudder, who considered it to be an Homopterous wing allied to the Cicada. S. H. Scudder described and figured a *tinted* Neuropterous insect-wing (*Brodia priscotincta*) from the Dudley Coalfield, and two other Carboniferous insects, *Archæoptilus* and *Ædæophasma*, from Lancashire. He added some notes on European species of *Etoblattina*, of which he enumerated 28 species (1896), also a new form, *E. Deanensis*, from the Forest of Dean, and gave an account of the Insect fauna of the Miocene of Oeningen, of which 876 had been described by Professor O. Heer and five figured by Scudder (1895). His earliest paper (not illustrated) was in 1868, on the fossil insects of North America (published by special request of Sir Charles Lyell). In 1867

Sir J. W. Dawson wrote upon, and S. H. Scudder gave diagnoses of, an insect-wing from the Coal-shale of Cape Breton, and four insect-remains from the Devonian of St. John's, Brunswick. In 1874 A. H. Swinton figured a fossil Orthopter of the genus *Gryllacris* (= *Corydalis Brongniarti*, Buck.) from Coalbrookdale. Charles Brongniart described (1879) a new genus of Phasmidæ (*Protophasma Dumasii*) from the Coal-measures of Commentry, Central France, and (in 1885) described various insects from the Primary rocks. H. A. Allen described (1901) *Fouquea cambrensis* (near to *Lithomantis*) from the Coal-measures of South Wales. The Rev. P. B. Brodie (1893) noticed the Eocene Tertiary Insects of Gurnet Bay, Isle of Wight, collected by A'Court Smith. Henry Woodward (1884) described the wing of a Neuropterous insect from the Cretaceous Limestone, Flinders River, North Queensland. He discoursed on British Carboniferous cockroaches and on their larval forms (*Etoblattina Peachii*), etc. (1887, pp. 49 and 431). He also described a Neuropterous insect (*Palæotermes Ellisii*) from the Lower Lias, Barrow-on-Soar, in which the clouded colour of the wing had been preserved in the fossil (1892).

Arachnida.—Henry Woodward described in 1871 a remarkably perfect Arachnid, *Eophrynus Prestvici*, from the Coal-measures near Dudley, preserved in a nodule of clay ironstone. He also figured *Architarbus subovalis* from the Coal-measures of Lancashire in 1872. R. I. Pocock redescribed *Eophrynus* and figured two new Arachnids, from the Coal-measures.

Myriopoda.—Henry Woodward illustrated some remarkable spined Myriapods from the Carboniferous rocks of England and Scotland.

(*To be continued.*)

II.—On the Relations of the 'Writing Chalk' of Tullstorp (Sweden) to the Drift Deposits, with reference to the 'Interglacial' question.

By Nils Olof Holst.[1]

In the district of Tullstorp in Scania (Southern Sweden) the white 'Writing Chalk' is dug rather extensively, and in exploring the ground numerous borings have lately been made which have shown that this Chalk is not actually in place as supposed by Angelin, B. Lundgren, J. Jönsson, J. C. Moberg, W. Dames, and others, but occurs only in extraordinarily large

[1] Dr. N. O. Holst's researches in Greenland on the Inland Ice and his views on Post-Glacial earth-movements in Scandinavia are already well known to English readers. The recently published paper of this eminent Swedish geologist, "Om skrifkritan i Tullstorpstrakten och de båda moräner, i hvilka den är inbäddad: ett inlägg i Interglacialfrågan" (*Sveriges Geol. Undersökning: Afhandlingar och uppsatser*, ser. C, No. 194, 1903), is of such general interest to all glacial geologists, that I have been glad to have had the privilege of rendering some little assistance to the author in his preparation of this English abstract of his paper. The doubts as to the validity of the evidence for even a single Interglacial Period, which have been expressed recently in several countries, are here put forward with great force, and it is clear that a general re-discussion of this very important question is rapidly becoming imperative.—G. W. Lamplugh.

transported masses or boulders (*Schollen*), up to 850 metres long, 300 metres broad, and 15 metres thick, which are embedded in the glacial deposits.

The true bed-rock of the district is the 'Saltholms Limestone,' i.e. a Chalk newer than the 'Writing Chalk.' The 'Saltholms Limestone' is not reached at a less depth than 33 to 70 metres, while the 'Writing Chalk' is met with at a couple of metres below the surface.

The transported masses of 'Writing Chalk' seem at first glance to be almost intact and undisturbed. But when more closely examined, they are found to be crushed and to form a brecciated chalk; and further, it is seen that the flint-bands are ground to pieces, that the thin clayey partings of the Chalk are slightly contorted, and that the moraines (boulder-clay) and the glacial gravels are sporadically carried down and sometimes squeezed into the Chalk to a considerable depth. Still more remarkable is the occurrence of portions of the antlers of *Cervus elaphus*, which are occasionally found entirely isolated in this Chalk; in one case, a piece of antler of this kind was found at a depth of 6 metres from the surface of the 'Writing Chalk.'

The transported masses of the 'Writing Chalk' rest upon the 'lower moraine' ('lower boulder-clay'). In a few instances they are also covered by this moraine, but as a rule their covering consists of the 'upper moraine' ('upper boulder-clay') and fluvio-glacial deposits.

The phenomena in the Tullstorp district have been compared by the author with the much discussed phenomena of similar character at Moen, Rügen, and Finkenwalde, and with the numerous transported masses or 'Schollen' which are found at so many places among the glacial deposits of Northern Germany. The resemblance between the mode of occurrence of these masses and that of the displaced '*Cyprina*-clay' has also been discussed, and for several reasons, partly borrowed from the well-known paper of Johnstrup on this deposit, the author has concluded that the '*Cyprina*-clay' is decidedly pre-Glacial.

The bearing of these facts as an argument against the hypothesis of an Interglacial Period will now be summarized.

The 'Writing Chalk' of Tullstorp occurs under the same conditions as many of the so-called 'Interglacial' deposits, i.e. between the two moraines (boulder-clays). But if we are to regard these morainic deposits as two separate ground-moraines belonging to two distinct Glacial episodes, there would be no good reason for refusing to assign the 'Writing Chalk' to an 'Interglacial' period, along with the other so-called 'Interglacial' beds which occur under the same conditions. The author holds, however, that only the 'lower moraine' is true ground-moraine, and that the 'upper moraine' consists of material which was originally incorporated in the ice-sheet as 'internal moraine' and was set free on the melting of its lower part. Indeed, the two moraines are so dissimilar in character that if, as is generally acknowledged, the lower deposit is a ground-moraine, the upper must have had a different origin.

The differences between the two moraines have elsewhere been fully discussed by the author. He has himself observed in Greenland that, whereas the lower or 'ground'-moraine is characterized by its rounded, often striated stones, and its clayey matrix of a bluish-grey colour, the upper or 'internal' moraine, on the other hand, is characterized by its more angular, rarely striated stones, its looser, more gravelly texture, and its weathered aspect due to oxidization during the melting of the ice. And the same difference exists between the two moraines in Germany and Sweden also. In the latter country this difference is just as conspicuous in the northern districts as in the country at the outer margin of the Scandinavian ice-sheet. The chief conclusions to be drawn from this difference may be recapitulated under the following five heads :—

1. As a rule, both in Germany and in Sweden, the thickness of the 'upper moraine' is too small and too uniform to represent a separate ice-age, being sometimes a couple of metres, sometimes 3 to 4 metres, and only exceptionally attaining a slightly greater thickness.

2. The 'upper moraine' enwraps the uneven contours of the underlying deposits, even when these are loose gravels and occur in abrupt ridges and mounds, so that the 'upper moraine' often reflects rather closely the contours of its underlying floor. No ground-moraine can behave in this manner.

3. The 'upper moraine' is less compressed and less coherent than the ground-moraine, because no ice-sheet has passed over it. It contains few stones, and not rarely has a more or less definite stratification, which shows that it has to some extent been acted upon by 'water of melting' (*Schmelzwasser*) during its deposition. The few striated stones which it contains have probably been derived from the 'lower moraine.'

This distinction has frequently been laid stress upon by other authors. James Geikie remarks upon it as follows: "One may note in many cases that the till which overlies interglacial deposits is not infrequently a somewhat looser clay than the generally excessively tough lower till that clings to the rocks underneath. Often, too, the stones and boulders of the overlying till are, as a whole, less well smoothed and striated than those in the boulder-clay below." The latter deposit he calls "unstratified" and the upper "indistinctly bedded."

This conspicuous difference also induced Johnstrup to regard the 'upper moraine' as having been formed in a special way, viz., by drifting or floe ice.

4. If the 'upper moraine' had been a separate and distinct ground-moraine originating from a separate ice-sheet, it ought to possess a definite outer limit marking the greatest extension of this ice-sheet. Such a limit has certainly been diligently sought, but it has never been found and will never be found, because it has never existed.

One of the most striking features in glacial geology is the great terminal moraine of the European ice-sheet, but its importance has been obscured by the idea of an 'Interglacial' period (*Interglazial-ismus*), which has diverted the attention of most observers chiefly to the two moraines, with the supposition that these have originated at widely different times.

5. If the 'upper moraine' had represented a separate ice-age, preceded by a long Interglacial epoch with an ameliorated climate, it ought to contain abundant vegetable remains. Plentiful traces of forest-growth should, in this case, have been found embedded in the moraine, for this 'upper' drift, unlike the 'lower moraine,' is not thick enough to bury and conceal the débris of any land-surface that might have existed outside the ice.

The stratified deposits of sand and gravel which lie between the two boulder-clays are most readily explicable as being, from the beginning, of intermorainic origin. In many cases they have probably been formed in ice-dammed water-filled basins over which the thin border of the ice-sheet was buoyed up, thus allowing the subglacial streams to deposit their sand and gravel below the ice which contained the internal 'upper' morainic material.

To this series of deposits belongs also the Rixdorf Sand. The great extent and thickness of the latter, as well as the manner of its stratification (sand alternating with coarse gravel and shingle, frequently showing conspicuous false bedding), clearly indicate that this deposit is glacial; for what streams could deposit such thick beds, including coarse gravel and shingle, on a plain, except under Glacial conditions! The fauna of the Rixdorf Sand is a mixed fauna; the fossils are exclusively, or at least principally, found in the coarse gravel, and must be derivative. This opinion regarding the Rixdorf Sand is maintained also by W. Wolff and G. Müller (*Protokoll der Januarsitzung*, 1902, *der Deutsch. Geol. Gesellsch.*).

Thus, in the opinion of the writer, the evidence tells strongly against the idea of an Interglacial Period. The crux of the matter lies in the correct interpretation of the two moraines. It has been shown that these belong to one and the same period of glaciation; and it is further held that the so-called 'Interglacial' deposits themselves, when correctly interpreted, afford confirmatory evidence to the argument against the 'Interglacial' hypothesis.

III.—The Fingers of Pterodactyls.

By Professor S. W. Williston, University of Chicago.

As is well known, all pterodactyls have three small, unguiculate fingers on the radial side of the patagial finger, evidently used in the support of the body, possibly also in prehension and ambulation. In the older forms these fingers were relatively much better developed than in the later ones, the metacarpals of the former, of considerable strength, all articulating with the carpus, whereas in the more specialized forms of later geological age the proximal ends of these bones had become either greatly attenuated or entirely lost. In *Nyctosaurus*, for instance, the very small anterior metacarpals were not more than one-eighth of the length of the wing-metacarpal, and were in life loosely attached by the soft parts only to the distal part of that bone.

Recently, in the examination of a specimen of *Pteranodon* or *Ornithostoma*, in which all the bones of the hand had been preserved in nearly their original positions, I have observed that these three small fingers have two phalanges in the first, three in the second, and four in the third, the terminal one of each a much curved and sharp claw. So far as I can learn, all known pterodactyls have the same number and arrangement of these bones. In any event, I believe that any possible variation will be found in a lessened rather than an increased number. Seeley ("Dragons of the Air," p. 129) confirms this arrangement of the phalanges in these animals. The patagial finger has, as is well known, four phalanges, probably in all known forms. It seems very probable, however, that in the evolution of this finger for the support of the volant membrane, the original clawed phalange had become lost, not that it had become greatly elongated as the fourth phalange. More especially does this seem probable from the fact that in the later, more specialized forms of these animals there is a marked tendency toward an increase in length of the proximal membrane-supporting bones, and a shortening of the distal ones. In a specimen of *Rhamporhynchus*, as stated by Seeley (op. cit.), the first wing-phalange measured $3\frac{1}{2}$ inches in length, while the fourth phalange had a length of 2 inches. In a specimen of *Pteranodon* now before me the proximal wing-phalange measures nearly 27 inches, while the fourth is only a little over 5 inches in length. A still greater disproportion exists between the fingers in *Rhamphorhynchus* and *Nyctosaurus*. Now, if my reasoning is correct, the phalanges in the four definitely known fingers of pterodactyls originally numbered, in succession from the radial to the ulnar side, 2, 3, 4, 5. It is well known that in all reptiles, save the turtles, the anomodonts, and certain extinct hyperphalangic forms, as well as in the birds, this phalangeal formula applies to the first four digits of both the hands and the feet, and it certainly does to the feet of pterodactyls. The conclusion, therefore, seems to me incontestable that the wing-finger of pterodactyls is the fourth, as was formerly held by all writers on these animals. In 1878, however, Oscar Fraas suggested that the so-called pteroid bone really represented the first finger, and that the wing-finger is the fifth. This view was adopted by both Marsh and Zittel, and is the one now universally accepted by palæontologists.

It therefore seems evident that the 'pteroid' is not a vestigial, abnormally reflexed metacarpal or phalange of the first digit, but an entirely distinct ossification. Just what this ossification is, it may be premature to suggest, but there is nothing unreasonable in the supposition that it is a carpal or sesamoid. This conclusion seems more probable from the fact that it was progressively developed in the later, more specialized forms reaching its maximum in *Nyctosaurus*, thereby subserving some progressively increasing functional use, which would hardly be expected were it a reflexed finger.

IV.—Notes on the Cephalopoda belonging to the Strachey Collection from the Himalaya. Part I: Jurassic.

By G. C. Crick, Assoc. R.S.M., F.G.S., of the British Museum (Natural History).

In 1851 Captain (now Sir) Richard Strachey [1] communicated to the Geological Society of London a paper "On the Geology of Part of the Himalaya Mountains and Tibet," based upon the observations which he had made during the years 1848 and 1849. The Palæozoic and Secondary fossils therein mentioned were described in 1865 by J. W. Salter and H. F. Blanford respectively in a work of which the title-page reads as follows: "Palæontology of Niti in the Northern Himalaya: being descriptions and figures of the Palæozoic and Secondary Fossils collected by Colonel Richard Strachey, R.E. Descriptions by J. W. Salter, F.G.S., A.L.S., and H. F. Blanford, A.R.S.M., F.G.S. Reprinted with slight corrections for private circulation from Colonel Strachey's forthcoming work [2] on the Physical Geography of the Northern Himalaya. Calcutta: O. T. Cutter, Military Orphan Press. March, 1865."

On p. 2 of this work Salter says: "The [Strachey] collection was brought home numbered and catalogued, but still required months of patient work in breaking up and chiselling out the specimens. When finally arranged upon tablets, with localities, he [Colonel Strachey] placed them all in the colonial collections of the Museum of Practical Geology, and left me the more pleasant task of comparing and describing them"; and in a footnote on p. 80 Salter adds that "all the figured specimens of Colonel Strachey's collection have been liberally presented by that gentleman to the Museum of Practical Geology, London." In 1880 the foreign collections (and among them the Strachey Collection) were transferred from that Museum to the British Museum. As many of the figured specimens were not marked as such, and having regard to the importance of this collection and in view of the interest which is now being manifested in the sedimentary deposits of the Himalaya, it seemed desirable that the collection should be carefully examined and the described and figured specimens identified and marked. The following notes are based on an examination of the collection as it now exists in the National Museum. The present part refers only to the Jurassic Cephalopoda; these were described by Professor H. F. Blanford in the work already mentioned (pp. 74–88 and 105–111). The systematic position of the species has not been discussed; this is being done by Professor V. Uhlig, of Vienna, who is preparing from a much larger amount of material a memoir on the fauna for publication in the *Palæontologia Indica.*

In Salter & Blanford's work on the "Palæontology of Niti," the plates are numbered from i to xxiii and are all marked vol. ii; of these the first nine are photographs of engraved plates, whilst the rest (x–xxiii) were lithographed and printed in Calcutta. As

[1] Quart. Journ. Geol. Soc., vol. vii (1851), pp. 292–310.
[2] This work was never published.

I have stated elsewhere,[1] besides a complete copy of the work, the library of the Geological Department of the British Museum contains a set of plates presented by Sir Richard Strachey in 1892. The first nine are engraved, and it is evident that it was from precisely similar imprints that the photographs issued with the work were taken; plates x–xiii, xvi–xviii, and xxi–xxiii were drawn and lithographed by W. H. Baily, the others, xix and xx, by C. R. Bone; and they were all printed by Ford & West, evidently in England. The two sets of plates present, in the drawing of the specimens, sufficient differences to show that the 'English' set was not copied from the 'Indian,' but that most of the figures at any rate were re-drawn from the actual specimens, additional details being given in several instances.[2] General Sir Richard Strachey informs me that the 'English' set of plates has never been "formally published," so far as he knows, "certainly not in England." The additional details given in this set of drawings has assisted in the identification of some of the figured specimens.

The majority, and probably the whole, of the figures are reversed. Some of them have been so much restored that the identification of the originals is attended with great difficulty. That they did not entirely meet with the approval of Professor Blanford is evident from Salter's remark at the end of the author's descriptions (p. 88) that reads as follows: "Since this was in type the figures have been corrected (as far as the state of the lithographic stones would allow) in conformity with Professor Blanford's instructions.—J. W. S."

In the first volume of his work entitled "Illustrations of Indian Zoology; chiefly selected from the collection of Major-General Hardwicke," published in 1830–32, J. E. Gray figured on plate c four figures of three species of Ammonites which he named *Amm. Nepaulensis* (figs. 1, 2), *A. Wallichii* (fig. 3), and *A. tenuistriata* (fig. 4). According to the legend on the plate, which is stated to have been "published [in] 1829," they all came from "Sulgranees, Nepaul."[3] Three of these specimens, viz., the originals of figs. 1, 3, and 4, are in the British Museum collection [No. C. 5052 = *A. Nepaulensis*; C. 5041 = *A. Wallichii*; and C. 5051 = *A. tenuistriata*], but the fourth, viz. the original of fig. 2 (*A. Nepaulensis*),

[1] G. C. Crick: Proc. Malac. Soc., vol. v, part 4 (April, 1903), p. 286.

[2] Compare, for example, in the two sets, pl. xi, figs. 1*c*, 2*c*; pl. xiii, fig. 1*a*; pl. xv, fig. 1*a*; pl. xvi, figs. 1*a*, 2*a*; pl. xvii, figs. 2*a*, *b*; pl. xxi, fig. 1*b*.

[3] Respecting the locality of these Ammonites Dr. W. T. Blanford, who was for many years connected with the Geological Survey of India, writes (Proc. Malac. Soc., vol. v, No. 6, October, 1903, p. 345):—"So far as I am aware, no such place as 'Sulgranees' is known, and I may add that it is very doubtful whether the Ammonites represented in the 'Illustrations' came originally from Nepal at all; it is more probable they were brought from further west, from the region whence Ammonites have been supplied to India in all probability for ages. It is certain that there has long been an importation of small Ammonites into India from the Tibetan side of the Himalayas, chiefly from the Spiti district, N.N.E. of Simla, or from the neighbourhood of the Niti pass, north of Kumaun. These Ammonites, together with certain other stones, are known to Hindus by the name of 'Saligram.' I think it is probable that this name, slightly modified and written *Sulgranees*, has been mistaken for the locality of the fossils."

I have not been able to trace. The example of *A. Wallichii* can be easily recognized as the figured specimen; and, although some of the matrix has been removed from the examples of *A. Nepaulensis* and *A. tenuistriata* since Gray's figures were drawn, there is abundant evidence as to the identity also of these specimens.

I have already shown elsewhere that Blanford refigured Gray's types of *A. Wallichii* and *A. tenuistriata* (in part) in pl. xv, figs. 1*a–c*, and pl. xv, figs. 2*b*, *c*, respectively. I also considered Gray's type of *A. Nepaulensis* (fig. 1) to have been refigured by Blanford in pl. xiv, figs. 1*a*, *b*, but quite recently I have seen the original of Blanford's figure in the Museum of the Geological Society of London (R. 10,116).[1] Professor Blake thought it possible that this was Gray's figured specimen, but such is not the case. The Geological Society's collection also contains the original of Professor Blanford's pl. x, fig. 7 (*Belemnites sulcatus*).

In the following notes the species are arranged in the order in which they were described in the "Palæontology of Niti," pp. 74–88.

1. Belemnites sulcatus, J. S. Miller.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 76, pl. x, figs. 1–8.)

Of the eight figured specimens seven are now in the National collection. These are the originals of figs. 1–6 [Nos. C. 2566–C. 2571][2] and of fig. 8 [No. C. 2572]. They are accompanied by a Jermyn Street Museum label bearing the inscription "Oolitic: Niti Pass. Belemnites sulcatus. Stra. Him. Pl. 10. Pres. by Col. Strachey." The original of fig. 6 [No. C. 2571] is marked in ink "L" with a cross; the specimen represented in fig. 3 [No. C. 2568] is numbered in ink "1015"[3]; the original of fig. 5 [No. C. 2570] is numbered "1691" in a similar manner, and each of the originals of fig. 1 [No. C. 2566], fig. 2 [No. C. 2567], and fig. 4 [No. C. 2569] is similarly numbered "1692." The original of fig. 8 [No. C. 2572] is numbered in ink "1720"; it has been broken across and shows a subcentral siphuncle; it does not exhibit any depression near the margin such as is indicated in the figure. It seems, therefore, to be referable to the genus *Orthoceras*, and is most probably of Triassic age. This age of the specimen is supported by its lithological character, which agrees with that of the example of *Orthoceras pulchellum*—a Triassic species—represented in pl. viii, fig. 10*b*.

The specimen depicted in fig. 7 is now in the Museum of the Geological Society of London[4] (R. 10,252).

[1] See Professor J. F. Blake, "List of the Types and Figured Specimens in the Collection of the Geological Society of London," 1902, pp. 34 and 55.

[2] The numbers in square brackets refer to the Registers in the Geological Department, British Museum (Natural History).

[3] From a comparison with the Silurian Cephalopoda in the Strachey Collection it is quite evident that these numbers refer to Colonel Strachey's Catalogue of Localities referred to by Salter on p. 4 at the end of his description of *Asaphus emodi*.

[4] The specimen is duly recorded in Professor Blake's "List of the Types and Figured Specimens in the Geological Society of London," 1902, p. 55.

Besides these seven specimens five fragments were also transferred from the Museum of Practical Geology as part of the Strachey Collection. They are accompanied by a Jermyn Street Museum label bearing the inscription "Oolite: Niti Pass. Belemnites sulcatus, var. canaliculatus. Stra. Him. Pl. 10. Pres. by Col. Strachey," and are now numbered C. 2565*a–e*. Only two of these have any original ink-marks on them; the specimen No. C. 2565*c* is numbered "1015," like the original of fig. 3, and the example No. C. 2565*b* is marked "Laptet." The "L" of the word Laptet is in the same handwriting as, and precisely like, the "L" on the specimen represented in fig. 6 [No. C. 2571]. It is therefore possible that the "L" on that specimen may stand for "Laptet."

On p. 106 of the "Palæontology of Niti," H. F. Blanford puts Oppel's *Belemnites Gerardi* as a synonym of the present species, for which he retains Miller's name *B. sulcatus,* this claiming priority of publication.

With regard to the dimensions of the specimens Professor Blanford says: "The largest specimen in Colonel Strachey's collection measures as follows:—length, 3·6 in.; antero-posterior diameter, 0·9 in.; transverse diameter, 0·9 in." There appears to be some mistake here, because the largest guard at present in the collection, the original of fig. 1, has the following dimensions:—length, 126·5 mm. (nearly 5 inches); antero-posterior diameter, 30 mm. (1·2 in.); transverse diameter, 28 mm. (about 1·1 in.). The specimen represented in fig. 2 is nearly of the same size, its measurements being:—length, 115 mm. (4·5 in.); antero-posterior diameter (at about 30 mm. from the anterior end), 27 mm. (1·05 in.); transverse diameter (at same place), 27 mm. (1·05 in.).

2. Ammonites alatus (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 76, pl. xviii, figs. 3*a*, *b*.)

Of this species three fragments belonging to the Strachey Collection are now in the British Museum. Two of these [Nos. C. 7364*a* and *b*] are accompanied by a Jermyn Street Museum label bearing the inscription "Oolitic. Niti Pass. Ammonites alatus. Coll. by Col. Strachey," but they are not numbered in ink like many of the Strachey specimens. With them there is a guttapercha squeeze of the example numbered C. 7364*a*. To the third specimen [No. C. 7365], which is numbered "1834" in ink, there is attached a label bearing the words "alatus. Spiti Shales" written in pencil.

One specimen [No. C. 7364*b*] is merely the impression of the half of one side of a shell; the other two [No. C. 7364*a* and No. 7365] are evidently "the two fragmentary casts" from which was "compiled" the "restoration" that is represented in Blanford's pl. xviii, fig. 3*a*. There is no specimen in the collection which can be identified with Blanford's fig. 3*b*, the original of which possibly furnished the dimensions given by the author.

Although two of the specimens [Nos. C. 7364*a* and *b*] are labelled "Niti Pass" and the third [No. C. 7365] merely "Spiti Shales," yet the matrix and mode of preservation of the specimens are such as to lead one to believe that they all came from the same locality.

3. Ammonites Nepaulensis, J. E. Gray.

(*A. Nepaulensis* [sic], J. E. Gray: Illustr. Indian Zool., vol. i, 1830–1832, pl. c, figs. 1 and 2. *A. Nepalensis* [sic], H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, pl. xiv, figs. 1*a*, *b*.)

There are two examples of this species in the National collection [Nos. C. 5052 and C. 7687].

One [No. C. 5052] is undoubtedly one of the specimens figured by Gray (op. cit., pl. c, fig. 1).[1] It is accompanied by a label belonging to the Museum of Practical Geology bearing the inscription "Oolitic; Niti Pass. Ammonites Nepalensis. Coll. by Col. Strachey." This is certainly an error; it could not have been collected by Colonel Strachey, because the specimen was figured in 1830–32 by Gray, whereas Colonel Strachey's specimens were not obtained until the years 1848 and 1849.[2]

The fossil is imbedded in a nodule, the greater part of one side only of the specimen being exposed. Since Gray's figure was drawn an attempt has been made to develop the fossil. A little more of the anterior part of the outer whorl has been uncovered, and some matrix has been removed in front of the aperture so as to display the commencement of the outer whorl, but only a little piece of this—a length of 12 or 13 mm.—has been successfully exposed close to the aperture. The surface of the rest of the first third of the outer whorl that was covered by matrix when Gray's figure was drawn has been injured during development. A small piece of the penultimate whorl bearing five principal ribs has been uncovered immediately beneath the aperture. The ribbing is well preserved over a little more than half of the outer whorl; it is very regular, and there are eighteen principal ribs in the last half-whorl. Notwithstanding the attempt at development there is no difficulty whatever in recognizing the fossil as the original of Gray's fig. 1. A specimen in the Museum of the Geological Society of London (R. 10,116) is thought possibly to be Gray's type (fig. 1), but an examination of the fossil clearly shows that such is not the case.[3] The dimensions of the exserted portion of the fossil, as nearly as can be measured, are:—diameter of shell, 101 mm.; height of outer whorl, 46·5 mm.; thickness of outer whorl, estimated at about 37 mm.; width of umbilicus, 23 mm.

The other specimen in the Museum collection [No. C. 7687] bears a label on which is written in pencil simply the name "*A. nepalensis*"; there is no other information with the specimen,

[1] G. C. Crick: Proc. Malac. Soc., vol. v, pt. 4 (April, 1903), p. 285.
[2] Quart. Journ. Geol. Soc., vol. vii (1851), p. 294.
[3] See Professor J. F. Blake's "List of the Types and Figured Specimens in the Collection of the Geological Society of London," 1902, p. 34.

but from its lithological character there can be no doubt whatever that it came from the Himalaya; it forms part of a nodule, like so many of the Niti fossils. It is 91 mm. in diameter.

I have not been able to recognize in the collection the original of Gray's pl. c, fig. 2.

I have elsewhere expressed the opinion that the original of Gray's fig. 1 was also the original of Blanford's pl. xiv, figs. 1*a*, *b*,[1] but this statement is incorrect, the original of Blanford's figures being in the Museum of the Geological Society of London (R. 10,116).[2] Blanford's figure is reversed. Both sides of the fossil are free from matrix, and well preserved, the side opposite to that which is figured being the better preserved of the two. On the figured side the surface of the first third of the outer whorl has been injured just as in the example figured by Gray; this was evidently the septate part; no septa are visible on the remaining two-thirds of the whorl, which therefore most probably constituted the body-chamber. The inner whorls, though incomplete, are better preserved than in Gray's type-specimen. There is a slight irregularity in the ribbing of the outer whorl, but not nearly so much as is indicated in the figure; on the side of the specimen opposite to that which is figured there are 33 or 34 principal ribs in the outer whorl, nineteen of these being in the last half-whorl. The measurements given by Professor Blanford are as follows:—diameter, 4·8 inches [= 122 mm.]; diameter [or height] of outer whorl, 2·2 inches [= 56 mm.]; thickness, 1·9 inches [= 48·5 mm.]. My own measurements of the fossil are:—diameter, 121 mm.; height of outer whorl, 55 mm.; height of outer whorl above preceding, 38·5 mm.; thickness of outer whorl, 48 mm.; width of umbilicus, 29 mm.

4. Ammonites tenuistriatus, J. E. Gray.

(*A. tenuistriata*, J. E. Gray: Illustr. Indian Zool., vol. i, 1830–1832, pl. c, fig. 4. *A. tenuistriatus*, J. E. Gray: H. F. Blanford, in J. W. Salter & H. F. Blanford, Palæont. Niti, 1865, p. 78 [pl. xiv, fig. 2 ?], pl. xv, figs. 2*a*–*c*.)

The British Museum collection contains Gray's type-specimen [No. C. 5051]. It is accompanied by a label belonging to the Museum of Practical Geology bearing the following inscription: "Oolitic; Niti Pass. Ammonites tenuistriatus. Coll. by Col. Strachey (belongs to Brit. Mus.)," but the statement that it belonged to the Strachey Collection is obviously incorrect, for, as we have already stated in regard to *A. Nepaulensis*, Gray's figures were published many years before Colonel Strachey's specimens were collected. Although some of the matrix has been removed since Gray's figure was drawn, there are still indications on the fossil of the original extent of the matrix, and there can be no doubt whatever about its being the figured specimen. I have already shown elsewhere[3] that a portion of this specimen in its present condition formed the original of Professor Blanford's pl. xv, figs. 2*b*, *c*.

[1] G. C. Crick: Proc. Malac. Soc., vol. v, pt. 4 (April, 1903), pp. 286–7.

[2] Professor J. F. Blake: "List of the Types and Figured Specimens in the Collection of the Geological Society of London," 1902, p. 34.

[3] G. C. Crick: Proc. Malac. Soc., vol. v, pt. 4 (April, 1903), pp. 288–9.

The National collection also contains the original of pl. xiv, fig. 2 [No. C. 5039] and the natural mould [No. C. 5036] from which the guttapercha impression figured in pl. xv, fig. 2*a* was taken; both specimens belonged to the Strachey Collection, and were transferred from the Museum of Practical Geology in 1880. Their exact locality is not recorded; they probably came from the Niti Pass, because this is the only locality given by Salter & Blanford in their "List of the Himalayan Oolitic Fossils from the Niti and Spiti Passes" (p. 102). The specimen No. C. 5039 was accompanied by a label bearing simply the name "*Amm. Jubar,* Strachey."

5. Ammonites umbo (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 78, pl. xvii, figs. 2*a–d*.)

Professor Blanford states that "the only specimen in the [Strachey] collection is a fragment of the whorl represented two-thirds of the real size." The fragment is now in the British Museum collection [C. 5040]; it was transferred from the Museum of Practical Geology, labelled "Oolitic. Niti Pass. Ammonites umbo (Stra.). Coll. by Col. Strachey." It is numbered in ink "1690." It is entirely septate: the suture-line is well shown, but is very difficult to follow; its details are not quite correctly represented in the figure (2*d*). The suture-lines are not indicated in the figure in the 'Indian' set of the plates of Salter & Blanford's work, but in the 'English' set they are distinctly represented.

The measurements of the specimen, taken at about its centre, are as follows:—height of whorl, 1·5 in. or 38 mm.; width of ditto, excluding nodes, 1·9 in. or 48 mm.; width of ditto, including nodes, 2·25 in. or 57 mm. The dimensions given by Blanford are:—diameter [= height] of whorl, 1·7 in.; thickness [or width], 2·1 in.

On p. 106 Blanford places this species, as well as Oppel's *A. Seideli,*[1] as a synonym of the species *A. Hyphaspis,* which he himself described in 1863.[2]

6. Ammonites guttatus (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 79, pl. xiii, fig. 2.)

The example that was in the Strachey Collection is described by Professor Blanford as "an imperfect external cast of one side of a shell." This specimen is now in the British Museum collection [No. C. 7358], having been transferred in 1880 as part of the Strachey Collection from the Museum of Practical Geology. It was labelled "Oolitic. Niti Pass. Ammonites guttatus. Coll. by Col. Strachey." The figure given in the "Palæontology of Niti" is a somewhat restored, and very unsatisfactory, representation of a cast taken from this natural mould; its unsatisfactory character was recognized by the author, who states that "the restoration herewith given at Plate 13, fig. 2, is . . . . erroneous, the diameter

[1] Pal. Mittheil., 1863, p. 283, pl. lxxx, figs. 3*a*, *b*.
[2] Journ. Asiatic Soc. Bengal, vol. xxxii, No. 2 (1863), p. 132, pl. iv, figs. 2, 2*a*, 2*b*.

of the whorls being probably at least half as much again as they are represented, while from each tubercle springs a bundle of 4 or 5 ribs, which cross the ventral region with a slight convex curve towards the mouth."

Owing to the imperfection of the external part of the outer whorl it is impossible to give accurate dimensions of the specimen.

This species was first described in 1863 by Professor Blanford,[1] who regarded Oppel's *Ammonites Cautleyi*[2] as a synonym.[3]

7. Ammonites biplex, J. Sowerby.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 79, pl. xi, figs. 1*a–c*; pl. xii, figs. 1*a–c*.)

Professor Blanford says:—"Two specimens of this Ammonite occur in the collection, together with some impressions of the shell on black siliceous nodules. I can detect no difference between them and the characteristic Oxford clay specimens of Europe. They are identical also in all respects (mineral character included) with those from Spiti, lately described by myself, from Dr. Gerard's collection."

From the Museum of Practical Geology were transferred two specimens [Nos. C. 5033 and C. 5034] belonging to the Strachey Collection, labelled, with one of that Museum's labels, "Oolitic. Niti Pass. Ammonites biplex. Coll. by Col. Strachey"; and two fragments [Nos. C. 7683*a*, *b*] accompanied by a label, "A. biplex. Spiti Shales," but it is not recorded how these were obtained.

To one of the two Strachey specimens [No. C. 5033] is attached another M.P.G. label, on which is written in ink simply the name "Ammonites biplex." This is evidently the original of pl. xi, fig. 1*a*, the figure being reversed and considerably restored; its anterior end, however, does not exhibit a septal surface such as is shown in fig. 1*b*, nor is its suture-line visible; it cannot, therefore, have formed the originals of the figures 1*b*, *c*. Nor are these characters displayed on the other specimen [C. 5034] in the Strachey Collection. This is numbered in ink "1032*a*," and it also bears a small square white label, originally bearing the number "24," but this has been crossed out and the number "1032*a*" substituted. There is no specimen in the collection agreeing with figs. 1*a–c* of pl. xii. Perhaps fig. 1*a* is in part a restoration of the example No. C. 5034, but this is far from certain.

The larger of the two fragments from the "Spiti Shales" exhibits the suture-line somewhat indistinctly, but I do not think it could have furnished the drawing of the suture-line given either in pl. xi, fig. 1*c* or pl. xii, fig. 1*c*.

8. Ammonites triplicatus, J. Sowerby.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 80, pl. xiii, figs. 1*a–c*.)

Professor Blanford says:—"This Ammonite is only distinguished

[1] Journ. As. Soc. Bengal, vol. xxxii, No. 2 (1863), p. 131, pl. iv, figs. 1, 1*a*, 1*b*. According to F. Stoliczka, the type-specimen "is deposited in the Asiatic Society's collection, Calcutta" (Mem. Geol. Surv. India, vol. v, 1866, p. 104, footnote).

[2] Pal. Mittheil., iv (1863), p. 279, pl. lxxviii, figs. 1*a*, *b*, 2*a*, *b*.

[3] Palæont. Niti, 1865, p. 106.

from the preceding by the fasciculate character of the ribs in adult specimens, young shells of the two species being undistinguishable."

Two specimens are represented on pl. xiii. Figs. 1*a*, *b* are the lateral and front views (reversed and somewhat restored) of the specimen in the British Museum collection bearing the register number C. 5042. This fossil was transferred from the Museum of Practical Geology, but there is neither one of that Museum's labels nor any other original label with it, nor can I see any numbers written upon the fossil. But its agreement with Blanford's figure cannot be doubted for a moment. The author gave no dimensions of the fossil. The measurements are:—diameter of shell, 85 mm.; height of outer whorl, 28 mm.; thickness of outer whorl, 31 mm.; width of umbilicus, 37·5 mm. The sutures are not shown.

Fig. 1*c* has been drawn from a guttapercha cast of a natural mould; both the cast and the natural mould are in the national collection [Nos. C. 5031 and 5031*a*]. They were transferred from the Museum of Practical Geology, and are accompanied by one of that Museum's labels as follows:—"Oolitic: Niti Pass. Ammonites biplex (Sow.). Coll. by Col. Strachey." This was written in ink, but the word "biplex" has been crossed out in pencil, and above it has been written in pencil the name "triplicatus." The fossil is clearly the original of Blanford's figure, but this represents only a part of the specimen, and has been somewhat restored.

9. Ammonites torquatus, J. de C. Sowerby.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 80, no fig.)

Professor Blanford's observations on this species are as follows:—

"The only character by which I can distinguish this species from *A. biplex*, Sow., are:—Its thicker and more depressed whorls, and a slight notching of the ribs above the siphuncle. These characters are exhibited by the typical Cutch specimens, as well as by those in Colonel Strachey's cabinet, and also by the specimens described and figured by me, in the Spiti collection of Dr. Gerard. The distinctness of the notching and the depression of the whorls vary, however, in different specimens, and a more extensive comparison is requisite to decide whether *A. torquatus* be really distinct from *A. biplex*.

"Mr. Sowerby, in his description of the figured specimens from Cutch, states that they are distinct from 'a Himalayan species,' in having an 'incurved inner margin.' On comparison of the specimens, I can, however, detect no such difference, nor, indeed, any other than that the Himalayan specimens have uniformly more numerous (about 55) ribs than those from Cutch, which have about 45."

Among the specimens which were transferred from the Museum of Practical Geology as the Strachey Collection there are four examples [Nos. C. 7676*a–d*] labelled "Oolitic: Niti Pass. Ammonites torquatus (Sow.). Coll. by Col. Strachey"; of these, three have the broad whorls characteristic of *A. torquatus*, whilst the fourth has somewhat more compressed and more finely ornamented whorls and is certainly specifically distinct. The largest specimen [No. C. 7676*a*], a broad-whorled form, has scratched upon it the locality "Lakur." Its dimensions are:—diameter of shell, 59·5 mm.; height of outer whorl, 18·5 mm.; thickness of outer whorl, 31 mm.; width of umbilicus, 25·5 mm. The largest specimen but one is a little better preserved, with sharper and somewhat coarser ornaments, but is not such a broad-whorled form as will be seen from its dimensions, which are:—diameter of shell, 57·5 mm.; height of outer whorl, 17·5 mm.; thickness of outer whorl, 26·5 mm.; width of umbilicus, 27·5 mm.

(*To be continued.*)

V.—Stevn's Klint.

By the Rev. E. Hill, M.A., F.G.S.

The fine cliff of Stevn's Klint on the Danish coast is seldom mentioned in English geological writings. As it presents a clean section several miles long of the uppermost Danish Chalk, and is easily visited in a day's excursion from Copenhagen, a short sketch may have some interest for readers of this Magazine. It has none of the astonishing scenery displayed by the coasts of Möen and Rügen; the land is level and bare, the cliff is not broken and not wooded: yet it possesses a prettiness of its own.

A railway running south from Kjöge, a town south-west of Copenhagen, forks at Haarlev: the western branch leads to the famous inland quarry of Fakse,[1] the eastern to a coast hamlet called Rödvig. The Chalk in the cliff here is only a few feet high, but it rises in the eastward direction and may be followed along its edge for the full length. Or the train may be left at Storre Hedinge, a little town with a respectable hotel, whence four miles of road lead to the cliff at Höjerup, where the section is most accessible.

The ancient church here stands on the cliff, closer to the edge than those at Dunwich or Sidestrand, and, unlike those, in full use still. Guidebooks print a local legend that it would have fallen long ago but that every Christmas night it shifts itself a handsbreadth (*hanefjed*, a cock's step) inland, to remain as before uninjured on the brink.

The country traversed from Storre Hedinge is level, almost without undulation, to the cliff edge. The cliff section shows this to be the upper surface of Glacial Drift, here a somewhat earthy or silty clay, containing stones and occasional boulders up to a foot across. Clean sections are not very frequent. In these, as elsewhere in Baltic Drifts, there is sometimes an appearance of divisions; e.g., about 1 or 1½ miles north of the Lighthouse I noted (in descending order): red earthy clay, 3 feet; light-brown, dry, cracked clay, with chalk and large boulders, 4 feet or more; pale chalky clay, tougher and less cracked, with more stones and flints, and with a boulder

[1] Commonly, but wrongly, Faxoe. See Geol. Mag., 1901, p. 486.

at its base, 8 feet or more; then chalk: the line between the second and third members is sharp. One object of my visit was to examine whether any disturbances in the Chalk had affected overlying beds. At Höjerup the upper surface of the Chalk is irregular, somewhat following the wavings of certain flint bands in it. There was a good section of a drift-filled hollow, where the drift showed an appearance of two members with streaks like bedding near the division. These streaks did not bend down into the hollow. If they marked beds, I concluded that here was a hollow filled by subsequent deposition, not Chalk with drift bent conjointly. The evidence would probably not have convinced a leader of opposition, but it will presently be seen that debate is silenced by a 'previous question.'

The Drift lies on an irregular surface of a white limestone, a rock which nothing I have seen in England represents or resembles. Nothing represents it, for here are the very highest beds of the Danish Chalk. Nothing resembles it, for we see white limestone seamed with bands of grey flint. Not flints, but flint (or ought I to say chert?) in solid continuous sheets. The flint is as continuous as the thicker sheets of white limestone which it divides. The flint bands may reach as much as 8 inches in thickness, and at Höjerup there may be six or eight in about 25 or 30 feet vertical. Elsewhere they are often further apart and, I think, fewer. Their colour varies from light to dark grey. The limestone resembles clunch in colour and texture. It is extensively worked all along the cliff for building material. It is sawn on the spot into rectangular blocks, which are hoisted up to the cliff edge and carted inland for cottages and farm buildings.

The flint bands in the limestone do not lie horizontal or straight. They undulate gently: I estimated one arc to have 50 feet of chord to 10 feet of vertical height (what when we studied Newton's "Principia" we were taught to call Sagitta). While considering these undulations I gradually became aware that they were not always parallel. The wavy bands were not identically bowed and wavy; the intervals between them thickened and thinned; here and there a band forked or died out. I had always supposed that flint beds marked original horizontal surfaces of deposition, but here were surfaces which hardly could have been all originally horizontal. Flint sometimes fills cracks and joints. I began to speculate on bowed surfaces of yielding to stress; segregation of silica along bending lines of weakness. But this would throw doubt on many conclusions, and undermine some theories, perhaps some of my own as well as others. While so "revolving sweet and bitter thoughts" my eye fell on a guidebook remark—"Geologists regard the Fakse Chalk as a coral-reef." Stevn's Klint is only some fifteen miles from Fakse. So, after all, these waving layers, I suppose, do indicate surfaces of an old sea-floor, but an uneven one.

I find that Ussing ("Danmark's Geologi," p. 82) regards only a few inches near the base as representing the proper Fakse beds. He designates the 30 or 40 feet above as Limsten, and considers this a deep-water deposit; though in earlier days Forchhammer had attributed the irregularity to shallowness and nearness to land. The series as a whole is designated the Newer Chalk.

At the base of this Newer Chalk I noticed a few inches of brecciated rock, possibly the part said to represent the Fakse beds. All below is often hid by a talus-slope, some thirty or forty feet high. Where this has been cleared away there is exposed also chalk, but a different chalk. It is softer, whiter, and shows lines of flints (flints, not flint; the black nodules with white skins that we know so well in our cliffs of Albion). It is designated by the Danish geologists Writing Chalk (*Skrivekalk,* translating the German *Schreibekalk*). The boundary between it and the overlying Newer Chalk is straight, and the lines of flints in it are straight also. This disposes of the question, mooted above, as to the origin of a drift-filled hollow. It shows that such hollow cannot be due to bending, for the Writing Chalk is not bent. My hope of evidence on the question whether the Drift has been affected by movements in underlying beds was destroyed. The chalk, however, has been slightly moved. A distant view of a long stretch of cliff, south of Höjerup, seemed to show a straight junction-line between the two chalks, with a straight line of flints in the lower, which rose northwards, approximating to the junction-line. (This would indicate some interval of time between the two.) Also, the top of the Writing Chalk, which at Höjerup is perhaps 30 feet above sea-level, some three miles north, at Eskesti, has risen to the top of the cliff, about 80 feet high. Though the Newer Chalk is absent there, it again caps the cliff a little further north, at Mandhoved Pynt, 120 feet high, the highest ground of the cliff. At Eskesti is an extensive quarry in which the straight parallel lines of flints are numerous and conspicuous.

This lower Writing Chalk yields to the sea-waves, and leaves the Newer Chalk overhanging it as a great cornice along most of the cliff. In consequence the beach can seldom be reached except by aid of ladders. In five or six miles of cliff there were only five or six spots where I found paths continuous down to the sea. The waste, however, must be slow, as the legend quoted above will show. Signs of landslip were rare. Even gullies in the cliff edge were shallow and short; only one ran 100 yards inland. The contrast between this level platform and the broken surfaces of Möen and Rügen was as great as that of Rügen's steeply dipping flint lines or Möen's contorted and shattered strata with these even, regular beds. The three localities have, however, much in common. They are all Chalk mantled with Drift; they all face east; they all stand out into the Baltic, lofty bastions against its assault.

The level strata of this cliff suggest one important reflection. Stevn's Klint presents vertical faces, sometimes over 100 feet high, to the south, east, and north. I saw the greater part, and saw no dislocation or disturbance of beds. Not twenty miles off, across the sea, is the mainland of Sweden. Where were these cliffs when a Northern Ice-sheet advanced? Or, what was the Northern Ice-sheet when it advanced against these cliffs? Were the cliffs then safe beneath the sea? Or, was the ice-sheet accommodating and pliable? The beds are undisturbed. "Facts bein' stubborn and not easy drove," says Mrs. Gamp. Was Stevn's Klint stubborn? At any rate, it is a fact.

A Tongue of Glacial Clay.

At Rödvig, on the west side of its little port, the top of the Stevn's Klint Chalk is only about eight feet above sea-level. Over it lies eight or ten feet of Glacial Clay. The line between Chalk and Clay was clean and clear, roughly but not perfectly level. At one spot a tongue of clay ran into the chalk, about twelve feet long, not more than three inches at its thickest. Such tongues are often to be seen at such junctions, but this attracted my attention. The cliff faced south; the point of the tongue was on my right hand, and its connection with the mass of clay on the left; the tongue therefore entered the chalk from the west. Any ice-sheet at this spot may have been moving from north or east, but no one would imagine a movement from the west. The tongue was not thrust in by an ice-sheet.

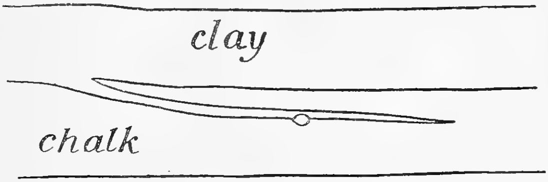

Fig. 1.—Tongue of Clay in Chalk.

In the clay of this tongue were two or three flints; one, pear-shaped with a narrow stem-end, had this narrow end imbedded in the lower surface of the chalk, while its thicker part extended nearly, but not quite, to the top of the clay. It was *in sitû*, but any thrust would have displaced it. So this clay had not been introduced by thrust, neither had any horizontal pressure acted on the flint. The fissure filled with clay may have been made by solution of water percolating along a crack, or by repeated freezing and expanding of water in such a crack, or by some lifting of an attached cake of ice; but certainly by no horizontal force.

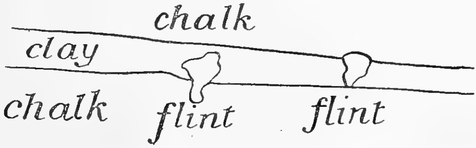

Fig. 2.—Middle portion of above, enlarged.

[*Figures represent tracing of diagrams in notebook made on the spot.*]

It may be worth while to notice carefully such tongues elsewhere, in case some of them may afford evidences of their causes. Here the Danish Clay seems to have put out its tongue against a Baltic Glacier.

Recent Ice-Transport.

The following extract from a sixpenny Danish Tourist's Guide to Kjöge and Stevn's Klint seems worth reproducing:—[Near Vemmetofte] "in the shore-wood there lies some distance from the water a vast block, called Musestenen, as large as a labourer's hut; in the severe winter of 1895 this was carried by the ice several hundred alen (*al*, about two feet) away from the water, inland."

REVIEWS.

I.—Round Kanchenjunga, a Narrative of Mountain Travel and Exploration. By Douglas W. Freshfield; with an Appendix on the Geology, etc., by Professor Garwood, F.G.S. pp. xvi and 367; 42 illustrations and 3 maps. (London: Edwin Arnold, publisher to H.M. India Office, 1903. Price 19*s*. nett.)

THE somewhat restricted territory of Sikhim, lying as it does between the native Himalayan States of Nepal and Bhotan, is yet extensive enough to enable the European traveller to penetrate into the heart of the mountainous region of the eastern Himalayas, which is dominated by the stupendous mass of Kanchenjunga. The most ordinary globe-trotter nowadays can take his trip to Darjiling and there enjoy the world-famed view of the monarch of the Sikhim mountains. Nay, more, from a point in the neighbourhood easily accessible he may, under favourable circumstances, obtain a telescopic view of the still mysterious Everest group, which the jealousy of the Khatmandu Government is reserving, perhaps, for the mountain-climbers of the middle of the twentieth century.

Returning, however, to the subject of Kanchenjunga, it is one thing to admire a mountain, and another thing to go round it, as did Messrs. Freshfield, Garwood, and the Sellas, during the early Autumn of 1899. Mr. Freshfield is a mountaineer and traveller of great experience, and he states emphatically his conviction that nowhere else on the earth's surface can there be found, within so small a radius, a combination of tropical luxuriance, sylvan beauty, and mountain sublimity equal to that which meets the traveller's eyes among the valleys and highlands of Sikhim and Eastern Nepal. It is small wonder, therefore, that such a country should have attracted a certain amount of notice from previous writers. Of these he principally mentions two, viz. Sir J. D. Hooker and Major Waddell, both of whom have contributed largely, with pen and pencil, to the description of this wonderful region. There is probably no one interested in 'earth-science' who has not at some time of his life read with delight "Hooker's Himalayan Journals," written in the middle of the nineteenth century. With good reason has the author of the present work thought fit to dedicate it to "The pioneer of mountain travel in the eastern Himalayas," whose graphic pages and characteristic illustrations are by no means superseded even at the present day, whilst in the comparative facility with which he could at that time travel in eastern Nepal he enjoyed advantages denied to more recent explorers.

In the present case photography has largely contributed to the value of "Round Kanchenjunga," and for most of these illustrations the author is indebted to Signor Vittorio Sella, who had previously proved his skill as a mountain photographer in the Alps, in the Caucasus, and in Alaska. Prints of the original photographs have already been in the hands of the public, and some of the illustrations have appeared in scientific periodicals. As regards maps, Mr. Freshfield complains of the inadequate delineation of the glaciers of Kanchenjunga. "Even Sir Joseph Hooker," he says, "had not approached near enough to it to explore its glaciers, which had consequently never been described by any competent hand; while many of them had never been visited by Englishmen. In the sheets of official surveys they had been alternately ignored and caricatured. There was no map in existence which even pretended to show the snows and glaciers of the region on any system recognized in modern scientific surveys." Consequently we are presented with what Mr. Freshfield considers a glacier-map of Sikhim should be, and in the construction of this he has mainly been indebted to his companion Professor Garwood. This map is a well-executed piece of work, and we doubt not that it attains to a fair accuracy of detail in those glacier-basins which the travellers themselves explored.

So far as we are aware, no glacier region of the Himalayas has been more characteristically delineated, and certainly in the eastern Himalayas nothing approaching the execution of this glacier-map of Kanchenjunga has ever been attempted. The topography of this huge mountain-knot, the ridge and valley system, the crests that are crowned with perpetual snow, and the hollows that are filled with ever-moving ice, all are brought out in a way which should rejoice the chartographer. Roughly speaking, Kanchenjunga is a gigantic cross, where a north and south ridge intersects with an east and west ridge. The north summit of Kanchenjunga, 28,150 feet, results from the intersection of the northern *arête*, whose buttress may be taken as the Pyramid, 23,350 feet, with the very crooked western *arête*, whose buttress is the wonderful mountain Jannu, 25,300 feet. The southern summit of Kanchenjunga, 27,280 feet, distant rather less than a mile from its neighbour, results from the intersection of the southern *arête*, whose buttress is Kabru, 24,115 feet, with the eastern *arête*, whose buttress may be taken as Simvu, 22,300 feet; or, if we extend the point a little further to the eastward, we reach Siniolchum, 22,570 feet, a most picturesque mountain, which serves both Waddell and Freshfield for a frontispiece. In the hollows between these *arêtes* we have, on the east, the gigantic Zemu glacier, on the north-west the Kanchenjunga glacier, on the south-west the Yalung glacier, on the south-east the Talung glacier,—all four, not to speak of minor ice-flows, radiating from the central massif of Kanchenjunga.

The first attempt of the party to round the mountain was by way of the Zemu glacier, and they attained an elevation towards the upper part of this immense *mer de glace*, which placed them face to face with its precipitous eastern cliffs. At that time it would seem that one of their possible objectives was to cross a depression in the northern *arête*, known as the Nepal gap, 21,000 feet, and so descend on the western or Nepal side. All these hopes were frustrated by an unprecedented snowstorm, and ultimately they had to make a long detour north-eastwards into the Lhonak valley, where the lines of the landscape are those of an ice-protected region. "The gentle, smooth surfaces of the lower slopes are obviously due to their long protection by snow and ice from the destructive agencies of air and water, and the rapid alternations of frost and heat that have carved out the loftier ridges and deeper valleys further south. It is a land of moraines, the monuments of departed or diminished glaciers. Their vast dykes stretch along the hill-sides or cross the valleys, enclosing flats that were first glacier-basins and afterwards lake-basins." Further on he says of the Lhonak landscape: "The rock surfaces are protected by a coverlet of snow, formerly permanent, even now raised only for a few weeks in the year. The action of water is consequently insignificant. The process of valley formation is checked, and the hillsides are scored by no deep lateral ravines." This is a valuable lesson in rock erosion which geologists may gladly accept from so experienced a mountaineer as Mr. Freshfield.

After toilsome journeyings in this region the party began to approach the continuation of the northern ridge or *arête* of Kanchengunja, taking to the ice once more at a considerable elevation, and gradually working their way upwards until they attained a height of 20,207 feet on the Jonsong La, on whose further side they had their first peep into Nepal. This was the supreme moment. It was doubtful if their native guide had ever been there before, whilst the prospect on the western side of the pass had all the appearance of an appalling *cul de sac*, whose possible outlet was completely concealed by the sinuosities of its containing walls. "Lasciate ogni speranza voi, che'ntrate" might well have been the feeling of some members of the expedition, but the stern determination of the leader prevailed, and down they all went into the abyss.

They were presently rewarded, however, by a view of the north-western face of Kanchenjunga, hitherto unseen by European eyes. "From this point of view," the author says, "as from all others, except the Guicha La, it appears as a colossal screen; but here, in place of gigantic rock precipices, it shows a snowy face." Continuing their descent, they obtained evidence that the gorge they were traversing had an opening into the lower world, and they ultimately encamped at an angle known as Pangperma, where they found themselves face to face with the glacier which descends directly from Kanchenjunga and joins the one by whose course they had come down. From this point was obtained the famous panoramic photograph which faces p. 172, and which may be regarded as a complete picture of the Kanchenjunga group as seen from the north-west. Continuing down the gorge of the Kangchen river, they passed from the U-shaped valley of ice erosion into the V-shaped valley of water action, and finally reached the inhabited village of Khunza, where the party found themselves on Hooker's track of fifty years ago. Having thus far stolen a march on the Nepalese authorities, it was advisable to return into Sikhim as quickly as possible. This was effected by way of the Chunjerma pass, immortalized by Hooker in his famous view of Jannu, and finally by way of the Kang La, 16,313 feet, where they crossed the continuation of the southern ridge into territory under British protection. From Jongri they reconnoitred the southern approaches of Kanchenjunga.

Professor Garwood contributes an appendix on the geological structure and physical features of Sikhim, which country, he says, consists entirely of crystalline rocks for the most part of a uniform and commonplace type. But to the physical geographer and petrologist the country is rich in suggestive facts, whilst the theoretical problems raised must await a more detailed survey. He does full justice to the accuracy of Hooker's original observations, and refers to attempts which have been made by Sherwill and others to study the geology of the region. He has prepared what he calls "material for a geological map of Sikhim," which is, in fact, a good unshaded topographical map with the local geological features marked in red ink.

Limiting our remarks to the western side of the deep Teesta valley, and more especially to the neighbourhood of Kanchenjunga, we note the prevailing dips to be about east-north-east, the rocks denoted being mainly varieties of gneiss with some mica-schists and quartzites. Frequently it happens that the higher grounds present the smallest degree of inclination. Thus, on or near Jannu dips to the eastward of 5° and 10° are noted. The curious rock-tower on the summit of Jannu, judging from pictures, has almost the appearance of a horizontal sedimentary series, but since the actual nature of the rock is probably unknown the appearance taken for dip may be deceptive. Selecting another buttress of the central massif, viz. Kabru, this is marked as augen-gneiss dipping east-north-east 20°. The mighty precipices north-east of Kanchenjunga towards the head of the Zemu glacier are marked as "fine gneiss, intrusive sheets of white granite and pegmatite," dipping 5° to the westward. On the other hand, very high dips, approaching the vertical, are noted towards the termination of the Zemu glacier in rock described as "gneiss with pegmatite." This, of course, is in a comparatively low position; we likewise notice in the principal valley of Lhonak dips of 30° to the southwards in quartzose gneiss. Again, in the deep valleys of the Rangit river-system, between Darjiling and Jongri, are shown high dips in all directions, though not seldom to the westwards, in mica-schists and gneiss. In these crystalline rocks the observed dip is more or less an unknown quantity; nevertheless, in the sedimentary beds of portions of the north-west Himalayas the feature of high dips in the valleys and lower dips on the hill-tops is by no means uncommon.

The petrology of Kanchenjunga and its buttresses is made out partly by way of inference from boulders in the moraines, and partly from observations *in situ.* No one, we presume, has hitherto closely approached the actual throne of the monarch, which probably consists of fine white or grey granite in a setting of augen-gneiss, which latter is by far the most abundant rock variety throughout the immediate vicinity of this mountain mass. Of actual granite the indications are by no means numerous. During the descent of the Jonsong glacier the party had good opportunities for observing the northern precipices of Kanchenjunga. "In their lower portion, at all events, they appear to be formed of massive augen-gneiss penetrated by pegmatites, these being the only rocks found on the moraines of the Kanchenjunga glacier. Sometimes the gneiss is finer and contains hornblende, but this mineral is absent from the Kanchenjunga gneiss, and it is probable that the hornblende-bearing variety belongs to a different rock into which the augen-gneiss is intruded. This gneiss forms the cliffs of the Kangbachen and Khunza valleys, and is recorded by Hooker as occurring also further west in the Yangma valley as far north as he penetrated. The same rocks again appear to form the massive walls of Jannu, and to stretch south-east to Kabru and the Guicha La." This class of rock Professor Garwood regards as a foliated granite intrusion. Its composition is simple, consisting almost entirely of porphyritic eyes of white orthoclase embedded in a foliated matrix of biotite, quartz, and plagioclase felspar. Crystals of tourmaline, hornblende, and garnet are invariably absent from the typical augen rock, but are plentiful in the pegmatites associated with it.

There remains one more subject for consideration with reference to the geology of this region, viz. the absence of specifically recognizable fossils, although there are evidences of altered limestones in connection with the gneissic masses. Three distinct and widely separated localities are marked on the geological map as follows :—

(1) In the far north-east, near the Donkhya Pass and Cholamo Lake, where Hooker observed "fossil limestone, much foliated and faulted; blue pisolitic conglomerate; shale and iron pyrites, some crystalline with encrinites, and (?) nummulites too altered for determination." This is at an elevation of over 18,000 feet on the borders of Thibet.

(2) Still on the Thibetan frontier, near the Chortenima La, which has an elevation of 18,650 feet, and only a little to the north of the track to the Jonsong Pass, are "altered limestones with Crinoid stems; sandstone altered into quartzites, and tourmaline-calcite rocks." One might be inclined to believe that these are limestones of Carboniferous age which have undergone alteration from contact with an igneous mass. Supposing them to be Carboniferous and not Eocene limestones, their presence has no particular bearing on the age of this part of the Himalayan uplift, though there is no reason to suppose that such uplift is otherwise than Tertiary in date.

(3) On the western slopes of Pandim (22,020 feet) we find indicated on the map "metamorphic sedimentary rock, with intrusive pegmatites and hornblende gneiss." These appearances had already been described by Hooker from a distance as looking

like *a stratified series into which veins of igneous rock had been injected*—an inference much to the credit of his powers of observance, the more so since the feature seems to have escaped the notice of subsequent investigators. The rocks of this series show great variety in hand specimens, but two types predominate, one of which is of considerable mineralogical interest. Under the microscope this green-bedded rock is found to contain, in addition to garnet and epidote, a considerable quantity of scapolite and white augite, which latter is plentiful together with numerous crystals of sphene. "The abundance of scapolite in an undoubtedly altered calcareous shale is perhaps the most noteworthy feature of this rock." Thus we find that if this metamorphic series has so far contributed nothing organic which might throw any light on its age or origin, yet as a contact rock it produces a greater variety of minerals than the more massive gneisses which surround it.

The general conclusion to which Professor Garwood arrives is, that the bulk of the gneiss, and particularly the augen-gneiss, must be regarded as an igneous rock, and he is disposed to attribute the metamorphism of the sedimentary series directly to its intrusion. The evidence is in favour of the sedimentary series, in two cases at least, being of Palæozoic age, and he suggests that the gneiss was intruded as a huge laccolitic mass during the folding which accompanied the elevation of the range. Such a fan-like fold would help to account for the inverted dip of the beds towards the roots of the chain, a feature which seems to be in accordance with the inward dip of the foot-hills in parts of the north-west Himalayas.

W. H. H.

II.—The Evolution of Earth Structure, with a theory of geomorphic changes. By T. Mellard Reade, F.G.S., etc. pp. xv, 342, with forty plates. (London: Longmans, Green, & Co., 1903. Price 21*s.* net.)

THE volume before us may be taken as the sum and substance of the author's observations and conclusions with respect to the structure of the earth, the changes which the rocks have undergone, and the origin of the movements which have effected the earth's crust. While he claims that "Nearly the whole of the matter is original, and the greater part quite novel," it is understood that this applies to work that has extended over something like forty years, and that much has previously been printed in Journals and Proceedings of Scientific Societies, in his essay on "Chemical Denudation in relation to Geological Time" (1879), and in his volume on "The Origin of Mountain Ranges considered experimentally, structurally, dynamically, and in relation to their Geological History" (1886). This last work was reviewed by the Rev. Osmond Fisher in the Geological Magazine for 1887 (pp. 229–233).

The present work is divided into three 'books,' of which the first deals with geomorphic changes. The subject is illustrated by a useful diagram, drawn to scale, showing half the sphere; with

(1) its interior spheroid or nucleus, "considered by many physicists to be mainly iron," (2) a 500-mile zone or shell of igneous magma, and (3) the lithosphere, 30 miles thick. The ten-mile zone of elevation and depression is shown by a strong line; within it "all the denudations, depositions, depressions, and elevations of the surface of our planet take place." A diagram of this kind is always useful. We have one before us now, printed in 1851, by James Nasmyth. It represents an arc of a circle 64 feet in diameter on which are indicated the relative magnitude of several mountains, the deepest mine, and the probable mean elevation of dry land. Nasmyth rightly remarked that "In contemplating Geological Phenomena, nothing more directly aids the mind in arriving at correct conclusions than the useful practice of comparing the magnitude of all such phenomena to that of the Earth itself."

Mr. Mellard Reade starts with the recorded instances of elevation and depression, making special though brief reference to those of Pleistocene and later times, such as Raised beaches, Submerged forests, and 'Drowned valleys.' These in some cases may have been contemporaneous; the 40 ft. beach at Irvine, in Ayrshire, being linked with a 10 ft. beach in the Isle of Man, and with a depression on the shores of the Bristol Channel. In other cases the evidence of 'raised beaches,' which indicate a former submersion of four or five thousand feet, requires confirmation.

Admitting movements of 1,000 feet, the author proceeds to show that these oscillations of level cannot be due mainly to the shifting of weight by denudation and sedimentation, though such changes exert influence in combination with other agencies. He believes that the relative proportions of land and water have been fairly constant throughout the ages, and that regional changes of level are due to alterations in the bulk of certain portions of the lithosphere without movement in mass.

The researches of various observers on the diffusion of metals, the differentiation of igneous magmas, the effects of temperature and pressure, and the change of physical properties and of volume with changed conditions, show that "the conception of the earth simply as an *inert* mass cooling in space is a fallacious one."

In his "Origin of Mountain Ranges" the author maintained that as the volcanic pipes from which lava emissions proceed are probably in communication with the subterranean heated matter, there would necessarily be some mixture of material differing in constitution and thermal condition. Consequent upon internal changes, the volumes and specific gravities of the mineral masses of the lithosphere would be subject to increase and decrease over large sections of the globe. Increase of volume by expansion would lead to continental uplifts, while the 'deeps' of the ocean would be depressions below the true spheroid, due to the superior density and less volume of the underlying masses of the earth.

On the other hand, the expansions and contractions to which mountain-building is due "are mostly lateral and intermittent, creating creeps of the lithosphere and surface rocks, ending in the folding and permanent ridging-up and corrugations of the earth's surface." These movements, it is held, may be initiated by a long course of sedimentation, causing a sinking of the sea-bed.

In connection with this subject the author points out that "a depression of the ocean bottom will draw the waters from the land and increase the land areas, while a rise of the sea-bed will cause a transgression of the oceanic water over the land." Here it may be remarked that in 1868 Mr. H. B. Medlicott observed that "The assumption of the absolute permanence of the sea-level (that its level has permanently maintained the same radial distance from the centre of the earth) has quietly taken the position almost of a postulate in geological induction. The notion is inconsistent with any progressionist doctrine, essentially so with Laplace's theory."[1] Mr. Mellard Reade, however, sees no evidence of enormous contraction of the earth's radius, although he observes that "in every known instance where proof is possible, the continents are at lower levels now with respect to the sea than they were on some former occasions during their lengthened history." The explanation given in these cases is that there has been a rise of portions of the floor of the ocean basins.

After referring to the persistence of certain lithologic characters in formations over wide areas, notably among the Carboniferous, Triassic, and Oolitic groups, the author remarks that the land areas grow by accretion from existing land, the ruins of former continents having added to their extent, and thereby securing the continuity of land areas throughout geologic time. That "New lands are the consequents of sedimentary loading and recurrent expansion" is a subject he dealt with in his "Origin of Mountain Ranges."

Turning to the sub-oceanic configuration, the author gives reasons for believing that the bed of the Atlantic is not a plain, "but a diversified surface like that of the dry land, and that a large portion of it has at some former geological age been carved out by sub-äerial agencies." These diversified contours lie beyond the continental shelves, which are mainly sedimentary.

In Book ii the author discusses the dynamics of mountain structure and experimental geology, a subject more fully treated in his work on the "Origin of Mountain Ranges." Herein he brings to bear his experience as an architect and engineer, and the practical experiments he has made combine to give weight to his conclusions. The results of experiments are depicted in numerous plates, illustrating compression, shearing, and contortion of various kinds. Microscopic sections of rocks are also given. The time has perhaps long passed when anyone would sympathize with Ramsay, who (in 1877), while A. Geikie and J. Clifton Ward were examining thin slices of rock under the microscope, exclaimed, "I cannot see of what use these slides can be to a field-man. I don't believe in looking at a mountain with a microscope."[2]

[1] Quart. Journn. Geol. Soc., vol. xxiv, p. 37.

[2] "Memoir of Sir A. C. Ramsay," by Sir A. Geikie, 1895, p. 343.

The author rightly seeks help from all quarters, and as a result of his deliberations he maintains that if a belt of rocks of varied character and some miles in thickness be subjected to fluctuating increases in temperature, then both vertical and horizontal expansion will ensue; but the principal forces will act horizontally. He points out the stresses and strains, the shearing, the faults and foldings, and the torsion-structure that would be produced by complex movements; and he observes that slaty cleavage is always accompanied by mineral changes in the body of the rock, which give the foliaceous character and supply the necessary cement to bind the overlapping constituent grains.

His experimental investigations lead to the belief that the forces affecting the earth's crust have been gradually applied, "that mountain ranges are built up by gradual and successive creeps, and that a sudden release of pent-up forces takes place on a scale not larger than what is experienced in a great earthquake."

Book iii comprises Reprints, Speculations, and Closing Remarks. Here the author refers to the supposed permanence of oceans and continents. While the very slowness of the processes has given practical permanency to the main features, yet "The conclusion is forced upon us that movements and interchanges of such magnitude have occurred in the distribution of the oceans and land masses during geologic time that it would be a misnomer to call them 'permanent' . . . . the changes are essentially forms of development, the permanence is that of land connection."

The volume is not one which can be looked upon as eminently readable or popular, nor on the whole is the subject-matter well arranged; but it comprises a mass of valuable data and of conclusions based upon observation and experiment that cannot fail to be of service to every student of 'Geomorphology' and to aid materially in the elucidation of the subject.

III.—Recent Researches on the Scottish Carboniferous Rocks.

1.—On the distribution of fossil Fish-remains in the Carboniferous rocks of the Edinburgh district. By Ramsay H. Traquair, M.D., LL.D., F.R.S. Trans. Roy. Soc. Edin., vol. xl, pt. 3, pp. 687–707, with two plates (tables of strata).

2.—The Canonbie Coalfield: its geological structure and relations to the Carboniferous rocks of the north of England and central Scotland. By B. N. Peach, LL.D., F.R.S., and J. Horne, LL.D., F.R.S. Ibid., pt. 4, pp. 835–877, with four plates.

THE appointment in 1895 of a Committee of the British Association to inquire into the possibility of dividing the Carboniferous rocks of Britain into life-zones, and the special researches of Dr. Wheelton Hind on the mollusca, of Dr. Traquair on the fishes, and of Mr. Kidston and Mr. Newell Arber on the plants, have aroused exceptional interest in the subdivisions of the Carboniferous system, and in the correlation of these divisions in different areas. A great deal has been learned, and while the two papers before us form substantial contributions to our knowledge, "there is abundance of room," as Dr. Traquair observes, for further investigation.

In dealing with the Carboniferous fish-remains of the Edinburgh district, Dr. Traquair remarks on the general similarity in the lithological characters and in the *facies* of the organic remains of the Scottish strata, which in mass are of estuarine origin. Elsewhere in Britain the Upper Carboniferous rocks are also mainly of 'estuarine' or 'lagoon' formation, but the Lower, except in the extreme north of England, are almost as exclusively marine in their origin; and in this grouping Dr. Traquair takes the Millstone Grit as the base of the Upper division. His researches, which have extended over a period of thirty years, show that in the Edinburgh district different assemblages of estuarine fishes characterize the two Carboniferous divisions. Indeed, it is remarkable that not one of the species from the Upper Carboniferous rocks "can safely be identified as occurring in the rocks below; we have evidently got into quite a new ichthyological stage."

Further, the Lower Carboniferous fish-remains found in the limestones of open-sea origin differ from those occurring in the estuarine beds, and belong to the marine fish-fauna characteristic of the Mountain Limestone of England and Ireland. Rarely is there any commingling of these types of fishes. At the same time the number of marine species is greater and of estuarine species less in the Lower Carboniferous series of Lanarkshire and Ayrshire, than in the rocks of the Lothians and Fifeshire.

Turning to the evidence obtained in other areas, Dr. Traquair points out that, whether in Northumberland, Yorkshire, or North Staffordshire, nearly all the common Upper Carboniferous estuarine fishes have a wide range in the Coal-measures, so that "it is not possible to divide these strata into ichthyological life-zones." Elsewhere also he finds a great difference between the species which occur below and above the Millstone Grit. "Only two species can with certainty be named as common to the two divisions, namely, *Callopristodus pectinatus* and *Acrolepis Hopkinsi*."

In the Scottish Millstone Grit no determinable fish-remains have been found, but among the fishes recorded by Mr. E. D. Wellburn from this division in Yorkshire and Lancashire, there are both Lower Carboniferous marine species and Upper Carboniferous estuarine species. The occurrence of the latter in the Millstone Grit coincides with the evidence of the plants, which according to Mr. Kidston "are entirely Upper Carboniferous in aspect." Dr. Traquair is thus led to ask, "Did the marine fish-fauna of the Carboniferous epoch change less rapidly than that of the estuaries and lagoons?"

The fact, however, remains that a great and wide-spread change took place in the fish-fauna at about the time of the Millstone Grit.

Dr. Traquair directs attention to a peculiar fish-fauna in the estuarine Lower Carboniferous beds of Eskdale. At Glencartholm, near Langholm, more than thirty species of fishes have been obtained, and of these only one, *Tristychius minor*, is found in the Lower

Carboniferous beds of Central Scotland. On this interesting point, which Dr. Traquair leaves unexplained, we turn to the later paper by Dr. Peach and Dr. Horne. These authors deal with the structure of the Canonbie Coalfield, which occupies a small tract between the Liddel Water and the river Esk in the south-eastern part of Dumfries-shire. They describe the Glencartholm shales as occurring in a volcanic group, above the Fell Sandstones, and probably below the horizon of the Scremerston coals of the eastern border counties. The shales form a rich palæontological zone, which was discovered by Mr. A. Macconochie, and found to contain a large number of new genera and species, including plants, brachiopods, lamellibranchs, cephalopods, scorpions, eurypterids, ostracods and other crustacea, as well as fishes. The zone has not elsewhere been detected, but some of the many species have been found in the Calciferous Sandstone group elsewhere in Scotland, and Dr. Peach is confident that other species will likewise be found away from the Canonbie district.

In their description of this district the authors begin with the Old Red Sandstone, which has yielded scales of *Holoptychius*; and they then give details of the strata and fossils of the Lower and Upper Carboniferous, the Millstone Grit being taken as the base of the Upper division. Workable coals occur at various horizons above the Glencartholm beds; and some estimates are given of the coal-supply in concealed portions of the area. The work is well illustrated by a coloured geological map and sections, and it contains an exhaustive account of what is known of the area from a scientific and practical point of view.

IV. — The Position of the Old Red Sandstone in the Geological Succession. By A. G. M. Thomson, F.G.S. 8vo; pp. vi, 224. (Dundee: John Leng & Co., 1903.)

THIS book is divided into five sections, but otherwise it has no headings, no illustrations, no details of sections, not even an index. The object of the author is to suggest "*certain hypotheses*, well supported by circumstantial evidence," and he proceeds to state that "These hypotheses, *in the first place*, are intended to show that the conditions under which the Old Red Sandstone was produced may not have been of the character of inland lakes without free connection with the sea; and, *in the second place*, that the conditions which produced the Old Red Sandstone may not have begun only after the close of the conditions which produced the youngest of the Silurian beds, nor have terminated before the date of deposition of the oldest of the Carboniferous beds."

The entire work appears to us to be a case of much ado about nothing. There is not a single reference to any other published view, otherwise the author might have spared himself the long and laboured arguments to support hypotheses with which perhaps a good many geologists would be inclined to agree. He might at any rate have fortified himself with reference to Hypothesis No. 1 by quoting the Rev. W. S. Symonds, "Records of the Rocks," 1872,

p. 215, and Professor Hull, Quart. Journ. Geol. Soc., xxxviii, 205. With regard to his second Hypothesis, the passage between Silurian and Old Red Sandstone and between Old Red Sandstone and Carboniferous has been pointed out by numerous geologists, although the evidence of passage between Silurian and Old Red Sandstone in South Wales and Monmouthshire has not been confirmed by the recent work of the Geological Survey.

The author dwells a good deal on "the suddenness with which vertebrate life, in well-developed types, appears within the British area in the uppermost beds of the Silurian system," and in order to make clear his phraseology he adopts "the rather awkward specific terms of, respectively, 'Prevertebrate Silurian,' 'Vertebrate Silurian,' 'Prevertebrate Old Red,' and 'Vertebrate Old Red,' as also the generic terms 'Prevertebrate Palæozoic' and 'Vertebrate Palæozoic.'" He recognizes that certain "'Prevertebrate Old Red' fresh-water, or, at least, brackish-water estuarine areas, were devoid of animal life," but maintains that some of these basal beds "were being formed when 'Prevertebrate Silurian' sediments were being laid down beyond the limits of the estuaries, and therefore under marine conditions." Here, as in other cases, we fail to find the precise evidence which would make the author's contentions of value, and we regret that we cannot recommend the work as likely to prove either attractive to our readers or of serious help to students. We can, in fact, only wonder why such a work has been published.

V.—Geological Rambles in East Yorkshire. By Thomas Sheppard, F.G.S., Curator of the Municipal Museum, Hull. 8vo; pp. xi, 235, with geological map and many illustrations. (London: A. Brown & Sons [1903].)

THERE are few districts that can offer so many attractions to the geologist and to the collector of fossils as that described in this volume. From Spurn Head to Redcar, a good deal beyond the limits of the geological map of the East Riding which accompanies this work, the author takes us in a series of rambles; and under his guidance we see and learn much about the Recent and Pleistocene deposits, the White and Red Chalk, the Speeton Clay, the many divisions of the Oolites, and the Lias of Robin Hood's Bay, Whitby, and Redcar. The information is imparted in a pleasant style, and is thoroughly 'up to date,' due regard being paid to the work of the geologists of old, to William Smith, Young and Bird, John Phillips and Leckenby (though we miss a reference to Martin Simpson), as well as to that of Judd, Tate and Blake, Hudleston, Fox-Strangways, Reid, Lamplugh, Kendall, Stather, and others. The author himself, too, has laboured with much enthusiasm on the geology of the newer deposits, and we can cordially recommend his book as a handy and reliable guide to this interesting region. The work is well illustrated, and mostly from photographs. There is a good index, but curiously enough no date is affixed to the volume.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—December 2nd, 1903.—Sir Archibald Geikie, D.C.L., D.Sc., Sec. R. S., Vice-President, in the Chair. The following communications were read:—

1. "Notes on the Garnet-bearing and Associated Rocks of the Borrowdale Volcanic Series." By the late Edward Eaton Walker, Esq., B.A., B.Sc. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

The first portion of the paper is occupied with an account of various intrusive rocks. A detailed description of sills and dykes of garnet-bearing rocks in the Langstrath Valley is given; and similar rocks are described occurring as dykes and sills around the Eskdale granite and the Buttermere granophyre, and also in the Armboth-Helvellyn area. These rocks vary in degree of acidity. They consist of diabase, porphyrite, and granophyre. Evidence of their characters being dependent upon differentiation accompanied by some absorption is offered. They appear to be related to the Eskdale and Buttermere masses of intrusive rocks.

The volcanic rocks are next considered. Garnets are found in the Falcon Crag Group, in a group of rocks below the great banded ashes and breccias of the Scawfell Group, and in the rocks of the Scawfell Group itself; but do not seem to occur, except as the result of contact-metamorphism, in the Eycott Group. The most interesting garnetiferous volcanic rocks are those which occur below the Scawfell ashes and breccias. These rocks often have a streaky structure which exhibits four distinct types: resulting from (*a*) infiltration along planes of weakness, (*b*) lamination of ash, (*c*) flow of igneous material, and (*d*) dynamic action on included fragments. The rocks are not intrusive, but consist of lavas and ashes, often exhibiting alternating bands of rhyolite and andesite.

The banded ashes of the Scawfell Group also contain garnets.

In the Haweswater district there is an intercalation of rocks of the Eycott type with rocks possessing the 'streaky' structure. This intercalation appears to be original, and not the result of subsequent earth-movements.

The garnets are of the almandine type. They often have a ring of felspar around them, which, when the intrusive rocks are studied, suggests that the mineral is original; but similar rings occur around garnets in the ashes, showing that the felspars may be formed in solid rock. In certain ashes of the Haweswater district, the existence of cavities in the garnets suggests a metamorphic origin for the mineral, but it is difficult to understand how the metamorphism has been produced.

The paper closes with a description of certain undoubted metamorphic changes.

2. "A Contribution to the Glacial Geology of Tasmania." By Professor J. Walter Gregory, D.Sc., F.R.S., F.G.S.

On reading the literature on the glaciation of Tasmania, the author came to the conclusion that, except for such traces of high-level glacial action as those of Mount Sedgwick recorded by E. J. Dunn and T. B. Moore, and those near the summit of Mount Ida recorded by Officer, Balfour, and Hogg, the evidence consisted of material that was either not of glacial origin or was due to glacial action at some upper Palæozoic date. After giving a detailed analysis of the previous contributions to this subject, the author describes the evidence obtained by himself personally in the northern portion of the island. The town of Gormanston stands on a glacial moraine of recent geological age, formed later than the excavation of the Linda Valley, and occurring as a bank projecting from the southern side of the valley and nearly damming it across. The moraine is composed of typical Boulder-clay, and behind it are bedded clays which probably accumulated in a glacier-lake above the moraine-dam. An erratic of fossiliferous limestone, $4\frac{1}{2}$ by $3\frac{1}{2}$ by $2\frac{1}{2}$ feet, scratched all over and partly polished, is mentioned, while the North Lyell Railway has cut through an enormous boulder of black Carboniferous Limestone at least 16 feet in length. The northern face of Mount Owen appears to be ice-worn to the height of about 1900 feet, while the basis of the glacial deposits is not more than 700 feet above the sea. The general evidence suggests that the Eldon Range and the Central Plateau formed the gathering-ground of the ice which flowed westward and south-westward. A map is given to show the range of Pleistocene glaciation so far as it has been recorded, and also to indicate localities at the glacial deposition which probably dates from the Carboniferous Period. The lowest level at which evidence of Pleistocene glaciation has been found is 400 feet on the Pieman River. This latest glaciation is later than the formation of the peneplain of North-Western Tasmania, and occurred after the dissection of this peneplain had begun. Many of the deposits are little more altered than those of Northern England, despite the heavy rainfall; and the aspect of some of the rock-scoring is very recent.

II.—December 16th, 1903.—Sir Archibald Geikie, D.C.L., D.Sc., Sec. R.S., Vice-President, in the Chair. The following communications were read :—

1. "The Igneous Rocks associated with the Carboniferous Limestone of the Bristol District." By Professor Conwy Lloyd Morgan, LL.D., F.R.S., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S.

Evidence for the contemporaneous origin of the igneous rocks is given for the following localities :—Middle Hope, or Woodspring; Spring Cove, near Weston-super-Mare; above Kew Stoke, Milton Hill; Uphill; Goblin Combe; and near Cadbury Camp. At Middle Hope the ejectamenta thin to the east, and lava is only found to the west; at Spring Cove small lapilli were found in the limestone 8 feet above the basalt. At Goblin Combe there is the most characteristic and convincing section of ashy beds in the district: the lenticular bands of coarse greenish tuff, the limestone intercalations, the close admixture of lapilli, limestone fragments, and oolitic grains are stamped with the hall-mark of submarine volcanic action; lava closely underlies these breccias and tuffs. There is evidence of only one volcanic episode, which occurred in all cases after the *Zaphrentis*-beds had been laid down, and before the strata characterized by *Chonetes* and *Streptorhynchus* were deposited. (A table of certain broadly-marked horizons in the Carboniferous Limestone, by Mr. A. Vaughan, F.G.S., is given for reference.) The lavas are olivine-dolerites or basalts; with phenocrysts of olivine or augite. They are frequently amygdaloidal, sometimes variolitic; and in the variolites highly altered felspar-phenocrysts occur. The rocks vary in grain, the coarsest being those from Uphill and near Cadbury Camp, of the contemporaneous character of which there is no direct evidence. The tuffs are all highly calcareous, and most of them are best described as "ashy limestones." The bulk of the lapilli varies from one-hundredth part of the rock to about one-third, and their composition is closely related to that of the basaltic lavas of the district. Quartz-grains are abundant in the Goblin Combe rocks, and these rocks are frequently oolitic.

2. "The Rhætic Beds of England." By A. Rendle Short, Esq., M.B., B.Sc. (Communicated by Prof. S. H. Reynolds, M.A., F.G.S.)

The paper opens with a description of four new exposures of these rocks: one at Redland rests upon Carboniferous Limestone, and is interesting because the 'Bone-bed' is very ill-developed on receding from the old shore; a second is at Stoke Gifford, with a continuous, well-developed landscape marble, the Insect Bed, and no bone-bed; a third at Cotham Road (Bristol) yields baryta, celestine, and *Naiadita* at special horizons containing no other fossils; and the fourth, at Aust, has given measurements of the uppermost 13 feet, which are inaccessible from below. Next an account is given of the constituent beds, with special reference to the conditions of deposition. The Bone-bed is of wide distribution; it frequently occurs in pockets on a flat surface, or spread out over that surface; it contains fragments of rolled marl, rounded pebbles of Carboniferous Limestone, and pebbles of quartzite and well-rounded quartz. The author concludes that it was formed during a stormy period, after the sea had made its first irruption into the dried-up or silted-up level surface of the Keuper Lake. The *Naiadita*-beds appear to have been formed in very shallow, and perhaps only slightly saline, water, and the calcareous matter associated with them may have been mud washed from the Carboniferous Limestone. Only after the White Lias period did the water finally become moderately deep. The area of deposit appears to have been a gigantic shallow lagoon connected with the open sea to the south, and the fauna was derived from the direction of Germany. A short account is given of some of the Continental Rhætic formations, followed by a list of Rhætic fossils recorded in England, with the range of each. A consideration of this list enables the author to suggest that the lower limit of the formation should be drawn at the first evidence of Rhætic life after the deposition of the gypsiferous and red or green marls, which (at any rate in their lower part) are certainly of Keuper age. The upper limit may, for convenience, be drawn at an indefinite level where *Modiola minima* and *Pleuromya crowcombeiana* become very rare, and the ammonitic and Liassic fauna begins. Further discussion of the lithological, physical, and palæontological evidence leads the author to recognize that the affinities of the Rhætic, thus defined, are rather with the Jurassic rocks than with the Trias. The following zones are suggested, in descending order :—

Zone of *Pleuromya crowcombeiana* = White Lias.
,, *Monotis decussata* = Cotham Marble and just above.
,, *Estheria minuta* var. *Brodieana*, and *Naiadita*.
,, *Pecten valoniensis*.
,, *Avicula contorta* = Black Shales and a limestone bed.
,, Bone-bed.

These zones seem to be fairly constant throughout England, and harmonize well with those of Germany, although they cannot be expected to fit in with the oceanic type of the Alps and the Mediterranean. Further consideration shows that the fossils give evidence of migration, but very little of evolution. The paper closes with the description of a new species of *Anomia* and a bibliography.

CORRESPONDENCE.

ATMOSPHERIC EROSION IN CORSICA.

Sir,—The remarkable mode of erosion described by Mr. Tuckett in the Geological Magazine for this month is not uncommonly met with in the drier regions of the globe, and excellent examples are described and figured by Walther in his "Die Denudation in der Wüste" (Abh. k. sächs. Ges. Wiss., Math.-Phys. Classe, 1891) and "Das Gesetz der Wüstenbildung" (Berlin, 1900). Fig. 7 in the latter work presents a particularly close resemblance to the Tête de Chien. It is a reproduction of a photograph taken near the Indian desert.

Walther attributes the peculiar mode of erosion in these regions to the relative persistence of dew and other moisture on the shady side of the boulder or cliff, and its rapid evaporation on the sunny side. The shaded side consequently weathers much more quickly than the other, and the weathered material is removed by the wind.

In the Northern Hemisphere the cavities formed are generally, though not always, on the northern or western side of the rock; but from the shadows shown in Mr. Tuckett's beautiful photograph of the Tête de Chien, I infer that this case the cavity does not face the north.

It would be interesting to learn whether the Corsican examples support Professor Walther's view. Philip Lake.

13, Park Street, Cambridge.
January 15th, 1904.

OBITUARY.

PROFESSOR KARL ALFRED VON ZITTEL.

Born September 25, 1839. Died January 5, 1904.

It would be difficult to estimate the loss sustained by geological and palæontological science through the lamentable death of Professor K. A. von Zittel, of Munich, who for many years has occupied so eminent a position as a writer and teacher in these subjects, and has been rightly regarded as the most eminent of all exponents in the domain of palæontology. To those who are acquainted with the splendid work of von Zittel, the sudden termination of his brilliant career will come as a shock; among all who had personal dealings with the man himself, more especially the fortunate ones who, in the capacity of pupils, were privileged to enjoy the advantages of daily intercourse with a teacher so inspiring and so lovable, there will not be one who does not experience poignant regret and a genuine sense of personal bereavement.

To the Professor's rare personal qualities and the unfailingly cordial and courteous attitude he displayed towards colleagues and students, must in no small measure be attributed the great success achieved by the Munich school of palæontology during the long period of von Zittel's tenure of the chair. By his zeal and thoroughness in handling the subject to which he patiently and strenuously devoted so great a part of his energies, he directly accomplished much for science, but also afforded an example which must clearly have borne valuable fruits, especially when we note that his teaching was a reflection of his own admirable method. An exceptionally lucid and eloquent lecturer, Professor von Zittel regarded palæontology primarily in its correct aspect as an important branch of biology, and his influence was in no slight degree responsible for the important status which his special subject has attained among the sciences in Germany, a position which even yet seems to be most reluctantly accorded to it in this country. A striking feature of the late Professor's discourses on palæozoology consisted in the remarkably even treatment which he devoted to all parts of the subject; he seemed to possess an equally extensive knowledge when dealing in turn with each class of animals, while throughout his lengthy course of lectures his deliverances were frequently brightened by an inspiring enthusiasm.

Scrupulous thoroughness, accurate observation, and cautious interpretation were the principles upon which Professor von Zittel most strongly insisted; and if he hesitated to express himself concerning the philosophic and speculative aspects of his subject, and, in his published writings, maintained in regard to these a somewhat conservative attitude, we may perceive in this reticence evidence of that cautious and judicial spirit which has ensured soundness and lasting value in his own work and in that of many of his disciples. In an excellent article recently contributed to the columns of *Nature*, to which the present writer is indebted for

I remain yours sincerly

Zittel

some of the following biographical details, a passage is quoted from an address delivered by Professor von Zittel before the International Congress of Geologists in 1894, illustrating his attitude towards certain modern tendencies in the treatment of biology. In this he says: "The domination of the Linnæan and Cuvierian principles threatened systematic biology with soulless paralysis: the unbridled subjectivity of recent times may easily lead to anarchy." It is regrettable to have to add that in some departments of palæontology this prophecy seems already to have become fully realized.

Professor von Zittel distrusted voluminous and hastily produced work; to one so painstaking as himself, unsoundness owing to lack of care was sufficiently abhorrent. Yet he was a lenient and generous critic of work which, though imperfect, had been conscientiously achieved, and he looked with the greatest disfavour upon the kind of criticism which, betraying a needless spirit of antagonism, is couched in terms that might prove offensive or injurious. It is delightful to recall the kindly encouragement with which this gifted man assisted the circle of students at work in the palæontological laboratory at Munich and in the field, and to note that, however busily occupied with his own researches, he was at all times willing to lay his work aside in order to answer a question or to discuss some point with even the humblest of his students. This ready accessibility, coupled with his modest bearing and the deferential manner in which he expressed his own opinions or offered criticism in discussion, served to endear Professor von Zittel to the many who, attracted by his fame, journeyed from almost every quarter of the globe in order to pursue their studies under his direction. The confident and independent attitude which he directly encouraged by making his pupils feel that he discussed subjects with them as equals, would have been fostered in less degree by the adoption of a more purely didactic tone, and must be reckoned among the most valuable results of the training he imparted. It may be remarked that he entertained very liberal views on the subject of education, and warmly advocated the admission of women to the full privileges of the university courses in Germany.

Karl Alfred Zittel was born at Bahlingen, in Baden, on Sept. 25th, 1839, and was the youngest son of Dean Zittel, a well-known Protestant divine. In the latter end of 1857 he entered the University of Heidelberg, where he studied under Bronn and Leonhard, afterwards devoting a year to complete his academic studies in Paris under Hébert. While still there, during 1861, he published, in collaboration with E. Goubert, his first palæontological paper, a short pamphlet dealing with the description of fossils from the Corallian rocks of Glos. After leaving Paris, Zittel joined the Geological Survey of Austria as a voluntary assistant, and commenced active work in Dalmatia. In 1863 he qualified himself as a 'Privatdozent' in the University of Vienna, and, refusing the offer of a professorship in Lemberg, accepted a post as assistant in the Mineralogical Museum in Vienna (now the Royal Natural History Museum). In the same year Zittel left

Vienna to occupy the position of Professor of Mineralogy in the Polytechnic at Carlsruhe, but here also his sojourn was a brief one, and on the death of the renowned Albert Oppel he was appointed in the Autumn of 1866, at the early age of 27, to fill the vacant chair of palæontology in the University of Munich, at the same time taking over the charge of the State palæontological collection preserved in the Old Academy. It is interesting to record that the selection of so young a candidate for this important position was warmly supported by C. W. von Gümbel, who, as the revered veteran among Bavarian geologists, lived almost long enough to follow to its untimely termination the brilliant career of the man upon whom he so wisely bestowed his patronage. In 1880 the chairs of geology and palæontology became combined in the Munich University, and ten years later, on the death of Schafhäutl, Professor von Zittel was appointed keeper of the State geological collection also. It is well known with what enthusiasm he laboured in order to enlarge and perfect the museum under his charge, and how far, in face of great initial difficulties, he succeeded in bringing the Munich palæontological collection into the very first rank among similar institutions.

It may be said that from the time of his appointment at Munich Professor von Zittel's life was one of restless and fruitful activity. He had already completed a monograph on the lamellibranch molluscs of the Gosau beds, a memoir which amply illustrated his painstaking and precise method of work, and this was followed by his able and comprehensive study of the fauna and relationships of the Tithonian stage (1868–1873). Various other works in the field of palæontology showed the versatility of the writer, and included papers on representatives of vertebrate classes. Researches of a geological character resulted in the publication of a treatise on the glacial phenomena of the Upper Bavarian plain (1874–1875), and after accompanying the Rohlfs Expedition to the Libyan Desert (1873–1874), von Zittel in 1880 produced his well-known work "Ueber den geologischen Bau der Libyschen Wüste." The fuller results of his fruitful journey have appeared in the pages of *Palæontographica*, and include special studies of the collections of fossils obtained, the investigation of which was entrusted to several collaborators, and has only been recently concluded (1883–1902). In addition to his other labours Professor von Zittel, in the capacity of principal editor, successfully conducted the publication of the important *Palæontographica* from the year 1869 until the time of his death.

The work by which the late Professor made his name most widely known, however, was the great "Handbuch der Palaeontologie," which, begun in 1876, required seventeen years of strenuous labour for its preparation. An enormous amount of original investigation was necessitated during the compilation of this wonderfully complete compendium, and the most important of these incidental researches, that which dealt with the classification of the sponges, occupied no less than three years of the author's time, and resulted in the production of a monograph of great value, which was published by the Royal Bavarian Academy (1877–1879). The

"Handbuch" appeared in five volumes, four of which include the whole range of palæozoology, while the fifth volume, comprising palæobotany, was contributed by Schimper and Schenk. The publication of this work was the greatest service rendered by its author, and the famous "Handbuch" still remains the most comprehensive and trustworthy treatise of reference on the subject with which it deals. It was translated into French by Professor Charles Barrois.

Prompted, no doubt, by his own requirements as a lecturer, the Professor directed the publication of an extensive series of palæontological wall-diagrams to illustrate generic characters (1879–1891), which have been very widely appreciated by teachers. To meet a long-felt want, he published in 1895 the "Grundzüge der Palaeontologie," a volume most admirably adapted to the requirements of students, which embodies, though with some revision, the principal outlines of the author's larger treatise on palæozoology. The translation of this work into the English language was undertaken, with the collaboration of several specialists, by Dr. C. R. Eastman, and thus under American auspices the first part of it, comprising the Invertebrata, was published separately, though with such far-reaching modifications as to render the volume for practical purposes an almost entirely new work. Professor von Zittel himself only lived to superintend the issue of that part of the second German edition which deals with the Invertebrata, but in order to preserve those features whereby, according to his belief, the work would best retain its utility as a student's manual, he adhered to the scheme employed in the first edition.

A little book adapted to supply the needs of a wider circle of readers had been many years previously published by the Professor, under the title "Aus der Urzeit," and in this the author attractively described and illustrated the progress of development in the organic world from the earliest times onwards. This work became much in request, and, having passed through a second edition, has for some time been out of print. One other work from the pen of von Zittel calls for special mention. This is his well-known and valued History of Geology and Palæontology, in itself a striking monument of conscientious toil, which demanded several years of steady application in its compilation. The preparation of this volume was a labour of love with the author, whose wide literary knowledge, proficiency as a linguist, and keen interest in tracing out the course of development in the study of these sciences, specially qualified him for such a task. This reliable, comprehensive, and well-written work has been translated into English by Mrs. M. Ogilvie Gordon, and issued in somewhat abridged form. It has with some justification been maintained that in this book, as in so much of von Zittel's purely scientific writings, the character of the work suffered in a certain degree from the author's too strictly objective method of treatment; it was not that he lacked the critical or imaginative faculties, but we must rather suppose that the exercise of these was often purposely held in check in the endeavour to ensure an entirely truthful and precise presentation of facts.

Professor von Zittel's ability and industry were rewarded by the bestowal upon him of abundant honours; he received various orders and medals, and was elected an honorary member of numerous learned societies. He became a foreign member of the Geological Society of London in 1889, and in 1894 was the recipient of the Wollaston medal. In 1875 he was made an ordinary member of the Royal Bavarian Academy of Sciences, and in 1899, on the retirement of von Pettenkofer, was chosen to fill the presidency of the Academy, with the position of Conservator-General of the State scientific collections. An honorary member of the Royal Academy of Sciences in Berlin, he became a foreign associate of the United States National Academy of Sciences in 1898, and a corresponding member of the Paris Academy of Sciences in 1900. He was Rector of the University of Munich in the year 1880, and in that capacity delivered an able inaugural address which afterwards appeared in print, entitled "Arbeit und Fortschritt im Weltall." Some time afterwards he was awarded a knighthood, and it is many years since he was made a Privy Councillor.

Rest and change during last year seemed to have warded off the dangerous cardiac trouble with which Professor von Zittel had for a time been threatened, but before he had completely recovered from the effects of an unfortunate accident which befell him last October, he suffered a return of the serious symptoms, and passed away on January 5th, at the age of 64. A large and very representative gathering assembled to pay a last honour to the memory of the man who had so well merited the impressive eulogium which was delivered at the graveside on behalf of his sorrowing colleagues of the Academy of Sciences. F. L. Kitchin.

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[The very admirable portrait of Geheimrath Prof. Karl Alfred von Zittel, Ph.D., For. Memb. Geol. Soc. Lond., accompanying this notice (Plate IV), is reproduced by kind permission of the Walter Scott Publishing Company (Limited), Felling R.S.O., co. Durham, and Paternoster Square, London, E.C.; and appeared as the frontispiece to the English edition of Zittel's "History of Geology and Palæontology" in their Contemporary Science Series.—Edit. Geol. Mag.]

In memory of Alfred Gillett, an excellent geologist, and a very dear friend of many years, one of the founders of the Street Geological Museum, who died at his residence, Overleigh, Street, Somerset, on the 24th January, 1904, in his 90th year.

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MARCH, 1904.

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ORIGINAL ARTICLES.

I.—A Retrospect of Palæontology in the last Forty Years.

(Continued from the February number, p. 56.)

Polyzoa, etc.—Among our early contributors stands the well-known name of George Busk, author of a "Catalogue of Polyzoa in the British Museum" (1852–54) and a most valuable monograph on the "Polyzoa of the Crag" (Pal. Soc., 1859). Busk sent a paper (in 1866) to this Magazine on "Polyzoa from the London Clay of Highgate," describing three genera and species new to science. Professor H. A. Nicholson wrote on *Callopora incrassata* from the Devonian of Canada; on *Heterodictya* from the Devonian of Ontario; and on the geological distribution of *Solenopora compacta* (1885). Professor Dr. Ferdinand Roemer (in 1880) recorded the genus *Caunopora* in the Devonian of South Devon. Robert Etheridge, jun. (1873), figured and described *Carinella*, a new genus from Carluke, Lanarkshire, and *Ramipora* from the Caradoc Beds of Corwen, North Wales. G. R. Vine discoursed on Carboniferous Polyzoa (in 1880); F. D. Longe on Oolitic Polyzoa (in 1881); and Dr. J. W. Gregory on some Jurassic species of Cheilostomata (in 1894).

Brachiopoda.—The historian of the Brachiopoda, Dr. Thomas Davidson, who finished his great work in 1885, and who was equally facile with pencil and pen, was a large contributor to the pages of our journal for twenty years. His great monograph on British Brachiopoda, published by the Palæontographical Society, fills five large quarto volumes, illustrated by over 200 plates drawn by the author's own hands. He was author of the article *Brachiopoda* for the "Encyclopædia Britannica," and monographed the specimens collected by the "Challenger" expedition. He wrote in this Magazine on the genus *Thecidium* (1864); on perforate and imperforate Brachiopoda (1867); on the earliest forms of Brachiopoda in British Palæozoic rocks (1868); Italian Tertiary Brachiopoda (1870); Tertiary species from Belgium, and on the genus *Porambonites* (1874); Scottish Silurian Brachiopoda, and on "What is a Brachiopod?" (1877); on those of the Boulonnais (1878); on Lower Llandeilo forms from Brittany (1880); on spiral-bearing forms and on the genus *Merista* (1881); on Scottish Silurian species (1883); also joint papers with Professor W. King on *Trimerella, Dinobolus,* and *Monomorella*; and with George Maw on Silurian Brachiopoda from Shropshire. Professor E. Ray Lankester (1870) wrote on a new large *Terebratula* from the Drift of Suffolk, which he named *Terebratula rex* (p. 413). C. J. A. Meÿer (1864) on the Lower Greensand Brachiopoda, Surrey; (in 1868) on the development of the loop and septum in *Terebratella*; Professor William King (1867) on perforated Palæozoic Spiriferidæ. John Francis Walker, in the same year, described new Terebratulidæ, *Waldheimia Davidsoni, W. Woodwardi,* and *T. Dallasii*; and in 1868 twelve other species of Brachiopoda, all from the Lower Greensand of Upware; he added two varieties of *T. depressa* and two new species, *T. Seeleyi* and *Rhynchonella Crossii,* also from Upware, in 1870. That author noticed (1878) the occurrence of *T. Morieri* in England, and in 1892, the discovery of *T. substriata* near Scarborough, Yorkshire. The well-known Canadian palæontologist Elkanah Billings (born 1820 and died 1876) achieved admirable work in his busy life in monographing Corals, Brachiopoda, Crinoids, Trilobites, Graptolites, and plants (see Decades of Survey on "Canadian Organic Remains"). He contributed an excellent paper and plate in 1868 on *Stricklandinia Davidsoni* and *S. Salteri* (p. 59). Professor G. Lindström, of Stockholm, wrote on the genus *Trimerella* (in 1868); the Rev. N. Glass described the modifications in the spirals of fossil Brachiopoda (1888), and of the loop in *Athyris læviuscula* (1891); S. S. Buckman had a paper on Jurassic Brachiopoda in 1886; E. Westlake on *Terebratula* from the Upper Chalk of Salisbury in 1887; Dr. John Young on the minute shell-structure of *Eichwaldia Capewelli,* and on the shell-structure of *Chonetes Laguessiana* from the Lower Carboniferous Limestone series of Lanarkshire. Dr. A. H. Foord noticed West Australian Brachiopoda; J. L. Lobley the range of British fossil Brachiopoda; R. Bullen Newton (1892) wrote on *Chonetes Pratti* from the Carboniferous rocks of West Australia; F. R. Cowper Reed on some abnormal forms of *Spirifera lineata,* Martin (1893), and on *Eumetria* (?) *serpentina,* a Carboniferous Brachiopod new to Britain (1898). Dr. G. F. Matthew described and figured the oldest known *Siphonotreta* (*Protosiphon*) *Kempanum* from Cambrian, Division 1*b* of the St. John Group, N.B. Canada (1897). Agnes Crane gave, in a clever paper, the evolution of the Brachiopoda (1895); and R. Etheridge noticed the fossils of the Red Beds, Lower Devonian, Torquay (1882).

Mollusca.—Many of the earlier and more important papers on Mollusca dealt with this class from a geological aspect, such as that by R. D. Darbishire (1865) on the fossil shells obtained from the Drift-beds of Macclesfield. The author refers to the Moel Tryfaen shells near Carnarvon at 1,350 feet above sea-level, from which 60 species of mollusca were obtained; to those of Gynn, between Blackpool and Fleetwood, Lancashire. The highest points about Macclesfield discovered by Sir J. Prestwich was at the Setter Dog Inn, on the Buxton Road, 1,200 feet above sea-level. Mr. Darbishire's specimens were obtained from the Free Park Cemetery, Macclesfield, where about 50 species were collected.

Dr. S. P. Woodward wrote (in 1864) on *Plicatula sigillina* from the Upper Chalk of Cambridge, and on the fossil shells from the Bridlington Crag (1864); 44 species were enumerated. In a later list (1881) supplied by C. W. Lamplugh, some 67 species were recorded. An admirable memoir by Mrs. McKenny Hughes was contributed in 1888 on the Mollusca from the Pleistocene Gravels of Barnwell, Cambridge, which dealt with both the geology and the shells, 80 species being accurately listed, also many other forms both of vertebrate, invertebrate, and plant-remains. G. Sharman and E. T. Newton (in 1896) recorded the occurrence of Cretaceous fossils in the Drift of Moreseat, Aberdeen, of which they gave a carefully prepared list of 40 species of Mollusca, besides Brachiopoda, Echinodermata, etc. A. J. Jukes-Browne (in the same year) noticed the fossils from the Warminster Greensand. J. Starkie Gardner (1873 and 1875) described the genus *Aporrhais*, and noticed other Gault Gasteropoda in a series of six papers (1876, 77, 84, 85). H. Woodward figured *Rostellaria Pricei* from the Grey Chalk, and F. G. H. Price *Rostellaria maxima* from the Gault, both extracted from the Folkestone cliffs. W. H. Hudleston discoursed on the Palæontology of the Yorkshire Oolites (1880), and on the Gasteropoda of the Portland Beds of the Vale of Wardour (1881). Edward Wilson (1887) figured and recorded 15 new species of Liassic Gasteropoda, and with W. D. Crick in 1889 wrote on the Gasteropoda from the Lias Marlstone of Tilton. E. Wilson also published in 1890 a list of types in the Bristol Museum; H. E. Quilter (1886) fossils from the Lower Lias of Leicestershire; and R. Tate from the Lias of Banbury (1875). Dr. John Lycett discussed (in 1881) the generic distinctness of *Purpuroides* and *Purpura*. R. Etheridge, jun., described (in 1873–74) new species of Lamellibranchiata from the Carboniferous of Scotland, the genus *Conularia* (1873), *Modiola lithodomides* (1875), and contributed five other papers (1876–79) on Carboniferous Mollusca. F. R. Cowper Reed (1901) figured and noticed some of Salter's undescribed Mollusca in the Woodwardian Museum.

The first article in 1864 was by J. W. Salter on the fossils from the Old Red pebbles at Budleigh Salterton. H. Woodward wrote upon an Upper Silurian *Chiton* from the Girvan district, upon recent and fossil *Pleurotomariæ* (both in 1885), and on *Pleurotoma prisca* (1901). The Rev. G. F. Whidborne described in the same year some Devonian fossils from Devonshire. Ralph Tate (in 1868) defined the genus *Axinopsis*. In 1871 Professor J. W. Judd gave an interesting account, with figures, of the anomalous mode of growth of certain oysters from the Cornbrash of Scarborough, Weymouth, and Peterborough, parasitic on Ammonite shells, etc. R. B. Newton contributed a paper on the genus *Leveillia*. F. E. Edwards (in 1865) described some new species of *Cypræa* and *Marginella*. In 1902 General McMahon and W. H. Hudleston figured a series of fossils from the Hindu Khoosh, and the latter communicated

(1884 and 1890) two papers on fossil Mollusca from South Australia. Professor T. Rupert Jones (1890) described bivalved shells from the Karoo formation of South Africa; R. B. Newton (1898–99) some Cretaceous and Miocene shells from Egypt; a large number of Pleistocene shells from a raised beach on the Red Sea (1900); Mesozoic fossils from Borneo (1897); and lastly, *Trematonotus*, an American Palæozoic Gasteropod, found in Britain (1892). R. J. L. Guppy gave a list of Tertiary fossils from Trinidad (1865); described *Crepitacella* and six new species of Mollusca from the Caribbean Miocene (in 1867); and some West Indian Tertiary fossils, chiefly Mollusca (in 1874). H. Woodward (in 1879) described a series of 74 species of Tertiary Mollusca, obtained by M. Verbeek from Sumatra (pp. 385, 441, 492, 535). Dr. A. H. Foord (1890) figured a number of fossils from the Kimberley District of Western Australia. H. M. Jenkins (1866) wrote on *Trigonia* from the Tertiary deposits of Victoria, Australia; and Professor M'Coy replied to his criticism on the species of *Trigonia*. Dr. O. A. L. Mörch (in 1871) described the Mollusca of the Crag formation of Iceland, giving a list of 61 species. "At present" (wrote Dr. Mörch) "the north coast of Iceland is *quite Arctic*, but in the Crag period the temperature must have been much milder, at least as mild as at present on the west coast of Reikiavik." The change had, the author believed, resulted from an elevation of the land, which had prevented the free passage northwards of the great equatorial current of the Gulf Stream. Sir J. Prestwich wrote, in 1882, on *Cyrena fluminalis* found at Summertown, near Oxford, and R. G. Bell, in 1884, on Land-Shells from the Red Crag.

Cephalopoda.—During the past forty years the class Cephalopoda received special attention from many expert writers, as will be seen from the following summary:—An excellent general history of the Cephalopoda, Recent and Fossil, was contributed in 1878 by Agnes Crane, which may still be read with pleasure and profit. In 1887 Dr. F. A. Bather wrote on "The Growth of Cephalopod Shells," and carefully described and figured the internal structure of the shell, giving his own views on the subject as well as Dr. Riefstahl's. Another article of general interest was that communicated by Dr. A. H. Foord describing the Cephalopod Gallery of the British Museum (Natural History), Cromwell Road (1895, p. 391), illustrated by 27 figures; it still serves as an excellent guide to the series of Ammonites exhibited. Among the dibranchiate forms abundantly represented among the living Cephalopoda, but so rare in a fossil state, there is a charming little form which was figured and described by H. Woodward under the name of *Dorateuthis syriaca*, from the Cretaceous beds of Sahel Alma, near Beirût, Lebanon, Syria (1883). Other and larger forms have since been recorded by that author and by G. C. Crick from the same locality. The remarkable thing is the preservation on the slab of the outlines and much of the details of the soft structures of the animal as was observed in *Belemnoteuthis* and other forms from the Oxford Clay of Chippenham, and described in 1842 by Pearce & Owen. G. C. Crick wrote in 1901 upon *Ammonites Ramsayanus* from the Chalk of Chardstock, Somerset; *A. euomphalus* (1899) from the Lower Chalk, near Lyme Regis, collected by Dr. Rowe and Mr. C. D. Sherborn; and on a deformed *Hoplites* from the Gault of Folkestone. Messrs. Foord & Crick wrote (in 1891) on the identity of *N. neocomiensis* with *N. Deslongschampsianus* from the Grey Chalk, and on *N. elegans* from the Lower Chalk and Greensand (1890). Dr. Blackmore (in 1896) endeavoured to prove that some of the bodies known as *Aptychi*, from the Chalk of Salisbury, belonged to Belemnites. His conclusion was that (1) *Aptychus rugosus* is the pro-ostracum of *Belemnitella mucronata*; (2) *Aptychus leptophyllus* is the same part of *B. lanceolata*; (3) *Aptychus Portlockii* is the pro-ostracum of *B. quadrata*; (4) the large, coarsely punctate *Aptychus* from the Marsupite zone is the true *Aptychus* of *Ammonites leptophyllus*. E. H. L. Schwarz wrote on *Aptychus* in Ammonites, and supported the conclusion of S. P. Woodward (see *The Geologist*, 1860) and H. Woodward (Geological Magazine, 1885) that the *Aptychus* is really equivalent to the calcified and coalesced pair of dorsal arms which form the 'hood' or *operculum* in the living *Nautilus*. He has a second paper in 1895 on the shell-structure in the Ammonoidea. In 1886 S. S. Buckman wrote on the lobe-line of Lias Ammonites, in 1887 and 1889 he described some Jurassic Ammonites, and in 1894 he discussed the species belonging to the genus *Cymbites* from the Lower Lias of Lyme Regis. E. T. Newton wrote (in 1891) on *Ammonites jurensis* from the Ironstone of the Northampton Sands; G. C. Crick on some Jurassic Cephalopoda from Western Australia (1894), on *Coccoteuthis hastiformis* (1896) and *Acanthoteuthis speciosa* (1897), both from the Lithographic Stone of Solenhofen; he pointed out that *Nautilus truncatus*, referred to the Lias, really belongs to the Cornbrash; he defined *Ammonites calcar* from the Lower Oxfordian (in 1899), and *Ammonites polygonus*, *A. discoides*, and *Tmaegoceras* (1902) from the Lias, and a Jurassic Belemnite from Somaliland (1896). R. Tate discovered and recorded the oldest British Belemnite (*B. prematurus*) from the Lower Lias, Antrim (1869). A. H. Foord and G. C. Crick figured in 1889 the muscular impressions of *Cœlonautilus cariniferus*; described *Pleuronautilus* (1891); *Vestinautilus* and *Discites Hibernicus* in 1893; described and figured *Prolecanites*, *Temnochilus* from the Carboniferous of Cork, Ireland, in 1894; and *Nautilus robustus* from the Middle Lias of Les Moutiers, Normandy, in 1902. G. C. Crick wrote on *Goniatites evolutus* and *Nautilus tetragonus* in 1896, and *Ephippioceras* (1900); and A. H. Foord figured *Acanthonautilus bispinosus* (1897). F. R. Cowper Reed described *Pleuronautilus Scarlettensis*, sp. nov., from the Carboniferous Limestone of the Isle of Man, in 1900. F. Roemer (1880) and J. E. Lee (in 1877) noticed the occurrence of *Goniatites*, etc., in the Upper Devonian of Torbay. The late Professor H. A. Nicholson gave, in 1872, a description and figure of *Endoceras proteiforme*, Hall, from the Coniston series (Silurian), Skelgill Beck, Ambleside. Dr. A. H. Foord (1887) wrote on Salter's genus

Piloceras from the Tremadoc Slates, and on the perforated apex and siphuncle of *Actinoceras* from the Black River Formation (Silurian), Canada. Professor G. Lindström (1888) described Barrande's genus *Ascoceras* from the Upper Silurian of Gotland, and announced the discovery of an earlier or *Nautilus* stage in the growth of this Cephalopod shell, which was evidently decollated in the later period of its life, leaving the *Ascoceras* form behind. This was more fully illustrated by Dr. A. H. Foord (in 1889). The earlier part of the shell seems to have been composed of a series of air-chambers, which were periodically thrown off by natural truncation. It is interesting to notice that some modern land-shells (e.g. *Bulimus decollatus*) throw off the apex of their spiral shells, living afterwards in a truncated shell, the top of which is closed by a diaphragm. In 1891 Dr. A. H. Foord discussed *Orthoceratites vaginatus*, Schl., from the Silurian of Sweden; and in 1903 G. C. Crick described some new forms of *Orthoceras* from the Silurian of the Province of Shantung, North China. In 1897 Dr. Gerhard Holm figured *Baltoceras*, a new genus of Orthoceratitidæ from the grey *Lituites* Limestone of the I. of Öland, a form of *Orthoceras* with a marginal or sub-marginal siphon.

Pisces.—In our retrospect of Vertebrate Palæontology we find in the Geological Magazine a vast store of most important contributions to all the great sections, that of fossil fishes being particularly rich and varied. Foremost among writers in Ichthyology stands the name of the veteran zoologist, Dr. Albert Günther, who from 1856 to 1895 devoted himself specially to the study of Reptiles and Fishes in the British Museum, and was Keeper of Zoology for 20 years (1875–95). He wrote a description in vol. i, 1864, of a new fossil fish from the Lower Chalk of Folkestone, which he named *Plinthophorus robustus*; and in 1876 described 10 species of fishes from the Tertiary Marl-slates and Carbonaceous shales of the Padang Highlands, Central Sumatra, collected by R. D. M. Verbeek, illustrated by five large folding plates. Our old chief, Professor Owen, who for 27 years (1856–83) held the post of Superintendent of the Natural History Departments in the British Museum, contributed numerous papers to the Magazine, six being devoted to fossil Ichthyology. In 1865 he described a jaw of *Stereodus melitensis* from the Miocene of Malta; he figured and named a sauroid fish from the Kimmeridge Clay, Oxfordshire, *Ditaxiodus impar* (1866); *Thlattodus suchoides* from the same horizon at Downham, Norfolk. In 1867 he made a large number of genera and species of fishes from the coal-shales of Northumberland; many of these minute fish-remains were later on (p. 379) suggested to be dermal ossicles of large fishes, and others to be the teeth of fishes already described by Agassiz and others. In 1869 Owen noticed a fine jaw of *Strophodus* from the Oolite of Caen, Normandy, a fossil shark closely related to the living Port Jackson shark, *Cestracion Philippi*, of which a woodcut was given on p. 236. He also described and figured a spine of *Lepracanthus Colei*, from the Coal-measures, Ruabon, North Wales (1869). Professor Ray

Lankester, now Director of the British Museum of Natural History, began in 1867 to write on fossil fishes, and described a new Cephalaspid (probably an *Auchenaspis* from Malvern); *Didymaspis Grindrodi* from the Lower Old Red of Ledbury; a new *Cephalaspis* (*C. Dawsoni*) discovered in Lower Devonian beds, Gaspé Bay, Canada (1870); and on *Pteraspis* and *Scaphaspis* (1873–74). In 1873 Professor Dr. Frederic Schmidt had a note on *Pteraspis Kneri*, pointing out that *Scaphaspis* is the ventral shield of *Pteraspis*! Lankester wrote also (in 1873) on *Holaspis sericeus* from the Cornstones of Abergavenny, and on the relationships of *Pteraspis, Cyathaspis*, and *Scaphaspis*; and on *Holaspis* (p. 331) and *Pteraspis* (p. 478). J. E. Lee described (1882) some Pteraspidean plates from the Devonian of Gerolstein, in the Eifel; and H. Woodward (1881) figured a head-shield of the genus *Zenaspis* from Old Red, Abergavenny. An old and highly esteemed member of the Staff of the Geological Department, William Davies, in 1871 contributed a catalogue of the type-specimens of fossil fishes in the British Museum. (A list of the 'types' in the Egerton Collection appeared in 1869, and those of the Enniskillen Collection in the same year. Both these most valuable collections have been acquired for the nation, and are now added to the Geological Department.) An important paper by William Davies was published in 1872 on the rostral prolongations of *Squaloraia polyspondyla*, Ag., from the Lower Lias of Lyme Regis; these are organs for holding the female, being only present in the male, and correspond to the rostral claspers of the male Chimæridæ. The frontal spine and rostro-labial cartilages of *Squaloraia* and *Chimæra* formed the subject of an important paper by O. M. Reis in 1895, in which a large amount of anatomical details was given, with careful figures and sections. Mr. Davies wrote also (1878) on *Saurocephalus lanciformis* and *S. Woodwardii* from the Chalk of Kent and Sussex, and on *Pholidophorus purbeckensis* and *P. brevis* from the Purbeck of Dorset. E. C. H. Day (1864) described and figured a very beautiful and perfect jaw of *Acrodus Anningiæ*, and dorsal spines belonging to the same shark, which must have been closely related to the living Port Jackson shark, having the mouth provided with numerous rows of crushing teeth (known by the quarry men as 'fossil slugs'). Sir Philip Egerton (1877) defined four species of Pycnodonts: *Cœlodus ellipticus*, Gault, Folkestone; *C. gyrodoides*, Greensand, near Lyme; *Pycnodus Bowerbankii* and *P. pachyrhinus*, both from the London Clay, Sheppey; illustrated by two excellent plates. James Powrie, of Reswallie, Forfarshire, wrote (1867) on the genus *Cheirolepis* from the Old Red Sandstone. T. P. Barkas figured teeth of *Ctenodus* from the Coal Shale of Newsham Colliery; and our old colleague, Professor John Morris, figured and described *Æchmodus orbicularis* from the Lias of Lyme Regis. The Rev. Professor E. R. Lewis, of the Syrian Protestant College, Beirût, gave (in 1878) an excellent account of the localities in the Cretaceous beds of the Lebanon where fossil fishes could be obtained. His collection from Hakel and Sahel Alma now enriches the British

Museum Geological Collection. In 1886 James William Davis noticed a number of teeth of fishes from Tertiary beds of New Zealand, comprising *Lamna, Carcharodon, Notidanus, Myliobatis,* etc. He gave a further note on New Zealand Tertiary fishes in 1888, which he referred to the genus *Scymnus.* He recorded thirteen species of fish-remains from the Carboniferous Limestone of Derbyshire, mostly palatal teeth of *Petalodus, Petalorhynchus, Streblodus, Psephodus,* etc. This bright and promising naturalist and geologist passed away at the early age of 47 years, a victim to overwork. A very interesting Ichthyodorulite named *Edestus Davisii,* discovered on the Gascoyne, Western Australia, was figured and described by Henry Woodward in 1886; this form is now supposed to be the coiled dentition of a Carboniferous shark. Entire coiled examples have been obtained from deposits of similar age in Russia by A. Karpinsky.

Nearly fifty separate papers on fossil fishes have been contributed by two authors in about equal proportions. Dr. R. H. Traquair's extended over 31 years, from 1871 to 1902, and number twenty-three; Dr. Arthur Smith Woodward's over 17 years, from 1886 to 1903, and number twenty-two.

Dr. Traquair's first paper, in 1871, dealt with the genus *Phaneropleuron* from the Lower Carboniferous (Burdiehouse Limestone) of Edinburgh, of which genus he gave an excellent plate and a restored outline (for Dr. Traquair, like Dr. Davidson, is equally facile with pen and pencil, his blackboard sketches as "Swiney Lecturer" being unsurpassed by anyone). In 1873 he described a new Dipnoid fish, *Ganorhynchus Woodwardi*; and in 1874 *Cycloptychius carbonarius* from the Coal-measures of N. Staffordshire. The fish-remains from Borough Lee, near Edinburgh, engaged Traquair's attention, when he published three papers (in 1881), and a fourth one, upon *Pleuracanthus horridulus,* in 1882. In 1884 he wrote on *Ctenacanthus costellatus* from Eskdale, and on the genus *Megalichthys* from the Hugh Miller Collection; and in 1885 on *Psephodus magnus* from the Carboniferous Limestone of East Kilbride. In 1886 and 1888 Dr. Traquair wrote on the English Palæoniscidæ, and on *Chondrosteus acipenseroides,* a sturgeon-like fish from the Lias of Lyme Regis, in 1887; on Carboniferous sharks and on the nomenclature of Old Red Fishes in 1888; on *Homosteus* and *Coccosteus* and on *Dipterus macropterus* in 1889. In 1890 Traquair discussed in two papers the Devonian Fishes of Scaumenac Bay and Campbelltown, Canada, including very perfect remains of buckler-coated fishes like *Bothriolepis canadensis, Coccosteus, Cephalaspis,* and many other genera. He wrote again on fishes from Borough Lee (1890); on *Myriolepis* from the Kilkenny Coalfield in 1893, and on *Diplacanthus* in 1894. In 1900 Traquair gave restorations of *Drepanaspis,* a wonderful new Cephalaspid fish from the Devonian Slates of Gmünden in Western Germany, and he added further and corrected figures in 1902. His Address (1900) to the British Association (p. 463) on the bearings of fossil Ichthyology on Evolution was a very important contribution to our science, and treated most philosophically by the author. In his paper on the Lower Carboniferous Fishes of Fifeshire, Traquair enumerated 37 fishes from the Calciferous Sandstone and Carboniferous Limestone series. These extraordinary fishes, with others from the Silurian of Lanarkshire (pp. 67–69, 1900), add to and complete a splendid record of Ichthyological research, to which must be added his memoirs in the Palæontographical Society's volumes and in those of the Geological Survey and elsewhere.

Science gained greatly when Arthur Smith Woodward, following in the steps of the veteran William Davies, took up the study of fossil fishes, for not only did he, by constant energy and perseverance, accomplish a vast amount of admirable work in this branch of science, but he was instrumental in inspiring his senior fellow-worker, Dr. Traquair, of Edinburgh, with a spirit of generous rivalry, which stimulated that very deliberate and careful anatomist to abandon his long accustomed habits of reserve and extreme caution, and to publish in an unusually brief time many new and important contributions to fossil Ichthyology. Dr. Arthur Smith Woodward commenced to write on fossil fishes in this Magazine in 1886, by giving an account of the Selachian genus *Notidanus*, a shark still living and extending back to the Lias; fourteen fossil species of which were duly recorded. Post-Liassic species of *Acrodus* and *Holocentrum* from Malta followed, also in 1887. A beautiful jaw of the Cretaceous shark *Synechodus* in the Brighton Museum was figured and described in 1888. A gigantic species of *Rhinobatis*, one of the Rays (commonly called 'old maids'), a Selachian fish from the Lithographic Stone of Bavaria, was delineated and noted by A. Smith Woodward; *Eurycormus grandis* and seven other British Jurassic fishes, and *Onychodus* from the Devonian of Spitzbergen, were recorded in 1889. In 1890 the same author described the head of *Eurycormus* from Ely; and remains of a huge fish, *Leedsia problematica*, from Peterborough. Fossil fish-teeth from the Cretaceous and Tertiary of Belgium and *Pholidophorus* from the Lias of Whitby were noticed in 1891; papers on Lower Devonian fish from New Brunswick, on the Devonian fish fauna of Canada, and on a fossil saw-fish, *Sclerorhynchus atavus*, from the Lebanon Cretaceous, followed in 1892. A gigantic Eocene Skate (*Myliobatis*) from Egypt, a Greensand Pycnodont fish (*Athrodon*), and other Upper Jurassic species appeared in 1893; a second British Jurassic *Eurycormus* in 1894; the fossil fish fauna of the English Purbeck beds, and Synopsis of Ganoid fishes of the Cambridge Greensand, in 1895; Wealden fishes in 1896; and as a companion to *Rhinobatis* a still grander specimen, a *Squatina*, the 'angel-fish' or monk-fish, a metre in length, most beautifully preserved, from the Lithographic Stone of Wurtemberg, showing the entire outline and skeleton of the fish; and lastly, a Carboniferous *Listracanthus* in 1903. In 1874 R. Etheridge, jun., described a *Petalorhynchus* from E. Kilbride; T. Stock a *Rhizodus* (nearly entire) from the Wardie shales (1881); the late J. C. Mansel-Pleydell a Purbeck *Histionotus* (in 1889).

J. H. Cooke recorded the remains of *Stereodon melitensis* from Malta (1891); E. T. Newton wrote on *Onychodus* from the Old Red of Forfarshire (1892); H. Bolton on *Listracanthus spinatus* from the English Coal-measures (1896); E. D. Wellburn on *Rhadinichthys* from the Coal-measures, Yorkshire (1900), and the fish fauna of the Millstone Grit (1901). Lastly, Professor C. R. Eastman wrote on a new *Edestus*-like form of fish-dentition named *Campyloprion*, from the Coal-measures of Nebraska, U.S., 1902.

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

II. — Sedgwick Museum Notes.[1]

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE V.)

New Fossils from the Haverfordwest District.

THE recent gift to the Museum of a fine series of Lower Palæozoic fossils from the Haverfordwest area by Mr. V. M. Turnbull, M.A., who has personally collected them with much care, has at length provided us with the means of determining many of the interesting species which were mentioned without specific names (on account of their imperfect preservation) by Messrs. Marr and Roberts in their paper on this district.[2] The collections from which their lists were drawn up are in the Sedgwick Museum.

Several species new to science or to the locality can now be accordingly described, but others must still await the acquisition of better material.

I. Phacops Robertsi, sp. nov. (Plate V.)

A large number of specimens of a species of *Phacops* were collected by Messrs. Marr and Roberts from the Sholeshook Limestone and Redhill Beds, but the material was scarcely good enough for a sufficient diagnosis of specific characters. Mr. Turnbull's new specimens of the same form have now supplied this want.

Description.—Head-shield nearly semicircular or broadly parabolic, obtusely pointed in front, about twice as broad as long, gently convex from back to front, strongly convex from side to side with the cheeks bent down; anterior border present.

Glabella elongated, expanding gradually towards the front to about double the basal width; rather narrow in relation to head-shield, the base being only about a quarter its width; nearly three times as long as wide at base; sides nearly straight behind frontal lobe, converging posteriorly at about 20°; gently and uniformly convex, rising but slightly above cheeks.

Frontal lobe of glabella not reaching front margin of head-shield, with rounded lateral angles projecting slightly at the sides; about half

[1] The series of articles in this Magazine which have been long known as "Woodwardian Museum Notes" will in the future be continued under the title of "Sedgwick Museum Notes," in consequence of the removal of the geological collections at Cambridge to the new Sedgwick Memorial Museum.

[2] Q.J.G.S., vol. xli (1885), pp. 476–490.

as long as whole glabella or rather more; transversely subquadrate in shape, with arched front end; not rising above general level of rest of glabella, nor detached from it; lateral angles circumscribed by facial sutures. Three pairs of lateral glabellar lobes present; first pair the largest, triangular in shape, extending back along axial furrows to middle of eyes; second and third pairs of lateral lobes of subequal size, and with subparallel anterior and posterior sides.

Three pairs of lateral glabellar furrows present; the basal pair the strongest. First pair straight, obliquely inclined to axial furrows at about 45° or 50°, arising a little in front of eyes and extending inwards for about two-fifths of the width of the glabella on each side; scarcely widening at their outer extremities. Second pair equal in depth and width to the first, horizontal, nearly straight or slightly arched forwards, arising nearly opposite middle of eyes and extending inwards for about one-third or rather more of the width of the glabella on each side. Third or basal pair deeper than the preceding pair, horizontal or slightly oblique, straight, situated half-way between second pair and occipital furrow, and extending on each side inwards for about one-third of the width of the glabella.

Occipital furrow strong, arched forwards in middle. Axial furrows rather weak, especially round lateral angles of frontal lobe; diverging anteriorly at about 20° in a slight concave curve from base of glabella to anterior end of eyes, in front of which they sweep outwards round the frontal lobe, merging imperceptibly into the nearly obsolete marginal furrow of the head-shield.

Fixed cheeks with anterior wing much reduced in size owing to lateral projection and width of frontal lobe; posterior wing with a basal width equal to about one and a half times that of the glabella at its base; posterior margin gently arched; neck segment marked off by strong deep furrow dying out before reaching lateral margin; lateral marginal furrow nearly obsolete. Genal angles measuring about 60° or more, and furnished with small sharp spinules. Eye-lobes large, prominent, semicircular, horizontally extended at same level as glabella.

Facial sutures with anterior and posterior branches making angle of about 70°; anterior branches curve round, defining lateral angles of frontal lobe, and unite in regular convex curve in front of it, which they thus bound; posterior branches curve slightly forward in a sigmoidal manner from base of eye to cut lateral margin a little behind the level of second lateral glabellar furrows.

Free cheeks small, triangular, united in front by the narrow, flattened, horizontal anterior border of the head-shield. Eyes large, prominent, high, strongly curved, but not angulated; extending from a little behind first lateral furrows to third lateral furrows of glabella; distant from posterior margin of head-shield about two-thirds their length; nearly touching side of glabella at their front end, but more remote at their posterior end; lens-bearing surface steeply inclined or vertical, with about 30–35 vertical rows of lenses having 10–12 lenses in the middle rows. Surface of glabella granulated, with small tubercles interspersed. Faint traces on the frontal lobe of the V-shaped mark found in *Chasmops.*

Thorax (imperfectly known) about twice as long as head-shield; axis regularly semi-cylindrical, prominent, convex, with slightly swollen lateral nodes on axial rings. Pleuræ strongly arched, with deep diagonal furrow; fulcrum situated about half-way out; extra-fulcral part sharply bent down and slightly curved forwards; extremities of pleuræ rounded.

Pygidium semicircular to semi-elliptical, gently convex, with regular margin. Axis prominent, convex, conical, tapering to a pointed extremity, not quite reaching posterior margin; composed of 9–11 rings, of which only the first 5–6 are usually well marked. Axial furrows straight, converging posteriorly at about 20°–25°. Lateral lobes gently arched downwards on each side, showing 5–8 regular, slightly curved pleuræ, dying out towards the margin and each with weak median pleural furrow. Border smooth, not crossed by pleuræ, but not marked off on upper surface by marginal furrow. Infra-marginal doublure (seen in casts) convex, of moderate width, extending inwards to tip of axis.

Dimensions.

	mm.
Length of head-shield...	18–20
Width of head-shield...	36–40
Length of pygidium	13–23
Width of pygidium	22–33

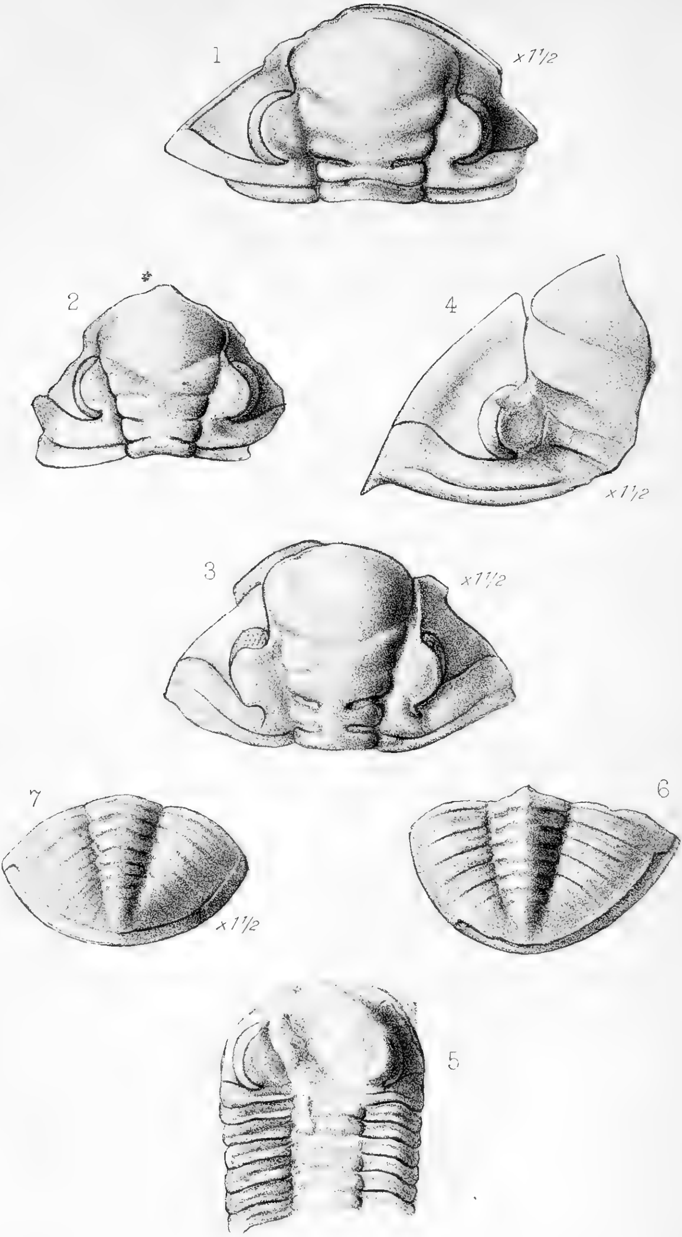
Affinities.—The general characters of this species indicate a close relationship to the Ordovician forms of *Dalmanites* (Barrande)[1] found in Bohemia. Hoernes[2] has carefully pointed out the characters which differentiate them from the typical Silurian and Devonian members of this genus as understood by Barrande, and they constitute a group which in one direction appears to lead to that of *D. Hausmanni* of Stages F, G, and H, and in the other direction to the typical forms of *Phacops*, sens. str., of the same Stages.

The chief points which distinguish this older group of *Dalmanites* are the rudimentary or absent frontal border, the slight separation of the frontal lobe from the rest of the glabella, the smallness or absence of the genal spines, the rounded or scarcely pointed extremities of the pleuræ, and the fewer segments in the pygidium.

In *Ph. Robertsi* the head-shield with its distinct frontal border, the lobation and shape of the glabella, and small genal spines resemble those forms leading on to the *D. Hausmanni* group; but the rounded extremities of the pleuræ and the non-mucronate, semicircular pygidium connect it with the species which seem to be the ancestors of the typical *Phacops* group. *D. socialis*, Barr. (and its varieties), *D. Deshayesi*, Barr., and *D. Hawlei*, Barr.—all from Stage D in Bohemia—show strong points of resemblance in the head-shield, but *D. Phillipsi*, Barr. in the thorax and pygidium. It is

[1] Barrande: Syst. Silur. Bohême, vol. i, p. 299 et seq. and p. 528 et seq.

[2] Hoernes, Jahrb. Geol. Reichsanst. Wien, Bd. xxx (1880), Heft 4, pp. 651–686; and Kosmos, Jahrg. iv, Bd. viii (1880), pp. 20–32.



G. M. Woodward del. et lith. West, Newman imp.

Phacops Robertsi *sp. nov.*
Ordovician. *Haverfordwest.*

obvious, therefore, that this Haverfordwest species belongs to this group of *Dalmanites*, in which there existed a combination of the subsequently well-differentiated characters of the later typical *Dalmanites* and *Phacops*.

The specific name, *Ph. Robertsi*, has been chosen in memory of the late Mr. T. Roberts, M.A., F.G.S.

EXPLANATION OF PLATE V.

FIG. 1.—*Phacops Robertsi*, sp. nov. Head-shield. Redhill Stage, Prendergast Place, Haverfordwest. × 1½.
,, 2.—Ditto. Head-shield. Redhill Stage, Redhill Quarry, Haverfordwest. Nat. size.
,, 3.—Ditto. Head-shield. Sholeshook Limestone, Prendergast Place, Haverfordwest. × 1½.
,, 4.—Ditto. Free-cheek. Sholeshook Limestone, Prendergast Farm, Haverfordwest. × 1½.
,, 5.—Ditto. Head-shield with portion of thorax. Same horizon and locality. Nat. size.
,, 6.—Ditto. Pygidium. Redhill Stage, Redhill Quarry, Haverfordwest. Nat. size.
,, 7.—Ditto. Pygidium. Sholeshook Limestone, Prendergast Place, Haverfordwest. × 1½.

III.—FURTHER NOTES ON THE MAMMALS OF THE EOCENE OF EGYPT.

By C. W. ANDREWS, D.Sc., F.G.S., British Museum (Natural History).

PART I.

DURING the last few months I have been engaged in examining the remains of the fossil Vertebrates from the Middle and Upper Eocene of the Fayûm district of Egypt, with a view to the preparation of the detailed monograph which it is proposed to publish on this subject. As it will be some months before this can appear, it seems desirable to give a brief account of some of the more important results arrived at, and preliminary descriptions of such new forms as have come to light in the course of the work. The collections examined include all the material belonging to the British Museum, as well as many of the more important specimens from the Geological Museum of Cairo. There still remains in Cairo a large collection of bones, which I hope to have an opportunity of working out during the next few weeks.

Mœritherium.

The figure of the skull and mandible of *Mœritherium lyonsi* lately published (Phil. Trans., vol. 196 B, figs. 14–17) was reconstructed from portions of a number of skulls from the Middle Eocene. Since then Mr. H. J. L. Beadnell has found an almost complete skull of a nearly adult animal from the Upper Eocene, and from this the accompanying restoration (Fig. 1) has been made, showing the boundaries of many of the bones, but otherwise differing in no important points from the earlier figure. The mandible has been reconstructed from several Middle Eocene specimens.

The most striking character of the skull as a whole is the great elongation of the cranial as compared to the facial region. The upper edge of the supra-occipital forms the lambdoidal crest and extends on to the roof of the skull, sending a wedge-shaped process between the hinder ends of the parietals, but there seems to be no trace of a distinct interparietal bone. The parietals are long, extending nearly to the front of the temporal fossa. Their most peculiar character is that they send back on to the occipital surface

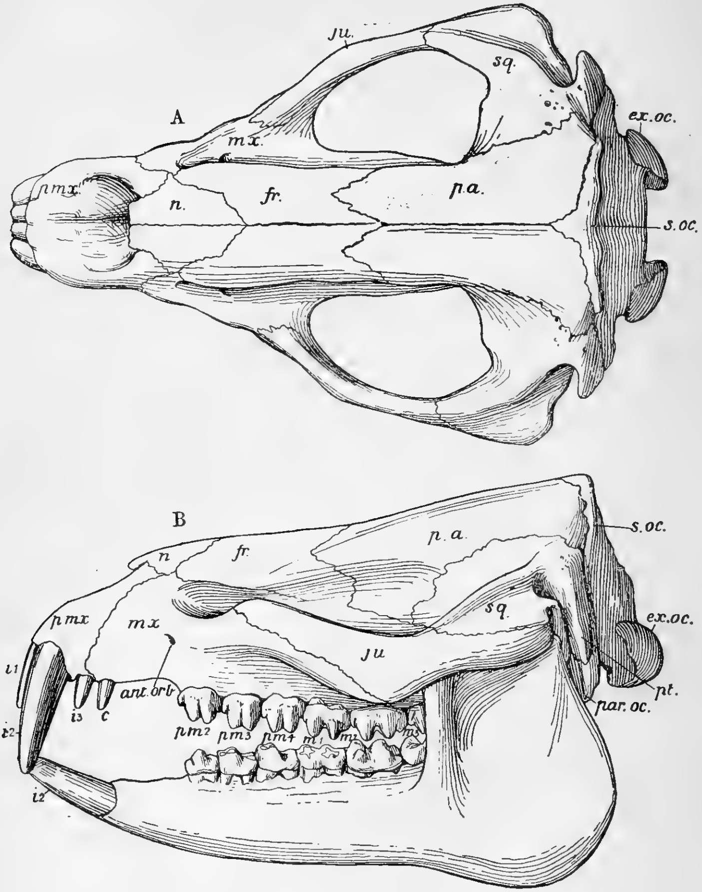


Fig. 1.—Skull of *Mœritherium*.—*A*, from above; *B*, from side. *ant.orb.* antorbital foramen; *ex.oc.* exoccipital; *fr.* frontal; *ju.* jugal; *mx.* maxilla; *n.* nasal; *pa.* parietal; *par.oc.* paroccipital; *pmx.* premaxilla; *pt.* post-tympanic process of squamosal; *s.oc.* supra-occipital; *sq.* squamosal. *i*1, *i*2, *i*3, incisors; *c*, canine; *pm*2, *pm*3, *pm*4, premolars; *m*1, *m*2, *m*3, molars.

a short process which is wedged in between the supra-occipital and the squamosal. The cranial part of the squamosal, as well as the neighbouring region of the parietals, is considerably swollen through the development of sinuses which communicate with the outside of the skull by a number of irregularly arranged foramina. The frontals are comparatively short; they are slightly marked by supra-orbital ridges, which run along the upper borders of the orbits; anteriorly they are cut off from the premaxillæ by the union of the maxillæ with the nasals. These latter bones are short, and overhang the narial opening to a very small extent; from behind forwards they form sutures with the frontals, maxillæ, and premaxillæ; in fact, their relations to the surrounding bones are exactly as in the later Proboscidea.

The nasal opening is large and looks forward, not upward as in *Elephas.* It is not at the end of the snout, and the upper surface of the premaxillæ in front of it is deeply grooved, probably indicating the presence of a short proboscis as in the *Tapir.* The orbit is very small, and there is a mere trace of supra-orbital processes.

In the young specimen above referred to, the last molar is still uncut, and from its position it is clear that the rest of the cheek teeth must move considerably forward in order to allow it to come into position.

The occurrence of a species of *Mœritherium,* probably identical with *M. lyonsi,* in the Upper Eocene beds in association with *Palæomastodon* raises the question of whether *Mœritherium* can be ancestral to *Palæomastodon.* If it is not, at least it must be extremely similar and very closely related to the actual ancestor, for it presents all the proboscidean characters in exactly the more generalised condition that one would expect to find. Moreover, it may be pointed out that *Palæomastodon* does not occur in the Middle Eocene beds in which *Mœritherium* is abundant, while in the upper beds *Palæomastodon* is common, and but few *Mœritherium* remains have been found.

From the vertebral column of a large, and at present unnamed, species of *Mœritherium* the number of the vertebræ in the different regions can be ascertained with reasonable certainty. These are: cervical, 7; thoracic, 20; lumbar, 3; sacral, 3; caudal, number unknown, but the tail must have been of moderate length. The axis has a peg-like odontoid, the lower surface of which bears a large facet for articulation with the atlas; the neural spine is high. The centra of the other cervicals are rather short, but longer in proportion to their size than in the later proboscideans.

The scapula is oval in outline; the coracoid process is large, and the glenoid surface for the humerus is continued on to its lower face. The humerus is in some respects more like that of some carnivores than that of an ungulate. Its most remarkable feature is the extreme compression of the shaft from side to side. The ent-epicondyle is very large, and there is no ent-epicondylar foramen. The supinator ridge is well developed. The femur is flattened from before backwards; the great trochanter rises a little above the head, and there is no third trochanter. The distal articular end is relatively small, and the condyles are as in *Elephas.* The feet are at present quite unknown.

Among the specimens collected by me last season is a portion of the right ramus of a mandible containing the three molars: of these m. 3 is in perfect and unworn condition, while m. 2 and m. 1 have lost portions of their outer sides. The character of the teeth here preserved proves the existence in these beds of another small proboscidean related to *Mœritherium*, but differing from it so considerably that when better known it may be necessary to refer it to a new genus; for the present it may be called *Mœritherium trigodon.*

The characters of the teeth are as follows:—

M. 1 was a bilophodont tooth with a small posterior lobe; each transverse crest consisted of two tubercles. Most of the outer half of the tooth is wanting; the inner half consists of a high anterior cusp and a somewhat lower posterior one, separated by a deep valley. The half of the posterior lobe still remaining is nearly flat.

M. 2 also wants a great part of its inner half. It is similar to m. 1, except that the posterior lobe bears a large blunt tubercle, which lies immediately behind the outer tubercle of the posterior crest. These two teeth are very similar to the corresponding ones of *Mœritherium.*

M. 3 is quite unworn; it differs widely from m. 3 of *Mœritherium.* Like the other molars, it consists of two transverse ridges and a talon. The transverse ridges are placed somewhat obliquely; the anterior one consists of a high pointed outer tubercle and an inner one, on the outer face of which a small secondary tubercle is present. In the posterior crest the outer lobe again consists of a pointed tubercle, but the inner half is formed by two subequal tubercles. The talon is composed of a large tubercle in the same antero-posterior line as the outer cusps of the crests, and on its inner side there are several small tubercles; on its outer side the cingulum is well developed. The talon as a whole is thus triangular in outline, its posterior angle being on the outer side of the tooth. In *Mœritherium lyonsi,* on the other hand, the talon is much broader, and consists of an outer and an inner tubercle, which form a third transverse crest, thus converting the tooth into a trilophodont one. This difference in the talons appears to justify the separation of the present form as a distinct species at least, and, as already remarked, further material will probably show that a new genus will have to be established. The enamel of the whole tooth is raised into irregular ridges and small tuberosities.

The dimensions of the specimen are:—

	Length.	Breadth.
m. 1	26 mm.	?
m. 2	32 mm.	?
m. 3	40 mm.	24 mm.

Palæomastodon.

The structure of the skull in this genus is now almost completely known. The most complete specimens yet found are (1) an adult skull wanting part of the occipital and most of the facial regions; (2) the anterior half of a young skull collected by Mr. Beadnell, and showing the whole of the facial portion in a perfect state of preservation. The figures here given have been constructed from these two specimens, and are sufficient to convey a general idea of the chief characters. It will be seen that in all essential respects this skull is proboscidean, and, in fact, it might almost be described as that of an exceedingly dolichocephalic elephant.

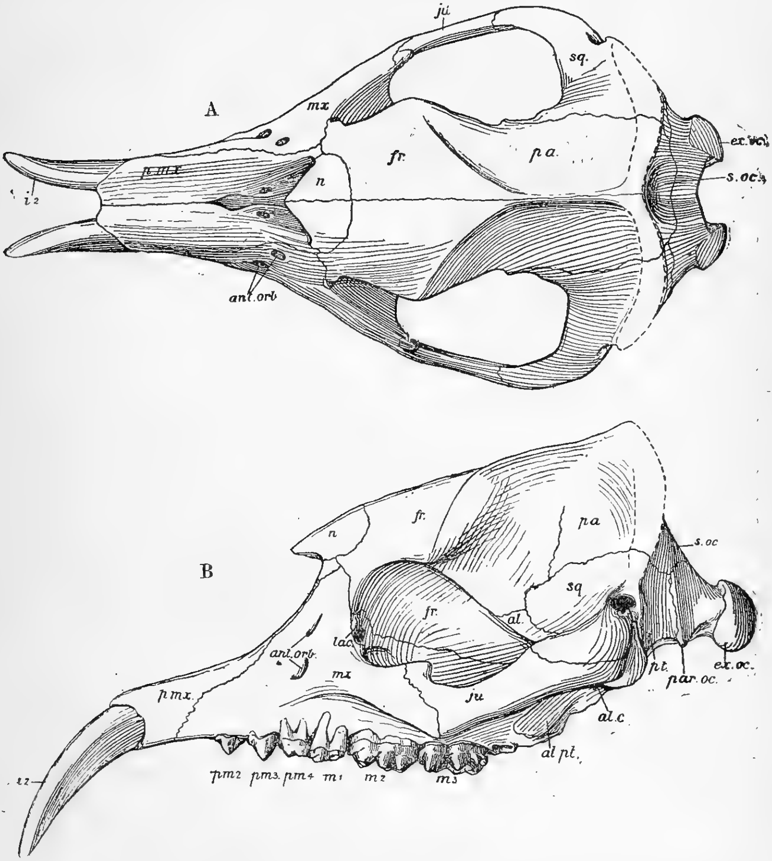


Fig. 2.—Skull of *Palæomastodon*. *A*, from above; *B*, from side. *al.* alisphenoid; *al.pt.* pterygoid wing of alisphenoid; *al.c.* alisphenoid canal; *lac.* lachrymal. The other letters are as in Fig. 1.

The supra-occipital surface slopes somewhat forward, and has a deep median fossa for the attachment of muscles and ligaments, exactly like that found in *Elephas*. The region of the lambdoidal crest, both in the squamosal and the parietal, is considerably swollen by the development of sinuses which communicate with the exterior and probably with the auditory meatus by several foramina. The swelling of the back of the head has not yet gone far enough to lead to the disappearance of the sagittal crest, which is fairly prominent, and divides anteriorly into the temporal ridges, which run out on to the post-orbital processes of the frontals. The nasals are short, and their relations to the surrounding bones much as in *Elephas.* The nasal opening has already been shifted back a considerable distance behind the anterior end of the snout, but not to the same degree as in the elephants, since it is still in front of the anterior border of the orbits, while in the later forms it has come to lie behind it and at the same time looks more upwards. The premaxillaries have exactly the same relations to the nasal opening and to the neighbouring bones as in *Elephas,* but the form of their anterior portion is quite different, owing to the fact that the tusks are still small, so that the great alveoli and the broad truncated anterior border of these bones, so characteristic of the elephants, are here unnecessary, and they terminate anteriorly almost in a point. The maxilla is greatly elongated. It bears a stout zygomatic process, the base of which is perforated by a large antorbital canal, which opens on the face by two foramina. The lachrymal is exactly as in *Elephas.* The jugal is large, and extends from the orbit back beneath the zygomatic process of the squamosal as far as the glenoid surface for the mandible. The cranial portion of the squamosal is considerably swollen by the presence of air sinuses; it completely surrounds the auditory opening, sending down behind it a post-tympanic (*p.t.*) process. The articular surface for the mandible is very large; it is slightly concave from side to side, and very convex from before backwards; the mandible must have much freer play both from side to side and up and down than in the recent elephants. The alisphenoid is perforated by an alisphenoid canal (*al.c.*), and sends down on to the pterygoid a pterygoid wing (*al.pt.*), the anterior edge of which forms the outer border of a deep groove, which is continued upwards and forwards towards the post-orbital process of the frontal. At the bottom of this groove are the anterior openings of the alisphenoid canal, the *foramen lacerum anterius* and the optic foramen, as in *Elephas.* The tympanic is small, less inflated than in the later type, and does not extend into the mandibular articulation.

There is no distinct condylar foramen; it appears to be confluent with the *foramen lacerum posterius.* The opening of the internal nares is higher than wide; the maxillæ, palatines, and pterygoids which form its side walls are all to some extent thickened by the development of coarsely cellular bone, which is particularly abundant in the portion of the maxilla immediately behind the last molar. The axis of the palate is somewhat bent up with regard to the basi-cranial axis, so that the two make a very obtuse angle with one another: in the elephants this character is carried still further.

The limb bones of *Palæomastodon* are comparatively rare, most of the very large number of bones now collected belonging to *Arsinoitherium.* Such specimens as can be referred with certainty to

Palæomastodon differ in no important points from the corresponding bones of *Elephas*. The calcaneum, however, is less short and stout than in the recent forms, the *tuber calcis* being more elongate; some calcanea from the Miocene of France, probably belonging to *Tetrabelodon angustidens*, approximate most nearly to the Egyptian specimen.

A portion of the right ramus of a mandible shows that there existed in the Upper Eocene beds a species of *Palæomastodon* considerably smaller than *P. beadnelli*, even allowing for a very wide range of individual variation in size in that species. The specimen in question consists of part of the ramus and the coronoid process of an immature mandible, in which m. 3 has not yet been cut, although it is completely developed. M. 3 differs from the same tooth in *P. beadnelli* in having the outer half of the third transverse crest more clearly composed of two distinct tubercles, and in the presence of a short fourth transverse crest separated from the third by a fairly deep valley and composed of three small tubercles. M. 2 is trilophodont, the anterior valley being partly blocked by an accessory tubercle; as usual in this genus, the second molar is considerably larger than the first. This latter, which is already considerably worn, is also trilophodont. Pm. 4 is bilophodont, the anterior crest being considerably the higher. Pm. 3 consists of a single high anterior cusp and a low heel. This species may be called *Palæomastodon minor*; its dimensions compared to those of *P. beadnelli* are shown in the following table, which in the first column gives the length of the teeth in the type of *P. minor*, in the second of those of a small individual (? female) of *P. beadnelli*, and in the third of those of the type of that species:—

	P. minor.	*P. beadnelli* (? female).	*P. beadnelli* (type).
m. 3...	47 mm.	65 mm.	78 mm.
m. 2...	45 ,,	55 ,,	65 ,,
m. 1...	32 ,,	41 ,,	48 ,,
pm. 4	28 ,,	39 ,,	48 ,,
pm. 3	28 ,,	30 ,,	?

IV.—Notes on the Cephalopoda belonging to the Strachey Collection from the Himalaya. Part I: Jurassic.

By G. C. Crick, Assoc. R.S.M., F.G.S., of the British Museum (Natural History).

(Concluded from the February Number.)

10. Ammonites scriptus (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 81, pl. xvi, figs. 2*a–c*.)

According to Professor Blanford the only example of this species in the Strachey Collection was the fragment which he figured. This is now in the British Museum collection [No. C. 5045]; it was transferred from the Museum of Practical Geology, labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites scriptus (Stra.). Coll. by Col. Strachey." The figures, which are all reversed, are not good. The portion of the fossil that is figured is entirely septate; the anterior part of the specimen that formed the base of the body-chamber is not included in the figure, nor does the figure show the shorter intermediate ribs which extend over the outer half of the lateral area of the whorl.

Blanford (p. 106) regarded this species as a synonym of Oppel's *A. Stanleyi*,[1] a species which he considered to have priority of publication.

11. Ammonites jubar (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 82, pl. xx, figs. 2*a*–*c*; pl. xxi, figs. 1*a*–*c*.)

The British Museum collection contains three examples of this species, numbered C. 5043, C. 5044, and C. 5030 respectively.

The specimen numbered C. 5043 is the original of plate xx, figs. 2*a*, *b*. The posterior half of the outer whorl, that is, the portion to the right of the break indicated in fig. 2*a*, is now missing, but the cement still adhering to the fossil indicates its former presence; it was possibly from the now missing part that the suture-line depicted in fig. 2*c* was drawn. About one-third of the rest of the outer whorl is septate, whilst the remainder formed part of the body-chamber. As part of the Strachey Collection this specimen was transferred from the Museum of Practical Geology, labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites jubar. Coll. by Col. Strachey."

The example No. C. 5044 is the natural mould, of which a gutta-percha impression (also preserved) is figured in pl. xxi, fig. 1*a*. Belonging to the same collection it was also transferred from the same Museum. It is labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites jubar (Stra.). Coll. by Col. Strachey." To it is fastened a small white label on which is written in ink "Ammonites jubar, R. S. Budarinathix"; but the word 'jubar' has been crossed out in ink.

The specimen No. 5030 also belonged to the Strachey Collection and was transferred from the Museum of Practical Geology, but the precise locality of the specimen is not recorded. It is the original of plate xxi, fig. 1*b*, and probably also furnished the restored outline given in fig. 1*c*.

I have not been able to recognize the original of the suture-line which is figured on pl. xx and numbered 2*d*; this appears not to be referred to in the text.

On p. 106 Professor Blanford placed this species as a synonym of Oppel's *A. Sabineanus*,[2] a name which he considered to have priority of publication.

[1] A. Oppel, "Ueber ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari-Khorsum in Tibet": Pal. Mittheil., iv (1863), p. 282, pl. lxxix, figs. 1*a*–*c*.

[2] A. Oppel, "Ueber ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari-Khorsum in Tibet": Pal. Mittheil., iv (1863), p. 288, pl. lxxxii, figs. 1*a*–*c*, 2*a*, *b*.

AMMONITES JUBAR, var. A. MULTIRADIATUS (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 82.)

Professor Blanford states that "this differs from the normal form in the greater number of its ribs (55), which are consequently more close set and filiform. The variation probably occurs only in young shells." In the Strachey Collection transferred from the Museum of Practical Geology, and labelled with that Museum's label "Oolitic: Niti Pass. Ammonites triplicatus (Sow.). Coll. by Col. Strachey," there is a fairly complete specimen [C. 7366], 46·5 mm. in diameter, which agrees very well with Blanford's description of this variety. It has about 52 ribs in the outer whorl, and although labelled '*Ammonites triplicatus*' it certainly does not agree with that species. This is the only specimen in the collection that corresponds to Blanford's description, and it is therefore most probably the variety referred to.

12. AMMONITES OCTAGONUS (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 83, pl. xii, figs. 2*a*, *b*.)

According to Professor Blanford's description, "the only specimen of this Ammonite in Colonel Strachey's Collection is a fragment, but of larger dimensions and in better preservation than that previously described from Spiti." This fragment is now in the British Museum collection [C. 5032], having been transferred from the Museum of Practical Geology, accompanied by one of that Museum's labels on which was written in ink simply the name "Am. octagonus, Strachey," without any record of either horizon or locality, and without any indication that it was the figured specimen. But of this fact there cannot be the slightest doubt; fig. 2*a* representing a lateral aspect of the fragment (reversed), and fig. 2*b* a much restored transverse section of the whorl.

Later in the same work (p. 106) Blanford united Strachey's *A. Hookeri* with the present species under the name *A. octagonus*, this species having been described some two years previously.[1]

13. AMMONITES HOOKERI (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 83, pl. xvii, figs. 1*a*–*d*.)

The figures illustrating Professor Blanford's description (pl. xvii, figs. 1*a*–*d*) have been drawn (reversed) from two specimens, which are now in the British Museum collection [C. 5048 and C. 5049]. Fig. 1*a* has been drawn from the example bearing the register number C. 5048, and the other figures have been taken from the specimen No. C. 5049. Both specimens were transferred, in 1880, from the Museum of Practical Geology, the smaller one [C. 5048] labelled "Oolitic: Niti Pass. Ammonites Hookeri (Stra.). Coll. by Col. Strachey." There is now no Jermyn Street Museum label with the larger specimen, but there is no doubt whatever as to its

[1] Journ. As. Soc. Bengal, vol. xxxii, No. 2 (1863), p. 128, pl. i, figs. 5*a*–*c*.

being the other specimen figured by Blanford. Each fossil has been numbered in ink "1830"; this is Strachey's original number, and indicates that the two examples came from the same locality, viz. the Niti Pass, this being the only locality mentioned in the list of fossils given on p. 102 of Salter & Blanford's work.

The posterior third of the outer whorl of the smaller example (fig. 1*a*) appears to be septate, whilst the rest seems to have formed part of the body-chamber. The larger example (figs. 1*b*–*d*) is entirely septate; it is part of a whorl which must have been at least 70 mm. in diameter. The suture-line has been painted in, and evidently formed the original of fig. 1*d*. The transverse section depicted in fig. 1*c* has been much restored.

On p. 106 Professor Blanford places this species as a synonym of Strachey's *A. octagonus*, to which species he also refers Oppel's *A. Sommerringi.*[1]

14. Ammonites medea (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 84, pl. xix, figs. 5*a*, *b*.)

Professor Blanford says: "The only specimen of this MSS. species of Colonel Strachey in his collection is the fragment figured, from which it is difficult to pronounce upon its affinities. It may be either, as surmised by Colonel Strachey, a species allied to *A. Jason*, Zieten, or a portion of a large specimen of the tuberculate form of *A. Wallichii*, Gray."

This specimen is now in the British Museum collection [C. 5047], having been transferred from the Museum of Practical Geology, in 1880, labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites medea. Coll. by Col. Strachey." It bears the number "18" in white paint. It is not well represented in the figures: the spines are not nearly so much elevated as shown in fig. 5*b*; and further, they are symmetrically disposed in regard to the median line of the flattened (i.e. the peripheral) area, and not irregularly placed as might be supposed from fig. 5*a*; the two rows of spines are 13 mm. apart, the spines being exactly opposite each other and arranged in each row at intervals of about 5 mm. The fragment shows no traces of septa, and appears to have formed part of the body-chamber.

15. Ammonites Wallichii, J. E. Gray.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 84, pl. xv, figs. 1*a*–*c*; pl. xix, figs. 1*a*–*c*, 2*a*–*c*.)

Besides the specimen [C. 5041] which was originally figured by Gray (Illust. Indian Zoology, 1830–32, pl. c, fig. 3) and refigured, as elsewhere shown,[2] by Blanford (op. cit., pl. xv, fig. 1), and the example [31,106] referred to by Blanford (p. 84, footnote) as measuring "not less than six inches in diameter," the British

[1] A. Oppel, "Ueber ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari-Khorsum in Tibet": Pal. Mittheil., iv (1863), p. 280, pl. lxxx, figs. 1*a*, *b*.

[2] G. C. Crick: Proc. Malac. Soc., vol. v, pt. 4 (April, 1903), p. 287.

Museum contains six specimens which were transferred from the Museum of Practical Geology. Five of these [Nos. C. 7675*a–e*] belonged to the Strachey Collection, and were labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites Wallichii. Coll. by Col. Strachey," but on one [No. C. 7675*d*] there has been written in ink the locality "nr. Chirchun." The sixth specimen [No. C. 7684] was labelled "A. Wallichii, var. γ. Spiti shales," but though there is no record as to its having formed part of the Strachey Collection, there is good reason to believe that it did, since it is numbered "11" in white paint exactly like the specimen No. 7675*d*.[1]

Professor Blanford's figures of this species represent several individuals. His pl. xv, figs. 1*a*, *b* represent Gray's type-specimen, to which also belongs the suture-line lettered in the published copies of the plate 2*b*,[2] evidently a mistake for 1*c*.

The specimen in the British Museum numbered C. 7675*a* is the original of pl. xix, figs. 1*a* and *b*; the figures, besides being reversed, have been very much restored, the first third of the outer whorl being very imperfect in the original. As it does not exhibit the suture-line, fig. 1*c* must have been drawn from another specimen; this we have not yet been able to identify in the collection.

The example in the same collection numbered C. 7675*b* is the original of pl. xix, figs. 2*a*, *b*; both figures have been reversed and restored; part of the matrix has been omitted, the first part of the outer whorl is now absent, and the peripheral terminations of the ribs are represented much too strong. The suture-line has been painted in and was evidently copied in fig. 2*c*, but this specimen does not exhibit the portion of the suture-line on the inner area of the whorl at all clearly; this portion of the line, however, is well shown and has been marked on the example No. C. 7684. It is concluded, therefore, that figs. 2*a*, *b* were drawn from the example No. C. 7675*b*, and that fig. 2*c* was taken chiefly from the same specimen, but partly also from the fossil No. C. 7684. Although there is no record that this specimen originally belonged to the Strachey Collection, there is, as we have already stated, good evidence for believing that such was the case.

Blanford (p. 106) regards Oppel's *A. Mörikeanus*[3] as a synonym of this species.

16. Ammonites robustus (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 85, pl. xvi, figs. 1*a–c*.)

Professor Blanford figured two specimens which he referred to this species; they are both in the British Museum collection

[1] Other specimens are similarly numbered. Thus, *A. medea* [C. 5047], pl. xix, figs. 5*a*, *b*, is marked "18"; *A. Wallichii* [C. 7675*a*], pl. xix, figs. 1*a*, *b*, is marked "12"; and *A. Wallichii* [C. 5041], pl. xv, figs. 1*a–c* (which is also one of Gray's type-specimens), is marked "10."

[2] G. C. Crick: op. cit., p. 288.

[3] A. Oppel, "Ueber ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari-Khorsum in Tibet": Pal. Mittheil., iv (1863), p. 281, pl. lxxx, figs. 2*a*, *b*.

[Nos. C. 5050 and C. 5046]. They were regarded as of Jurassic age, but they are much more probably Triassic fossils, and have been elsewhere described as such by the present writer.[1]

17. Ammonites Griffithii (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 86, pl. xx, figs. 1*a*–*c*.)

This species was founded upon a single specimen, which, as described by Professor Blanford, "is an imperfect shell, and bears the remains of three-fourths of another whorl. The figure is three-fourths of the real size of the specimen." This fossil is now in the British Museum collection [No. C. 5038]; it was transferred from the Museum of Practical Geology, labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites Griffithi. Coll. by Col. Strachey." The specimen is entirely septate; the suture-line (fig. 1*c*) seems to have been taken from quite close to the anterior end of the fossil, where it has been traced in white paint.

According to Blanford (p. 106) this species is a synonym of *A. Theodorii*, Oppel,[2] a name which claims priority of publication.

18. Ammonites strigilis, H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 87.)

Professor Blanford refers to an example in the Strachey Collection in the following terms:—"A single specimen (cut in half and polished) of this Ammonite (without specified locality) only differs from the original Spiti specimen in its somewhat larger size. Diameter of shell, 2¼ in. Diameter of outer whorl, 1¼ in."

I have not been able to identify an example of this species in the Strachey Collection in the British Museum, but the National collection contains the specimen [39,797], to which, when describing this species in 1863 (Journ. Asiatic Soc. Bengal, vol. xxxii, 1863, p. 126) from the half of a cut specimen, Blanford refers as possibly the fellow of the type-specimen. It is labelled "Himalaya"; but its history and exact locality are unrecorded.

19. Ammonites acucinctus (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, p. 87, pl. xviii, figs. 1*a*–*c*; pl. xix, figs. 4*a*–*d*; var. α (*A. mundus*, R. Strachey MS.), pl. xviii, figs. 2*a*, *b*.)

Of this species the British Museum collection contains five more or less incomplete examples [Nos. C. 7360*a*–*e*] that belonged to the Strachey Collection and were transferred from the Museum of Practical Geology, labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites acucinctus (Stra.). Coll. by Col. Strachey"; also two other examples [Nos. C. 7361*a*, *b*], with a plain

[1] G. C. Crick: Proc. Malac. Soc., vol. v, No. 4 (April, 1903), pp. 290 et seq.

[2] A. Oppel, "Ueber ostindische Fossilreste aus den secundären Ablagerungen von Spiti und Gnari-Khorsum in Tibet": Pal. Mittheil., iv (1863), p. 280, pl. lxxviii, figs. 3*a*–*c* (and pl. lxxxiii, figs. 2*a*, *b*).

label bearing in pencil the words "A. acucinctus Spiti shal[es]," that were also transferred from the same Museum, but there is no record whether they belonged to the Strachey Collection or not. Amongst the specimens that undoubtedly belonged to the Strachey Collection there is no single specimen from which all the figures 1*a*–*c* on pl. xviii could have been drawn. Allowance must, however, be made for the illustrations, for in his description of the species Blanford says "The figure of this species given in plate 18 is, in some respects, erroneous. The ribs in fig. 1*a* should conform to the shape of the mouth, instead of being but slightly flexuous, and the periphery should be ornamented with minute sharp teeth, instead of crenulations."

The specimen registered C. 7360*a* appears to be the original of fig. 1*b*, the figure being reversed; its size agrees also with fig. 1*a*, but its sculpture is much less distinct, and its suture-line is not visible. The sculpture of the species is best shown upon the fragment registered C. 7360*d*, and numbered in ink "1840," which at one time appears to have another piece attached to it; this fragment also exhibits traces of the suture-line, but these are quite insufficient to have furnished the drawing of the suture-line given by Blanford (fig. 1*c*). The form of the peristome indicated in fig. 1*a* appears to have been drawn from the example No. C. 7360*b*, which is, however, only about one-half of the size of the figure. The sculpture could not possibly have been taken from this specimen, the surface of which is nearly smooth; nor the suture-line, for although feebly indicated it is not sufficiently preserved to have formed the original of fig. 1*c*.

Of the two other examples of this species [C. 7361*a*, *b*] which were also transferred from the Museum of Practical Geology, and which most probably belonged to the Strachey Collection, although direct evidence of this is wanting, one [C. 7361*b*] exhibits the suture-line very clearly, and there is every probability, not only that these specimens originally formed part of the Strachey Collection, but that the specimen C. 7361*b* furnished the original of the suture-line represented in fig. 1*c*.[1]

With regard to the figures of this species in the "Palæontology of Niti," I conclude, therefore, that fig. 1*b* has been drawn from the specimen No. C. 7360*a*; that fig. 1*a* has been drawn in part from the example No. C. 7360*b*, and possibly in part also from the specimens C. 7360*a* and C. 7360*d*; and that fig. 1*c* has been taken from the specimen C. 7361*b*. I have not been able to recognize in the collection the original of figs. 4*a*–*d* on pl. xix.

The species was originally described by H. F. Blanford in 1863 (Journ. Asiatic Society of Bengal, vol. xxxii, 1863, p. 126, pl. i, figs. 3, 3*a*). He considered (p. 106) *A. Lymani*, A. Oppel (Pal. Mittheil., iv (1863), p. 272, pl. lxxvi, figs. 3*a*–*c*), to be a synonym.

[1] F. Stoliczka (Mem. Geol. Surv. India, vol. v, pt. 1, 1865) says (p. 93), "Fig. 1*c* in Strachey's Pal. pl. 18 gives no good idea of the true form of the lobes and saddles. The figure was evidently taken from a specimen with a very much eroded surface."

Var. *a* (=*Ammonites mundus*, R. Strachey MS.).

In his description (p. 88) of this variety Professor Blanford states that "the two fragments in the [Strachey] collection are those of larger shells than any of the normal form." Amongst the examples forming part of the Strachey Collection which was transferred from the Museum of Practical Geology, this variety is represented by a single imperfect specimen [No. C. 5035] enclosed in a portion of a nodule in association with a part of the phragmocone of a Belemnite (probably the form which Blanford referred to Miller's *B. sulcatus*), and a fragment of a thick-whorled biplicated Ammonite (like *A. torquatus*); it is labelled with a Jermyn Street Museum label "Oolitic: Niti Pass. Ammonites acucinctus (Stra.), Ammonites biplex (Sow.), Belemnites sulcatus (Mill.)." The specimen comprises only about the last third of the outer whorl; this seems to have formed part of the body-chamber, as no septa are visible; of the rest of this whorl and of the earlier whorls there is an impression on the nodule that shows clearly the character of the ornaments of the test. This fossil is most probably the figured example, the figure having been reversed and very much restored. The direction of the striæ has been indicated on the fossil in pencil, probably to assist the artist. The dimensions of the specimen appear to have been:—diameter of shell, about 53 mm.; radius of shell, 31 mm.; height of outer whorl, 24·5 mm.; thickness of outer whorl, 14 mm.; width of umbilicus, 12 mm.

The following are figured among the Jurassic Cephalopoda, but are not referred to in the text of the work:—

20. Ammonites Batteni (R. Strachey MS.), H. F. Blanford.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, pl. xi, figs. 2*a–c*.)

These figures are placed among the illustrations of Jurassic Ammonites, and are named at the foot of the plate "*Am. Batteni*," but the species appears not to be referred to in the text. The original of the figures is in the British Museum collection [No. C. 4867]; it was transferred from the Museum of Practical Geology labelled with one of that Museum's labels "Oolitic: Niti Pass. Ammonites Batteni. Coll. by Col. Strachey"; but I think there can be no doubt about its being, as has already been pointed out, a Triassic species referable to the genus *Gymnites*.[1] It will therefore be more fully dealt with among the Triassic species belonging to the Strachey Collection.

21. Ammonites, sp.

(H. F. Blanford, in J. W. Salter & H. F. Blanford: Palæont. Niti, 1865, pl. xix, figs. 3*a–c*.)

The original of these figures—fig. 3*a* representing the specimen of the natural size—is in the British Museum collection [No. C. 7677]. It is not referred to in the text. The specimen was transferred

[1] See C. Diener: Mem. Geol. Surv. India, Pal. Indica, ser. xv, vol. ii, pt. 2 (1895), p. 53 et seq.

Alphabetical List of the Strachey Collection of JURASSIC CEPHALOPODA figured and described by Professor H. F. Blanford, in Salter & Blanford's Palæont. Niti, 1865.

No. in Paper.		Page.	Plate.	Figure.	Location and registered number of specimen.
19	*Ammonites acucinctus* (R. Strachey MS.), H. F. Blanford	87	xviii	1*a*	B.M. { C. 7360*b*, ? C. 7360*a*, ? C. 7360*d*
		87	xviii	1*b*	B.M., C. 7360*a*
		87	xviii	1*c*	B.M., C. 7361*b*
	,, ,, ,, ,,	87	xix	4*a–d*	?
	,, ,, var. α (*A. mundus*, R. Strachey MS.)	88	xviii	2*a, b*	B.M., C. 5035
2	,, *alatus* (R. Strachey MS.), H. F. Blanford ...	76	xviii	3*a*	B.M. { C. 7364*a*, C. 7365
	,, ,, ,, ,,	76	xviii	3*b*	?
20	,, *Batteni*, H. F. Blanford		xi	2*a–c*[1]	B.M., C. 4867
7	,, *biplex*, J. Sowerby	79	xi	1*a*	B.M., C. 5033
	,, ,, ,, ...	79	xi	1*b, c*	?
	,, ,, ,, ...	79	xii	1*a–c*	?
17	,, *Griffithii* (R. Strachey MS.), H. F. Blanford	86	xx	1*a–c*	B.M., C. 5038
6	,, *guttatus* ,, ,,	79	xiii	2	B.M., C. 7358
13	,, *Hookeri* ,, ,,	83	xvii	1*a*	B.M., C. 5048
		83	xvii	1*b–d*	B.M., C. 5049
11	,, *jubar* ,, ,,	82	xx	2*a, b*	B.M., C. 5043
	,, ,, ,, ,,	82	xx	2*c*	B.M., ? C. 5043
	,, ,, ,, ,,	82	xx	2*d*	?
	,, ,, ,, ,,	82	xxi	1*a*	B.M., C. 5044
	,, ,, ,, ,,	82	xxi	1*b, c*	B.M., C. 5030
	,, ,, ,, var. α, *multiradiatus* (R. Strachey MS.), H. F. Blanford	82		no fig.	? B.M., C. 7366
14	,, *medea* ,, ,,	84	xix	5*a, b*	B.M., C. 5047
	,, *multiradiatus* ,, v. *A. jubar*, var. α				
	,, *mundus* ,, v. *A. acucinctus*, var. α				
3	,, *Nepalensis*, J. E. Gray	77	xiv	1*a, b*	G.S.M., R. 10116
12	,, *octagonus* (R. Strachey MS.), H. F. Blanford	83	xii	2*a, b*	B.M., C. 5032
16	,, *robustus* ,, ,,	85	xvi	1*a, c*[1]	B.M., C. 5050
	,, ,, ,, ,,	85	xvi	1*b*[1]	B.M., C. 5046
10	,, *scriptus* ,, ,,	81	xvi	2*a–c*	B.M., C. 5045
18	,, *strigilis*, H. F. Blanford	87		no fig.	?
4	,, *tenuistriatus*, J. E. Gray	78	[xiv	2 ?]	B.M., C. 5039
	,, ,, ,, ...	78	xv	2*a*	B.M., C. 5036
	,, ,, ,, ...	78	xv	2*b, c*	B.M., C. 5051
	[,, ,, ,, ...	78	xv	2*d*[2]]	
9	,, *torquatus*, J. de C. Sowerby	80		no fig.	
8	,, *triplicatus*, J. Sowerby	80	xiii	1*a, b*	B.M., C. 5042
	,, ,, ,, ...	80	xiii	1*c*	B.M., C. 5031
5	,, *umbo* (R. Strachey MS.), H. F. Blanford ...	78	xvii	2*a–d*	B.M., C. 5040
15	,, *Wallichii*, J. E. Gray	84	xv	1*a, b*. 2*d*[3]	B.M., C. 5041
	,, ,, ,, ...	84	xix	1*a, b*	B.M., C. 7675*a*
		84	xix	1*c*	?
	,, ,, ,, ...	84	xix	2*a, b*	B.M., C. 7675*b*
		84	xix	2*c*	B.M. { C. 7675*b*, C. 7684
21	,, sp.		xix	3*a–c*	B.M., C. 7677
1	*Belemnites sulcatus*, J. S. Miller	76	x	1	B.M., C. 2566
	,, ,, ,, ...	76	x	2	B.M., C. 2567
	,, ,, ,, ...	76	x	3	B.M., C. 2568
	,, ,, ,, ...	76	x	4	B.M., C. 2569
	,, ,, ,, ...	76	x	5	B.M., C. 2570
	,, ,, ,, ...	76	x	6	B.M., C. 2571
	,, ,, ,, ...	76	x	7	G.S.M., R. 10252
	,, ,, ,, ...	76	x	8	B.M., C. 2572

[1] Triassic specimens.
[2] This figure has been wrongly lettered; it belongs to *A. Wallichii* and should be 1*c*.
[3] This figure should have been letter 1*c*, since it belongs to *A. Wallichii* and not to *A. tenuistriatus*.

from the Museum of Practical Geology apparently with the rest of the Strachey Collection, although there is now no information with the fossil. There is, however, a loose Jermyn Street Museum label, without any specimen, to the following effect:—"Oolitic: Niti Pass. Ammonites orbiculatus. Coll. by Col. Strachey." I have not met with this specific name in any descriptions of Himalayan fossils, but the form of the present specimen would most likely suggest such a specific name, and I therefore think there is every probability of this label having belonged originally to this example, although direct evidence of the fact is wanting. If, however, the name *A. orbiculatus* has been used in connection with any Jurassic Cephalopod from the Himalaya, it probably refers to this specimen.

V.—The Zone of *Hoplites interruptus* (Bruguière) at Black Ven, Charmouth.

By W. D. Lang, B.A., F.Z.S., British Museum (Nat. Hist.).

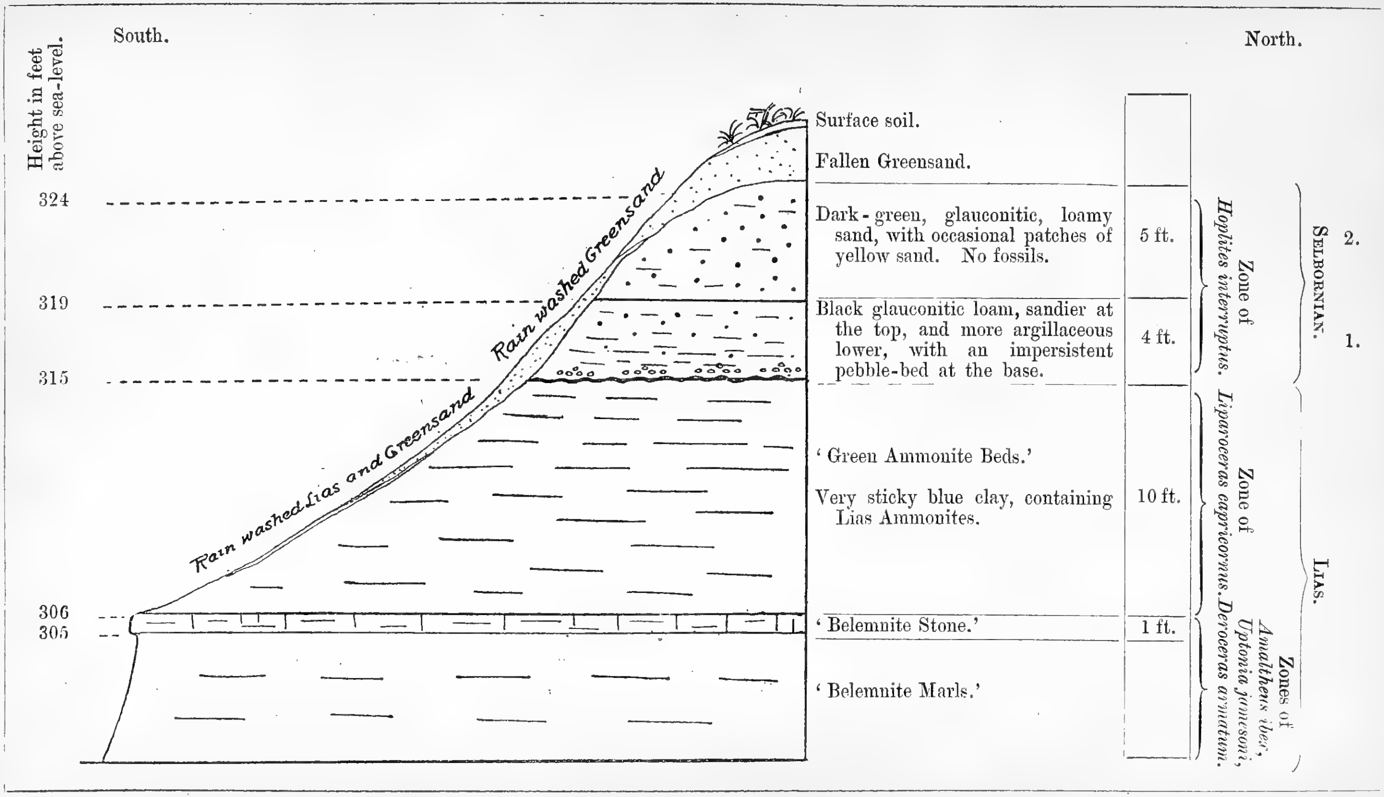
LYING unconformably upon the well-known Liassic beds of Black Ven, the cliff which overhangs the sea-shore between Lyme Regis and Charmouth, occur beds of Cretaceous age, representing the Gault and Upper Greensand of other localities. The lower beds consist of loams, dark and almost black where the clay predominates over the sand, and lighter where the sand is present in larger quantities. Above these loams are yellow sands containing indurated nodules called 'Cowstones,' which, with the 'Foxmould' sands above them, have been considered to represent the zone of *Schlœnbachia rostrata* (Sowerby).[1] The dark loams below them represent, therefore, the zone of *Hoplites interruptus* (Bruguière).

Of this zone some account has been given in the Survey Memoir;[2] but as the section given, measured in 1895, agrees only generally with those measured by the author in 1901 and 1902, differing conspicuously in the absence of the hard shales to be described later; and as the two last-mentioned sections, though separated for some distance, are obviously continuous, it may not be out of place to describe the sections that are exposed at the time of writing. For the cliff frequently falls, causing the covering up of old sections and the exposure of new. And though, until it was measured in detail, the western section was thought to be that described in the Survey Memoir and measured in 1895, the author now thinks that a new section is exposed, showing three bands of hard shaly loam unrecorded before.

Concerning the eastern section, which shows the junction with the Lias, it may be that described as having been found by Mr. C. Reid in 1875.[3] At present, however, it is not at all obvious, being covered by some thickness of 'rainwash,' so that to expose the junction some amount of digging has to be performed.

[1] A. J. Jukes-Browne: "The Gault and Upper Greensand of England," 1900, p. 183.
[2] Jukes-Browne: loc. cit., pp. 187–189.
[3] Jukes-Browne: loc. cit., p. 189.

FIG. 1.—SECTION SHOWING THE JUNCTION BETWEEN THE LIAS AND THE CRETACEOUS.



The reason why this zone is so rarely exposed in section is that the beds above it are sandy and pervious to rain, and those belonging to it are also to a large extent pervious. On the other hand, the Lias clay upon which it rests is extremely impervious. Consequently the line of junction between this zone and the underlying Lias is marked by a succession of springs, forming boggy ground covered with overgrowth. Sections are therefore of rare occurrence.

This tract of boggy ground lies on Black Ven at a height of over 300 feet above sea-level, and from 50 to 100 feet below the new Lyme road. This it crosses on its descent, eastwards of Charmouth cutting, and is not very noticeable as it turns northwards over the old Lyme road. Thence it sweeps round the hillside above and parallel with the Axminster road, and becomes very obvious in the fields below "Fernhill," where the springs which supply the village lie. Further, this boggy tract can be traced across the Axminster road, in the neighbourhood of Hogchester farm, and so up the valley; but no inland sections have been found.

On the eastern side of the Char valley, on Stonebarrow cliff and round Stonebarrow hill, this tract of land is not so obvious, doubtless because the line between the pervious and the impervious is not so clearly defined. For the Cretaceous beds on Stonebarrow cliff rest on the lowermost beds of the zone of *Amaltheus margaritatus*, Mont., known as the "Three Tiers,"[1] which are loamy; whereas on Black Ven they overlie the lower beds of the zone of *Liparoceras capricornus* (Schlotheim),[2] which consist of impervious clays.

The more eastern section on Black Ven shows the junction between the Cretaceous and the Lias. It lies on the cliff face, at a height of about 315 feet, directly beneath the Charmouth end of the Charmouth cutting, where the descent to the village begins. It is covered with fallen Greensand, and was found as follows:—

The edge of a steep precipice just below the section is formed by the outcrop of a limestone a foot thick, the 'Belemnite Stone.' Above this the cliff face slopes backwards at a moderate angle, and on this slope Lias fossils and worm-tubes from the Cretaceous beds are found mixed. This slope was followed upwards until the highest Lias fossil was found. A foot or so above this a hole was dug, and after clearing away perhaps a foot of loose fallen sand, the junction was hit. The section was measured in December, 1902, and the hole dug was still visible in December, 1903, and easy to find.

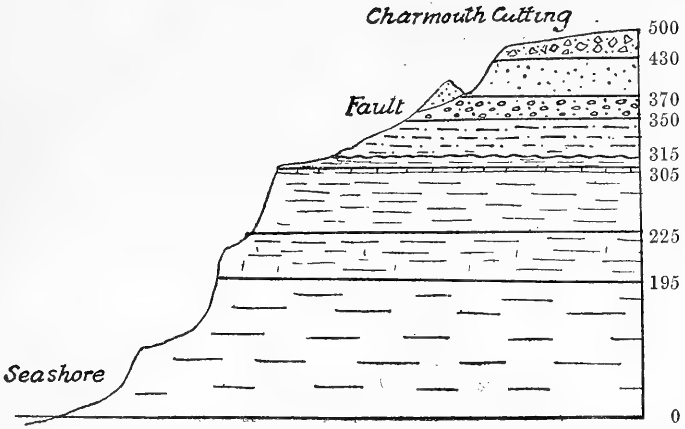
The details of the section are given in Fig. 1 (p. 125).

Bed 1. The pebbles at the base of the black loam do not form a continuous bed, but occur in pockets, which may be six inches thick at the widest part. Between these pockets are spaces where no pebbles occur, but the dark green-black loam is directly superimposed upon the blue clay of the Lias, forming a contrast, and contains itself so much clay that it is coherent enough to allow quite small specimens to be dug out, showing the junction as a sharp wavy line (see Fig. 3, p. 128).

[1] H. B. Woodward: "The Lias of England and Wales," 1893, pp. 195, 196.
[2] H. B. Woodward: loc. cit., p. 68.

FIG. 2.—GENERAL SECTION OF BLACK VEN.

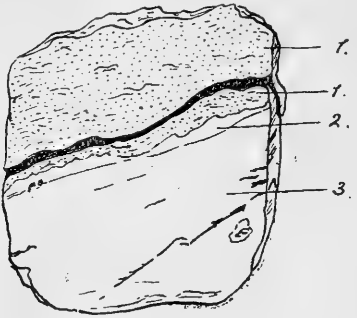
South. North.



Height in feet above sea-level.	Beds	Zones	
500	Weathered remains of Chert Beds.	Remains of zone of *Pecten asper*.	SELBORNIAN.
430	Foxmould.	Zone of *Schlœnbachia rostrata*, upper division.	
370	Cowstones.	Zone of *Schlœnbachia rostrata*, lower division.	
350	Black Loams.	Zone of *Hoplites interruptus*.	
315	Green Ammonite Beds.	Zone of *Liparoceras capricornus*.	LIAS.
305	Belemnite Marls.	Zones of { *Amaltheus ibex*. *Uptonia jamesoni*. *Deroceras armatum*.	
225	Blue Marls and Limestones.	Zones of { *Echioceras raricostatum*. *Oxynotoceras oxynotus*.	
195	Blue Marls and Limestones.	Zone of *Asteroceras obtusum*.	
0			

In these specimens there is a very thin layer of clay varying from about $\frac{1}{8}$ inch to an almost imperceptible thickness, of paler colour than the clay below. The upper boundary of this layer is the jagged, wavy, but sharply defined line already mentioned, and the lower boundary a much less clearly defined though comparatively straight line. This pale layer is described from dried specimens, and it was not seen whether it was noticeable when they were freshly cut.

Fig. 3.—Specimen showing the Junction between the Selbornian and Lias on Black Ven, natural size.



1. Selbornian Loam.
2. Pale band at the top of Lias Clay.
3. Lias Clay.

The pebble bed is not easy to see, as the pebbles are very inconspicuous, but its presence is easily detected by the grating of the pebbles against the trowel when the bed is dug into.

The pebbles vary in size from that of a pigeon's egg to that of coarse sand. They are mostly subangular, but some are well rounded, and are nearly all of silica in various forms. Vein quartz is the chief of these, forming the largest pebbles. Others are of brown chert with a very smooth pale-green altered surface. A few were of white limestone and of black grit. A few fragments of Belemnite were also found. The constituents of a washed sample are given in the Survey Memoir.[1]

The matrix in which the pebbles lie is a loam of dark greenish colour, the darkness being due to the presence of blue clay, and the green to that of a small quantity of glauconite. The loam also contains a little mica. The bed becomes sandier towards the top, gradually passing into the next bed.

No fossils were found in this bed, nor in bed 2.

Bed 2. This is like bed 1, but sandier, and consequently lighter in colour. Yellow patches of comparatively pure sand occur in it.

A few feet up this bed is overlain by a mass of yellow sand fallen from the higher beds, upon which rests the soil of the cliff slope above. This slope is very slight, and is marked by a tract of overgrown land from 50 to 100 yards wide, backed by a cliff of yellow

[1] Jukes-Browne: loc. cit., p. 189.

sand of the beds known as 'Foxmould' in the zone of *Schlœnbachia rostrata*. This cliff immediately underlies the road, and is the seaward face of a large mass of land which has slipped bodily down the cliff, forming the fault shown in the diagrammatic section of Black Ven (see Fig. 2, p. 127).

About 250 yards west of that just described is a section showing the upper part of the zone of *Hoplites interruptus* and the lower part of the zone of *Schlœnbachia rostrata*. The cliff arises from the platform of boggy ground mentioned early in this paper, and is about 70 feet high, the top being formed of 'Foxmould' just above the highest layer of 'Cowstones.' The details of the beds in the first-mentioned zone are shown in the following figure (Fig. 4, p. 130).

Bed 2. This bed agrees lithologically with that numbered 2 in the eastern section; and being, as far as can be determined, at the same height, is obviously identical with it. Thus the two sections are continuous, and the whole thickness of the zone is exposed. The total thickness of this bed is probably about ten feet, and so the sections overlap for three feet, two feet being hidden below the western section, and three having been removed above the eastern.

Bed 3. This is the most interesting bed in the zone, for it abounds in fossils in its lowest part. The nearest locality whence abundance of Gault fossils has been obtained is distant about thirty miles at Okeford Fitzpaine, where the lower beds have been recognised[1] as belonging to the zone of *Acanthoceras mammillatum* (Schlotheim), which is there five feet in thickness. So it is possible that beds 1 and 2 may represent this zone on Black Ven, but the absence of fossils makes this point impossible to decide.

Of the fossils from bed 3 a list is given in the Survey Memoir.[2] But in addition the British Museum has the following species located from here:—

Astarte sp.
Crassatellites gracilis, Sowerby.
Gervillia Forbesiana, Sowerby.
Lucina sp.
Meretrix sp.
Modiola albensis (d'Orbigny).
Modiola aff. *subsimplex*, d'Orbigny.
Nucula albensis, d'Orbigny.
Pecten (*Syncyclonema*) *striatopunctatus* (Mantell).
Pholadomya sp.
Tellina sp.
Thetis minor, Sowerby.
Thracia sanctæ-crucis, Pictet & Campiche.

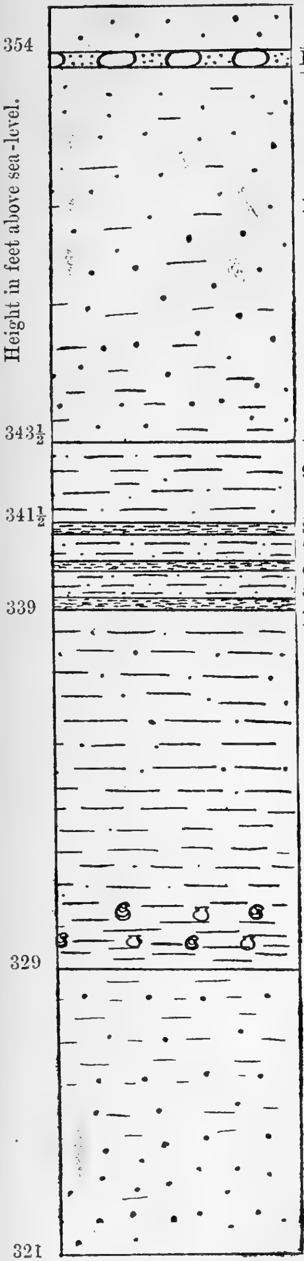
The following, too, have been found by the author, which are neither in the list in the Survey Memoir nor in the British Museum:—

Cuspidaria sanctæ-crucis, Pictet & Campiche.
Ostrea sp.
Avellana inflata, d'Orbigny.
Lingula subovalis, Davidson.
Shell of a Cirripede, ? *Scalpellum*, sp.

By far the commonest fossils are *Pecten orbicularis*, Sowerby, *Lima parallela*, d'Orbigny, and *Inoceramus concentricus*, Parkinson; but *Grammatodon carinatus* (Sowerby), *Pinna* sp., and a small Gasteropod, ? *Fusus*, were plentiful.

[1] R. B. Newton, "Cretaceous Zones in Dorset": Geol. Mag., 1896, p. 198, and Proc. Dorset Nat. Hist. and Ant. Field Club, vol. xviii (1897), p. 66.
[2] Jukes-Browne: loc. cit., p. 188.

FIG. 4.—SECTION IN THE SELBORNIAN OF BLACK VEN.



		Zone of Schloenbachia rostrata.
Lowest layer of Cowstones.		
10. Grey, loamy, micaceous sand, with very little glauconite, and with small patches of bright red iron oxide; becoming more argillaceous lower down, and containing a few worm-tubes.	10 ft.	*Zone of Hoplites interruptus.*
9. Blue, loamy, glauconitic clay, with a little mica. No fossils.	2 ft.	
8. Very hard, shaly loam. A few fossils.	4 in.	
7. Blue, loamy, glauconitic clay, with a little mica.	9 in.	
6. Very hard, shaly loam. [No fossils.	4 in.	
5. Blue, loamy, glauconitic clay, with a little mica.	9 in.	
4. Very hard, shaly loam. A few fossils. [No fossils.	4 in.	
3. Bluish-black loamy clay, containing a little mica, with fossils, becoming more argillaceous and much more fossiliferous lower down.	10 ft.	
2. Dark-green glauconitic loam, becoming sandier lower down. No fossils.	8 ft. shown.	
	32 ft. 6 in.	

Bed 3 is again exposed in two little sections a few feet high, about twenty yards further west. These yielded specimens of *Turritella.*

Beds 4, 6, *and* 8. These three beds are like each other, and in composition resemble closely the last bed and beds 5, 7, and 9, but differ from them in their structure, which is hard and difficult to break with the hammer, owing to the rock immediately beneath the hammer-head becoming pulverised and acting as a cushion to the rest of the mass. Moreover, it does not break along bedding-planes (though the existence of these can be seen on a weathered surface), but into irregular lumps. These beds are conspicuous on the face of the section, for being harder they weather back less quickly than those above and below them. They contain traces of fossils, and a cast of *Thetis minor*, Sowerby, was found in a fallen block from one of them, lying in the bog beneath the section.

Beds 5, 7, *and* 9. These beds are like the last in composition, only not indurated, but rather sticky and coherent. No fossils were found in them.

Bed 10. This bed ushers in sandy conditions again, being really a passage bed between this zone and the zone of *Schlœnbachia rostrata* above, which consists of slightly loamy sands throughout, its base being marked by the lowest layer of Cowstones. As this layer is approached, bed 10 becomes more sandy, being more argillaceous in its lower part and containing a few fossil worm-tubes. In places it is characterised by small bright patches of blood-red iron oxide.

To sum up:—On the face of Black Ven the total thickness of the zone of *Hoplites interruptus* is about 38 feet, and lies between 315 feet and 353 feet above sea-level. The whole is seen in two sections. The beds are loams with varying proportions of sand and clay. They are sandiest at the top, becoming more argillaceous on descending, the predominance of the clay reaching a maximum in bed 3, at about 15 feet from the base of the zone. The bottom few inches of the zone also contain much clay, and are characterised by an impersistent pebble bed. Fossils occur sparingly throughout the zone above bed 3, but become abundant at the base of this bed, simultaneously with the maximum amount of clay. The bottom two beds may represent the zone of *Acanthoceras mammillatum*, but there is not a particle of fossil evidence to justify the assertion.

NOTICES OF MEMOIRS, ETC.

I.—Singleness of the Ice Age.

(Die Einheitlichkeit der Quartären Eiszeit. Von E. Geinitz in Rostock. Aus dem Neuen Jahrbuch für Mineralogie und Palaeontologie. Beilage-Band xvi, S. 1–98. Stuttgart, 1902.)

He who attempts to collect, harmonize, and arrange into a scheme of classification the accounts of the North European Drift in separate areas is confronted with divergence of view in every direction. The number of Glacial and Interglacial periods, their importance, their equivalence, all present difficulties. He finds adjacent and probably equivalent fossiliferous beds ranked differently by different authors; a series will by one be designated Interglacial which another calls no more than a local deposit of sand or clay. The latest researches in Quaternary geology have led to the following conclusions:—For Sweden it has been shown that the Ice Age there was single, unbroken by Interglacial periods. Examination of the moraines south of the Baltic shows that these are no boundaries of ice-extension, but only mark stages of retreat. The so-called 'First Ice Age' covered a narrower area than the 'Second or Principal Glaciation'; the 'Third,' again, less than the Second. Views on the importance of the 'Upper' and 'Lower' Boulder-clays are more and more extending the domain of the Upper. The list of the fossiliferous 'Interglacial beds' is continually increasing.

It must be remembered that while in the northern districts removals of material will have predominated, accumulations will have been the rule in the centre, fluvio-glacial formations in the southern border-region. Glaciers, and in like manner ice-floes and ice-packs, will have produced plentiful disturbances of beds.

Considering everything, the author is driven to the conclusion that "for the southern area of glaciation as for the northern, the whole Drift is to be treated as a single sequence, only broken by oscillations"; that "only one Ice Age has existed, instead of the supposed three (or four) sandwiched in with Interglacial periods of long duration. Consequently the facies accepted as intermorainic must be ascribed only to somewhat larger oscillations of the ice-front, not to periods wholly free from ice."

He quotes Holst's views on an elevation of Scandinavia, which would increase its glaciers; while the increase of ice would produce depressions; and discusses the probable sequence and consequences.

Depressions would extend areas of submergence; connection with cold-water seas would bring deposits of Arctic forms; with warmer waters, temperate. On land, animals and plants would follow advances and retreats of the ice-front.

Discussing the records, he decides that "the fauna and flora of the Quaternary period indicate a climate like the present, only slightly warmer." But the mighty mass of ice affected climate, lowering it over North Europe. The northern ice advanced, with many oscillations, pushing forward especially into bays and valleys, leaving intervening areas free of ice. Consequent alterations of level would produce or remove submergences. Finally, the period of retreat seems a time of somewhat greater warmth than the present, and lasted considerably longer than the period of advance.

One may say that the Ice Age to a certain extent worked its own downfall—rise of Scandinavia and vast development of glaciers; consequent depression; access of warm currents and rise of temperature; commencement of melting.

The same considerations are applicable to Great Britain, where the marine deposits, in close relation to the Boulder-clay, play a yet more important part.

The author proceeds to give reasons for these views. Under a heading "First and Third Ice Age," he discusses the formations which have been attributed to these. There is no characteristic, he says, which can be relied upon for assigning a particular Boulder-clay to the Upper or the Lower Drift.

He enumerates and discusses in detail "the Fossiliferous Drift Deposits of North Germany and Denmark," classifying them as—(1) Lacustrine deposits: (*a*) Pre-Glacial, (*a*) River, (*β*) Subsidence deposits (these, he remarks, collectively lie along a line which he describes); (*b*) Interglacial fresh-water formations, (*a*) Peat-beds, (*β*) Diatom-beds, (*γ*) Beds with fresh-water shells. (2) Marine Diluvium or Pleistocene Drift: (*a*) Cimbrian Peninsula (the occurrences collectively indicate an extension of the Elbe Estuary 100 km. inland from Hamburg, also access of the North Sea to the Baltic, affecting Möen and Rügen); (*β*) Prussian Province (the occurrences collectively indicate an arm of the sea extending into the heart of East Prussia).

A folding page at the end gives the Author's Scheme of Interpretation:—(1) Rise of the Scandinavian Archæan massif, increase of ice, and production of the Norwegian and Baltic Ice-stream. (2) Floes and bergs in Atlantic and Baltic, with deposit of various materials. (3) Advance of ice into Germany. (4) Ice reaching maximum extension in Holland, Saxony, Silesia, Central Russia. Then a short period of rest. (5) Long period of melting, leaving remains of terminal moraines. (6) Further retreat of the ice, leaving well-known terminal moraines of the Baltic ridges. (7) Retreat to the Scandinavian *terra firma*. (8) Circumstances of to-day. A map marks the positions and natures of fossiliferous localities, lines of terminal moraines, areas indicating marine submergence, and southern limits of glaciation. E. H.

II.—International Geological Congress.

1.—Report of the Commission on International Co-operation in Geological Investigation laid before the International Geological Congress at Vienna in 1903. By Sir Archibald Geikie, President of the Commission.

HAVING been appointed at the last Congress to preside over the Commission formed at Paris in 1900 for international co-operation in geological research, I wrote individually to each of the members of this Commission asking them to be good enough to give me their views and suggestions on the subjects submitted to our consideration. To these letters I have only received two replies. I cannot therefore to-day—and it is to be regretted—submit to the Congress the conclusions of the full Commission. Nevertheless, the importance of the subjects proposed is such that it justifies me in recapitulating them to you. The questions submitted to the Commission were the following:—(1) What are the branches of geological research in which international action appears the most desirable; and (2) what are the best means of ensuring uniformity of method in the investigations?

1. With regard to the first of these questions it is obvious that international co-operation may be profitably adopted for the consideration of problems connected with dynamical geology—such as earthquakes, the movements of the terrestrial crust, the course, fluctuations and geological functions of glaciers, the rate of progress of denudation under the action of epigene agents in different climates.

2. The reply to the second question ought to be treated from two points of view. In the first place, there are international scientific investigations which by reason of their special character ought to be undertaken by geologists properly so called. For this kind of research the Congress has only to follow the lines already laid down by it, and the end will be attained by the organization of special commissions similar to those now in operation for the geological map of Europe, glaciers, petrography, which have already obtained such important results. New special commissions may have to be appointed, but this is not the place to propose them.

But there is a second series of international researches of capital importance to geology, the prosecution of which appears to me to require an organisation and resources superior to those of our Congress. For some years several scientific Associations have existed which, like our own, have proposed international combination for the furtherance of different branches of science. I think our Congress might profit by this tendency, and endeavour to effect a collaboration for the study of the problems which interest us and whose solution involves varied technical knowledge and considerable expense. Thus it is a problem of the greatest interest to geologists, whether a chain of mountains subject to earthquakes undergoes at the same time slow movements of elevation or depression. The solution of this question necessitates particular measurements, both numerous and prolonged. But why should geologists undertake it alone? It is as interesting for geodesists as for geologists; the accuracy of their methods would be most valuable to us. Now there already exists an "International Geodetic Association," established for the study of the shape of the earth. Why should we not seek the co-operation of our colleagues for investigations like these, where geodesy plays an all-important part, but which have also great geological value? On the other hand, since the Geological Congress met at Paris the "International Association of Academies," composed of delegates from all the Academies of the world, has been founded. It has the double object of co-ordinating scientific investigations and of obtaining from the Governments of the different countries definite and effectual support. This powerful Association appears to be so well adapted to deal with international scientific questions that we may well ask ourselves if it would not more easily and fully than our Commission determine the questions that I have submitted to the Congress.

If such should be your opinion, and the Congress should judge it fitting to apply to the "International Association of Academies," I would suggest that a Committee be appointed to define the geological researches to be undertaken and to indicate the methods suitable for arriving at the desired end.

This programme, sanctioned by the authority and prestige of an International Geological Congress, would be submitted to the International Association of Academies at its next meeting, which will be held in London at Whitsuntide, 1904.

2.—Report of the Commission on the Raised Beaches of the Northern Hemisphere. Presented to the International Geological Congress at Vienna in 1903, by Sir Archibald Geikie, President of the Commission.

The Commission submits the following propositions for the consideration of the Congress:—

1. Hitherto the height of old coastlines (raised beaches) has been measured from high-water level, mean sea-level, from the zone of *Fucus*, etc. But no one of these boundaries is precisely defined, and they vary perceptibly in the same district. To determine them exactly it is necessary to have a point or level for each country cut, or marked in some durable manner, on the solid rock near the high tide. From this fixed point all the altitudes along the coastline should be measured or calculated.

2. Note should be taken of all the possible variations of the mean level of the sea, and to this end the archives of the ports should be consulted.

3. The height of a raised beach or strand-line should always be calculated from its interior or superior margin, where this is visible, but the height of the exterior or inferior edge should also be given when it can be observed, as an indication of the extent of tide at the time of that coastline.

4. It is important to follow the horizontal extent of a coastline from one end of a country to the other.

5. The variations in altitude of a coastline should be measured in two directions where that is possible: (1) along the coast, i.e. parallel to the axis of a country; (2) transversely to this axis, in the bays or fjords.

6. It should be ascertained if a coastline or a series of these lines disappears in a given direction, and the conditions under which this disappearance takes place should be exactly stated. In Scotland, for example, the raised beaches, so clearly defined along the west and east coasts, disappear towards the northern extremity of the kingdom in the county of Caithness, and in the islands of Orkney and Shetland.

7. The diversities of character in a line of raised beach deserve to be registered. Parts have perhaps been cut in the solid rock (*seter* of Norway), others have been formed of deposits of detritus. The relations of these diversities to the contours and to other varieties of topographical configuration should be examined.

8. In a successive series of raised beaches it is important to determine with precision their relative variations in level, in such a manner as to demonstrate whether or not the movements to

which they owe their origin have been unequal, and to show the direction of these inequalities. Differences in the depth of the erosion of the solid rocks and in the breadth and the thickness of the detritic deposits should also be noted.

9. It is obvious that great importance attaches to the organic remains of the raised beaches. Not only should the detritic deposits be carefully looked over, but research should also be made in the rocky platforms, the cliffs, and caves, where one might find boring shells, cirripedes, or adherent corals.

REVIEWS.

I.—The Marine Tertiary Fauna of America and Europe. By Clement Reid, F.R.S.

THE completion of Professor W. H. Dall's monograph on the Tertiary Fauna of Florida, begun in 1885, places in our hands exceedingly valuable material for the study of certain problems that have much exercised European geologists.[1] It is at last possible to make some sort of comparison between the molluscan faunas inhabiting the two sides of an ocean in Tertiary times; fresh light is thrown on the vexed question of the connection or isolation of the Atlantic and Pacific Oceans at various periods; and incidentally we may perhaps learn something as to the former course of the Gulf Stream.

We are not prepared to criticise, and it is impossible to analyse in detail, the descriptions of the mollusca in so large a monograph. Attention should be drawn, however, to the beautiful way in which the book is printed and illustrated; and we must congratulate the Wagner Free Institute on the high standard which has been kept up. The only complaint that might be made from an artistic standpoint is that the numerous plates look perhaps a trifle hard. But anyone who has worked much at the critical determination of closely allied species will recognise that this, if a fault at all, is a fault on the right side; these illustrations, for scientific purposes, are far better than the soft and somewhat woolly lithographs to which we often have to refer.

The deposits which yield the mollusca range in time from Eocene to Pliocene, and include various strata on the western side of the Atlantic besides those of Florida. Almost all the species differ from those of Europe; and thus they do not support the idea, suggested by a study of the echinoderms, that during Oligocene times the Mediterranean region may have been connected with the Antilles by a continuous coast or belt of islands.

The discordance between the mollusca and the echinoderms, just referred to, raises a question of some interest. Is it not a discordance

[1] "Contributions to the Tertiary Fauna of Florida," by Professor W. H. Dall, Wagner Free Institute of Science, Philadelphia, pp. 1620 and pls. lx (1890–1903).

between free-swimming and sedentary forms, or rather between sedentary forms and forms that go through a floating or free-swimming stage lasting some time? On looking through Professor Dall's monograph we are disappointed to find, though it is no fault of his, that practically the whole of the molluscan faunas described consist of sedentary forms. If we could compare the pteropods, *Ianthina*, ship-worms, barnacles, sharks, and such like on the two sides of the Atlantic, we should probably discover the true 'Atlantic' fauna for each period, which would leave no doubt as to the exact correlation. At present, for instance, we only know the American and European Eocene faunas of the shallow seas, we are only slightly acquainted with the true Atlantic Eocene fauna. In time these gaps will be filled up, and we shall be able to correlate with greater certainty.

The careful and sober account of the physical changes in the Antillean region, given in the "Discussion of the Geology" (pp. 1541–1620), needs close study and cannot easily be condensed; it is in striking contrast with much of the wild speculation that has been rife. The physical and climatic changes are traced step by step, evidence being given for each statement. In Eocene times the two oceans were separate. The Oligocene deposits of Florida are of enormous thickness, and there is evidence of a connection between the Atlantic and the Pacific. In Miocene times the two Americas became again connected, and the fauna of the Gulf coast changes completely. "The change was not only in the species and prevalent genera of the fauna, but a change from a subtropical to a cool temperate association of animals. Previously, since the beginning of the Eocene, on the Gulf coast the assemblage of genera in the successive faunas uniformly indicates a warm or subtropical temperature of water. . . . . With the incursion of the colder water the change becomes complete. Not only do northern animals compose the fauna, but the southern ones are driven out, some of them surviving in the Antilles to return later. Some change along the northern coast permitted an inshore cold current to penetrate the Gulf. . . . ." A cool Miocene sea in the Gulf of Mexico is a phenomenon which will have to be taken into account by the student of geographical distribution. In conjunction with a temperate Miocene climate in the Arctic regions it may help to explain the occurrence of closely allied land-animals and plants on the two sides of the Atlantic, and in the northern and southern hemispheres.

As to subsequent changes, Professor Dall writes: "I concur with Hill in the belief that, whatever changes of level may have taken place since, no discontinuity of the link between North and South America from the Miocene to the present time is probable, and certainly none amounting to a free communication between the two oceans."

Towards the close of the Miocene period Florida became united to the continent, and the influx of cold water into the Gulf of Mexico ceased. Gradually the temperature rose, and the exiled subtropical species began to return; a still warmer sea-temperature inaugurating the Pliocene. "The end of the Pliocene is the beginning of the Glacial epoch. The Pleistocene of Florida shows a change for a cooler and an elimination of the most purely tropical forms from the fauna, but nothing like the clean sweep at the beginning of the Miocene. The latter is the sharpest and most emphatic faunal change since the Cretaceous on our coasts." The curious discordance between Tertiary climatic changes, as evidenced in America and as recognised in Europe, is a striking commentary on any attempts to trace secular climatic variations in successive faunas in a limited district. The influence of changes in physical geography must be enormous; but probably in the case of Florida quite exceptional, as is recognised by Professor Dall. One wonders, however, whether any echo of these geographic changes reached our shore, diverting ocean currents and perhaps reversing the climatic changes on this side of the Atlantic.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—January 6th, 1904.—Sir Archibald Geikie, D.C.L., D.Sc., Sec. R.S., Vice-President, in the Chair. The following communications were read:—

(1) "On a Palæolithic Floor at Prah Sands, in Cornwall." By Clement Reid, Esq., F.R.S., F.L.S., F.G.S., and Eleanor M. Reid, B.Sc.

Prah Sands lie about 7 miles east of Penzance, and have long been known as exhibiting a ~~good~~ section of 'head' or rubble-drift, over raised beach, which rests on a wave-worn rocky platform. Recent storms have cleared away the talus at the foot of the cliff, and have exposed, between the 'head' and the raised beach, a Palæolithic land-surface, consisting of loamy soil penetrated by small roots. In and above this occur black seams full of small fragments of charcoal and bone; these are particularly abundant round groups of large flat stones, which seem to have formed ancient hearths. The black seams contain implements made of vein-quartz. For a few feet above this land-surface the angular 'head' consists mainly of loam with fragments of vein-quartz, some of which are worked. This seems to be the first record of Palæolithic man in Cornwall.

(2) "Implementiferous Sections at Wolvercote (Oxfordshire)." By Alexander Montgomerie Bell, Esq., M.A., F.G.S.

This section shows the following beds:—(1) Oxford Clay; (2) old surface, in which are pits or troughs chiefly filled with gravel and enveloped in weathered clay; (3) a large river-bed, containing gravel at the base, and layers of clay above; (4) Neolithic surface-layer, 2 feet thick. The gravel of the river-bed contains quartzite pebbles, some of exceptional size, and is covered by a thin lenticular layer of peat and sand, yielding thirty flowering plants and many mosses; the clays over this have probably been formed in a lake, possibly due to a beaver-dam. In the gravel-bed are found implements formed of flint quarried from the Chalk, or of quartzite from pebbles of the Northern Drift, all remarkable for their size, beauty, and freshness, together with the remains of large mammals, including the mammoth. The old surface, from which the river-bed has been eroded, has also yielded implements associated with quartzites, quartz-pebbles, and lydianstone, gravel from the Thames Valley, limestone pebbles, Oolitic fossils, and sand. This deposit is regarded as remanié from the Northern Drift, probably laid down under the action of ice, as shown by the flask-like shape of the pits, the vertical position of some of the pebbles, and the jamming-in of masses of sand, probably in a frozen condition. Further, the Oxford Clay beneath the surface is weathered and shaken to a depth of 10 or 12 feet, except where cut off by the descending depth of the river-bed. The implements are small, ordinary in shape, and made of flint, not quarried, but mostly taken from the Drift, and they are much weathered, stained, and patinated. The occurrence of an older set of implements, differing so markedly from those of the river-drift, leads the author to explain the peculiar implementiferous drift of Iffley as containing implements of two kinds and two dates. Those that are unweathered are contemporaneous with the deposit, and like those of the Wolvercote river-bed; while those that are stained with ochre, or deeply patinated, have been derived, like the Oolitic fossils, Tertiary conglomerate, quartzites, and volcanic rocks, from an older deposit. The author believes that the frequent occurrence of weathered and unweathered implements in a single deposit may be explained generally in this way; and he further infers that the time between the Drift and the river-bed was prolonged, and that the interval may have been as long as that which separates the epoch of the river-bed from the present day, his evidence being simply the patination of the flints. In conclusion the author suggests that there are three classes of implement-bearing drifts, the ice-drifts being the earliest and the river-drifts the latest, while the wash-drifts may belong to more than one stage.

2.—January 20th, 1904.—Sir Archibald Geikie, D.C.L., D.Sc., Sec. R.S., Vice-President, in the Chair.

The Secretary announced that the Council had communicated the following resolution of sympathy to Mrs. Etheridge:—

"That the Council desire to place on record their great regret at the death of Mr. Robert Etheridge, F.R.S., formerly President of this Society, who did so much during his long life to advance Geological Science and to promote the interests of the Society."

The following communications were read:—

(1) "On the Jaws of *Ptychodus* from the Chalk." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., F.G.S.

Hitherto no traces of the cartilaginous jaws of this fish have been found in association with the dentition; but Mr. Henry Willett has recently found a specimen of *Ptychodus decurrens* in the zone of *Holaster subglobosus* of the Lower Chalk at Glynde (Sussex). Fragmentary remains of both jaws are seen in the specimen, each bearing many of the characteristic teeth arranged in natural order. There are four series, and one small displaced tooth (probably belonging to the fifth series), on the left of the large median series in the lower jaw; while in the upper jaw the teeth are clearly arranged in six paired series. The specimen proves that the peculiarly effective disposition characteristic of the living Myliobatidæ had not been assumed, but that *Ptychodus* more nearly resembled the Trygonidæ in its jaws. The probable explanation of the new discovery is, that in the Cretaceous Period the great rays of the 'families' Myliobatidæ and Trygonidæ had not become fully differentiated. Professor Jækel has already arrived at a similar conclusion from general considerations, and has proposed to place all these fishes in one comprehensive family, termed Centrobatidæ. If this arrangement be adopted, *Ptychodus* represents a primitive sub-family, which still awaits definition from lack of complete specimens; while the Trygoninæ, Myliobatinæ, and Ceratopterinæ are equivalent sub-families which survive at the present day.

(2) "On the Igneous Rocks at Spring Cove, near Weston-super-Mare." By William S. Boulton, Esq., B.Sc., A.R.C.S., F.G.S.

A traverse from end to end of the exposure at the locality shows that the 'basalt-mass' varies in structure and appearance, and that it is by no means a simple lava-flow. It may be roughly divided into three portions. Beginning at the cliff end to the north, the rock for the first 30 yards is a pillowy basalt, with tuff and limestone often occupying irregular spaces between the spheroids of amygdaloidal basalt; then, for about 20 yards, the rock is mainly a coarse 'agglomerate,' with lapilli and bombs of basalt and limestone; while the remaining 100 yards or so is an ordinary basalt-coulée, with very few and always small lumps of burnt limestone. The limestone below is reddened and altered, and although tuffy-looking, does not contain indubitable lapilli; the limestone above contains lapilli. The pillowy basalt probably represents a river of agglomeratic material carrying finer lapilli, larger and plastic masses of scoriaceous basalt, and lumps of limestone, possibly ejected from a vent. The intervening tuff may present an analogy with the 'volcanic sand' of the West Indian eruptions. There is no evidence of the quiet deposition of ashy material, but rather of the tumultuous aggregation of a fluxion-tuff taking place under some depth of sea-water. The large and irregular fragments of limestone, oolitic and fossiliferous, found mainly in the lower part of the basalt-mass, have not come in from above through cracks in the lava, but seem to have been picked up while in a soft and powdery state from the sea-bed in which it had been accumulating, and to have been involved with and altered by the volcanic material. The conditions existing in submarine flows appear to be very like those in a sill or intrusive sheet.

3.—February 3rd, 1904.—Sir Archibald Geikie, D.C.L., D.Sc., Sec. R.S., Vice-President, in the Chair. The following communications were read:—

(1) "On a Deep-Sea Deposit from an Artesian Boring at Kilacheri, near Madras." By Professor H. Narayana Rau, M.A., F.G.S.

The village of Kilacheri is about six miles due south of the railway station of Kadambattur. Here permeable beds of sandstone and felspathic grits dip at low angles seaward, and are overlain by impervious clays and shales. The boring, after penetrating the upper clays and sandstones, passed through carbonaceous shales, and at a depth of about 400 feet reached a blue homogeneous rock, effervescing with acid and showing radiolarian tests under the microscope. Most of the latter display the inner reticulate structure in thin sections, and some of them, when isolated, show radiating spines as well; they are, however, not capable of specific determination. One or two specimens of foraminifera have also been seen. The deposit underlies beds of the Upper Gondwána Stage. The bed also contains palagonite, volcanic glass, pumice, mineral fragments (such as plagioclase, quartz, augite, and possibly hornblende), and black metallic spherules of iron and manganese. The last sometimes partly fill the radiolarian tests, and sometimes encrust the pumice and palagonite; they give the manganese reaction with a borax-bead. The author concludes that the deposit is of truly abysmal origin, similar to those described in the "Challenger" Reports; and he points out the remarkable interest of such an occurrence in Peninsular India, a region which appears to have been a land-area since Palæozoic times.

(2) "The Rhætic Beds of the South Wales Direct Line." By Professor Sidney Hugh Reynolds, M.A., F.G.S., and Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

After a reference to the literature of the subject the following exposures are described: the Stoke Gifford and the Lilliput or Chipping Sodbury sections. From the first section the Bone-bed is completely absent. The beds here rest upon tea-green marl, and are covered by the Cotham Marble. A section to the east of Lilliput Bridge shows two large rounded hummocks of Palæozoic rock projecting into the Rhætic, and in both cases the Black Shale is deposited on it in an arched manner, forming an anticline of deposition. There is also a very rich Bone-bed at the base, which is not uniformly distributed. The upper beds correspond with those of Stoke Gifford. In correlating these rocks with those of neighbouring areas, a table of general sequence is given, in which the Lower Rhætic is divided into three and the Upper into two stages, which are correlated with the notation of Richardson and Wilson. This is followed by a range-table of the typical Rhætic mollusca: *Cardium rhæticum* and *C. cloacinum*, *Schizodus Ewaldi*, *Pecten valoniensis*, and *Avicula contorta*. Palæontological notes on the invertebrata and vertebrata follow. New species of *Anomia*, *Plicatula*, *Modiola*, and *Cardinia* are described; notice is given of other Rhætic mollusca; and a range-table is appended of the commonest mollusca that occur at Sodbury and Stoke Gifford. The reptiles, amphibia, and fishes referred to are all known species. A general account is given of the distribution of the Bone-bed in the Bristol district. In Somerset, except at Emborough and Watchet, no true Bone-bed has been recorded; in the district immediately north of Bristol there is a single, well-marked Bone-bed at the base of the Black Shale series, or very slightly above it; while in the Gloucester district the principal Bone-bed tends to lie at a greater distance from the base of the Black Shales. For these reasons, the authors think that the principal Bone-beds in the various sections cannot be regarded as homotaxial equivalents.

II.—Mineralogical Society, Feb. 2nd, 1904.—Dr. Hugo Müller, F.R.S., President, in the chair. Mr. Harold Hilton contributed a paper on the Gnomonic net. This net consists of lines giving equal longitudes and latitudes for every ten degrees on a plane touching a point on the equator, the former being hyperbolæ and the latter straight lines. The author pointed out how the net could be used for the graphical determination of angles between poles on the sphere.—Mr. G. T. Prior described a new sulphostannite of lead from Bolivia, to which he gave the name Teallite, in honour of the Director of the Geological Survey. The mineral in its graphite-like appearance resembles franckeite and cylindrite, but differs from them in not containing antimony. It has the simple formula $Pb\ Su\ S_2$, and is orthorhombic with angles $c\ (001) \wedge o\ (111) = 62°$, $c\ (001) \wedge p\ (221) = 75°$, and $m\ (110) \wedge m'''\ (1\bar{1}0) = 86°$. It has a perfect cleavage parallel to c (001), and a specific gravity of 6·36. In connection with the investigation of this mineral, new analyses were made of franckeite and cylindrite.—Mr. W. F. Ferrier gave an account of his discovery of deposits of corundum in Canada; and Professor H. A. Miers described a visit to the Rashleigh Collection of Minerals now deposited in the Museum of the Royal Institution of Cornwall at Truro.

CORRESPONDENCE.

MR. A. G. M. THOMSON'S BOOK ON THE OLD RED SANDSTONE.

Sir,—Without dissenting from the opinions expressed by your Reviewer (this vol., p. 84, Feb.), may I suggest that the expression of them is not quite fair? You give the name of John Leng & Co., Dundee, as that of the publishers, and you "can only wonder why such a work has been published." I have, however, the highest authority for stating that the work has not been published, but distributed privately, as a gift by the author, while Messrs. Leng are only the printers. It seems to me that the proper way to treat unpublished communications is to ignore them: if such a course be agreeable to the author, well and good; but if it is not agreeable to him—so much the better!

Bibliographer.

ABSENCE OF *LEPUS EUROPÆUS*, PALLAS, FROM BRITISH PLEISTOCENE DEPOSITS.

SIR,—Having had an opportunity of examining the remains of Hares from the Pleistocene of this country, preserved in the Natural History Museum, I find that all the specimens which are determinable, including the originals of Buckland's and Owen's figured specimens, belong to the Mountain Hare (*Lepus timidus*, L.), there being no evidence of the common Hare (*Lepus europæus*, Pallas). In consequence, I am inclined to assume that the latter has been introduced into this country by man, possibly as late as the Roman period. I ask you kindly to give publicity to this letter in the hope that if there is conclusive evidence of Pleistocene remains of the *Lepus europæus* in some public or private collection it may be forthcoming.

C. I. FORSYTH MAJOR.

OBITUARY.

WILLIAM VICARY, F.G.S.

BORN JULY 26, 1811. DIED OCTOBER 22, 1903.

WILLIAM VICARY was born in 1811 at Newton Abbot in Devonshire. Early in life he removed to North Tawton, where he started business as a tanner, and with so much success that he retired in 1856 and removed to Exeter, where he resided for the remainder of his long life. He was one of the founders of the Devonshire Association, established in 1862, and an original contributor to Symons' "British Rainfall," the first volume of which, for the year 1860, was published in 1861. He was elected a Fellow of the Geological Society of London in 1864. Mr. Vicary was an enthusiastic collector of fossils, and his museum was especially rich in the fossils from the Upper Greensand of the Haldon and Blackdown Hills. He is best known to geologists by his discovery of fossils in the quartzite 'popples' of the Triassic pebble-bed of Budleigh Salterton. The fossils were described and figured by Salter in a joint paper brought before the Geological Society, while Salter dealt more generally with the subject in the first Original Article published in the GEOLOGICAL MAGAZINE (July, 1864). The species, all new to British geology, were identified with forms found in the older rocks of Normandy, some belonging to the *Grès Armoricain* (Arenig group). Mr. Vicary's valuable collection, embracing a large number of type-specimens, was bequeathed by him to the Natural History Museum, Cromwell Road.

1864. "On the Pebble-bed of Budleigh Salterton"; with a Note on the Fossils by J. W. Salter: Quart. Journ. Geol. Soc., vol. xx, p. 283.

1865. "On the Feldspathic Traps of Devonshire": Trans. Devon Assoc., vol. i, p. 43.

1867. "On the Source of the Murchisonite Pebbles and Boulders in the Triassic Conglomerates of Devonshire": Trans. Devon Assoc., vol. ii, p. 200.

1872. "Fossil Coral allied to *Merulina* (Ehrenberg), from the Upper Greensand of Haldon Hill, near Exeter": Ann. & Mag. Nat. Hist., ser. IV, vol. ix, p. 84.

WALTER DRAWBRIDGE CRICK, F.G.S.

BORN DECEMBER 15, 1857. DIED DECEMBER 23, 1903.

BY the death of Mr. W. D. Crick, of Northampton, geological science has lost an earnest and amiable local worker. Born at Hanslope, in Buckinghamshire, he was educated for a business career, and became in 1880 a partner in the firm of Latimer, Crick, and Co., manufacturers, in Northampton. His interest in geology and natural science in general was aroused by Mr. Beeby Thompson, F.G.S., who was then headmaster at the old Science School at Northampton. Together they noted the strata and collected the fossils of the Lias and Oolites for many a mile around the town. One new species from the Upper Lias of Heyford was named *Mathilda Cricki* by Mr. Hudleston, and another from the Middle Lias of Daventry was named *Trochus Cricki* by Mr. E. Wilson. Mr. Crick took up the special study of Foraminifera, and was locally the best authority on this subject. We are indebted for these particulars to an Obituary by Mr. B. Thompson, Journ. Northamptonshire Nat. Hist. Soc. (1903), xii, 134 (with portrait). He was author or joint author of the following geological papers :—

1883. "Notes on the Geology of Wymington Tunnel": Journ. Northamptonshire Nat. Hist. Soc., ii, 272.

1887. "Note on some Foraminifera from the Oxford Clay at Keyston, near Thrapston": ibid., iv, 233.

1889. "The Lias Marlstone of Tilton, Leicestershire" (with E. Wilson): GEOL. MAG., Dec. III, Vol. VI, 296, 337.

1891, 1892. "On some Liassic Foraminifera from Northamptonshire" (with C. D. Sherborn): Journ. Northamptonshire Nat. Hist. Soc., vi, 208; vii, 67.

E. J. CHAPMAN, LL.D., PH.D.

WE notice the death on the 28th of January at The Pines, Hampton Wick, of Mr. E. J. Chapman, LL.D., Ph.D., who was formerly professor of mineralogy and geology at the University of Toronto. *The Canadian Journal of Industry, Science, and Art,* of which, during the fifties and sixties, he was general editor, contains a large number of his notes and papers. Among these may be mentioned "A New Species of *Agelacrinites* (*A. Billingsii*)," "Rib-formulæ in Brachiopods," and "A Popular Exposition of the Minerals and Geology of Canada," which was subsequently revised and republished as an independent work. He is also responsible for one of the many classifications of the Crinoidea.

PROGRESS OF THE MINERALOGICAL SURVEY OF CEYLON.—We learn from a correspondent in Kandy, Ceylon, under date 2nd February, 1904, that a new room has recently been set apart in the Colombo Museum as a Mineral Gallery, and has been arranged by A. K. Coomáraswámy, Director, and James Parsons, Assistant Director of the Mineralogical Survey of Ceylon. The exhibit is formed entirely of Ceylonese rocks and minerals; a large part of the specimens has been collected by the two officers of the Mineral Survey. Diagrams and geological photographs find a place upon the walls. Two wall-cases are devoted to economic specimens, amongst which a series illustrating the manufacture of iron and steel by the Sinhalese (now quite given up) is of special interest.

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HORACE B. WOODWARD, F.R.S., &c.

APRIL, 1904.

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GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. IV.—APRIL, 1904.

ORIGINAL ARTICLES.

I.—A Retrospect of Palæontology in the last Forty Years.

(*Concluded from the March Number, p.* 106.)

Reptilia et Aves.—Our two greatest Anatomists of the past century, Owen and Huxley, both contributed to this section of our palæozoological record. Owen (in 1865) described some remains of a small air-breathing vertebrate, *Anthrakerpeton crassosteum,* from the Coal-shales of Glamorganshire, corresponding with those described by Dawson from the Coal-measures of Nova Scotia; and in 1870 he noticed some remains of *Plesiosaurus Hoodii* (Owen) from New Zealand, possibly of Triassic age.

Huxley made us acquainted with an armed Dinosaur from the Chalk-marl of Folkestone, allied to *Scelidosaurus* (Liassic), *Hylæosaurus* and *Polacanthus* (Wealden), the teeth and dermal spines of which he described and figured (1867), and in the following year he figured and determined two new genera of Triassic reptilia, *Saurosternon Bainii* and *Pristerodon McKayi,* from the Dicynodont beds of South Africa.

R. Etheridge recorded (in 1866) the discovery by Dr. E. P. Wright and Mr. Brownrig of several new genera of Labyrinthodonts in the Coal-shales of Jarrow Colliery, Kilkenny, Ireland, communicated by Huxley to the Royal Irish Academy, an account of which appeared later on in the Geological Magazine in the same year by Dr. E. P. Wright (p. 165), the genera given being *Urocordylus, Ophiderpeton, Ichthyerpeton, Keraterpeton, Lepterpeton,* and *Anthracosaurus.* Besides these genera there were indications of the existence of several others (not described), making at that time a total of thirteen genera from the Carboniferous formation in general.

In 1872 the distinguished Canadian geologist, Professor Sir Wm. Dawson, gave an account of and figured *Sauropus unguifer*, being the footprints of an *unknown* labyrinthodont reptile from the Carboniferous Sandstone of Nova Scotia; and in 1891 he announced in two separate papers the discovery of new specimens of *Dendrerpeton acadianum* and *Hylonomus Dawsoni* from the South Joggins Coalfield, Nova Scotia.

Our old friend William Davies gave an account (in 1876) of the exhumation and working out of a large Dinosaurian, named by Owen *Omosaurus armatus,* from the Kimmeridge Clay of Swindon, Wilts. This specimen is preserved in the Natural History Museum, Cromwell Road, and is a good example of the heavy vegetable-feeding land reptiles of the Jurassic period. In 1880 he described the remains of an Upper Miocene Ostrich from the Siwalik Hills, India.

Professor Prestwich (1879) recorded the discovery of a species of *Iguanodon* in the Kimmeridge Clay near Oxford. In the same year E. T. Newton described *Emys lutaria* from the fluviatile deposit at Mundesley on the Norfolk coast; an Iguanodont tooth from the 'Totternhoe Stone' at Hitchin; "British Pleistocene Vertebrata in Britain" (1891); and Dicynodont and other reptiles from the Elgin Sandstone. He noticed the occurrence (1883) of the Red-throated Diver, *Colymbus septentrionalis,* at Mundesley.

W. H. Twelvetrees (1882) figured some Theriodont reptilian teeth from the Permian of Russia; this formation quite lately has yielded a marvellous series of remains to Professor Amalitzky, of Warsaw. Professor A. Liversidge gave (in 1880) an analysis of Moa egg-shell from New Zealand. So long back as 1864 the veteran anatomist, W. K. Parker, made some important remarks on the skeleton of *Archæopteryx.* He pointed out that although this primitive bird had, in the adult state, 21 caudal vertebræ, a recently hatched duckling possesses 22 caudals if we count the fifth post-femoral as the first of the caudal series; so that, after all, this large number of free caudals is only an embryonal character retained in the adult.

The late Professor O. C. Marsh, of Yale College, New Haven, Connecticut, who died in 1899, was for 23 years a contributor to the pages of this journal, and a very constant visitor to this country; indeed, from his return after his student days in 1864 to the end of his life he was a familiar figure in the British Museum and at the meetings of our scientific societies.

In 1876 Marsh contributed a paper on birds with teeth (Odontornithes) from the Cretaceous of Kansas. The most interesting is perhaps the *Hesperornis regalis,* a gigantic diver. The brain was quite small; the maxillary bones, which were stout, had throughout their length a deep inferior groove thickly set with sharp pointed teeth. The vertebræ were like those of recent birds. The sternum was without a keel, and the wings were quite rudimentary. It has, in fact, been described as a swimming ostrich. In *Ichthyornis* the teeth were in distinct sockets, the vertebræ were biconcave; the sternum possessed a keel; and the wings were well developed for powerful flight.

In 1881 Marsh wrote on the structure of the skeleton in the *Archæopteryx,* and pointed out the many interesting features in which this earliest known bird approaches to the reptilian type and especially to the Dinosauria. In 1882 he proposed a classification of the Dinosauria which (with some modifications) is still followed by palæozoologists.

In the same year this author discussed the wings of Pterodactyls, basing his remarks on the specimen discovered at Eichstädt, Bavaria, in 1873. This long-tailed form, named *Rhamphorhynchus phyllurus* by Marsh, has both the wing membranes preserved, and shows that the long stiff tail had a broadly expanded extremity like the blade of a paddle, which was evidently used as a rudder. We have a similar form named *Dimorphodon*, which was obtained from the Lias of Lyme Regis (see 1870, p. 97, Pl. IV). In 1884 Marsh figured and described the skull of the great *toothless* American Pterodactyl from the Chalk of Kansas (named *Pteranodon*), with a skull a yard in length, and wings having an expanse of about 18 feet across!—as large as our great toothed *Pterodactylus Cuvieri* and *P. giganteus* from the English Chalk of Burham, Kent.

He also (1884) named *Diplodocus longus*, a new Jurassic Dinosaur, from Cañon City, Colorado, giving figures of the skull, teeth, etc. It possessed one of the most remarkable heads of this singular group of land reptiles and the weakest possible dentition, the teeth being entirely confined to the front of the jaws and of simple slender peg-like form, and they must have been easily detached from their shallow sockets. The nasal opening was at the apex of the cranium, and the brain was of the very smallest dimensions possible.

Then followed an account, with figures, of various other new forms of Jurassic Dinosaurs—*Allosaurus*, *Cœlurus*, *Labrosaurus*, and *Ceratosaurus*. These were all carnivorous forms (Theropoda), the last-named being near to our own *Megalosaurus*, the teeth and claws both displaying their predaceous character. *Allosaurus* had extremely diminutive fore-limbs and long slender hind ones, adapted evidently for springing upon its quarry.

Passing from these lithe and active beasts of prey, we come (in 1888) to one of quite another character, namely, Marsh's *Stegosaurus*, a huge plated lizard of the Jurassic period. It had the smallest brain of any known land vertebrate. All its bones were solid, the vertebræ biconcave. Its body was defended by a row of twelve flattened dorsal bony plates, the largest being nearly four feet in height and of equal length; with four pairs of sharply pointed spines fixed erect like bayonets on the caudal vertebræ. A restoration was given by Marsh of this huge herbivore in 1891.

A further comparison of the principal forms of Dinosauria of Europe and America was given by Marsh in 1889, in which he defined the group Sauropoda or lizard-footed forms. Many of these are known in Europe as well as America, but here they are more fragmentary. A large part of one has just been set up from the Oxfordian of Peterborough, whilst limb-bones of *Cetiosaurus* (as large as those of *Atlantosaurus*) may be seen in the Oxford Museum and in the British Museum (Natural History), London. The section Stegosauria is represented by *Omosaurus*, from Swindon; *Hylæo-*

saurus, Wealden; *Polacanthus, Acanthopholis,* and *Scelidosaurus* (all British forms) belong to the armoured Dinosaurs.

The section of the great bird-footed ORNITHOPODA is well represented by *Iguanodon* and its allies in this country and in Belgium, while that of the THEROPODA was known here by *Megalosaurus* since the days of Buckland (1824).

In 1890–91 Marsh brought before the public his gigantic CERATOPSIDÆ, horned Dinosaurs, with skulls of marvellous form, nearly 6 feet from the tip of the pointed snout to the edge of the huge bony frill which expanded between 3 and 4 feet in breadth, like an immense Elizabethan collar, over the creature's neck behind. The skull had three horns, two over the orbits and one on the nasal bone (hence the generic name *Triceratops*); the jaws had sharp horny beaks in front and *two-fanged* molar cheek teeth. It had besides a covering of dermal armour.

An interesting investigation as to the makers of the footprints, so long attributed to *Dinornis*-like birds, met with upon the slabs of fine-grained sandstone in the Connecticut valley, resulted in the discovery by Marsh of a small light-footed Dinosaur named *Anchisaurus colurus*, a little over 4 feet in height, which, although not tridactyle, only impressed three of its four toes on the wet sands in running, touching the tip of the nail only of the fourth toe on the ground. The restoration of this early Dinosaur in 1893 is accompanied by two others, a large carnivorous form like our *Megalosaurus*, the *Ceratosaurus*, and a bird-footed and beaked form, *Claosaurus*, near to our *Iguanodon*, with which it also agrees in size.

A restoration of *Camptosaurus dispar* from the Upper Jurassic of Wyoming appeared in 1894, also footprints of Coal-measure Labyrinthodonts from Kansas. Other restorations of European genera were continued to be published in 1896. First and smallest of all these is the *Compsognathus longipes*, Wagner, preserved on a slab of Lithographic Stone from Bavaria. Next follows *Scelidosaurus Harrisoni* (Owen) from the Lias of Charmouth. Then another very small Dinosaur named *Hypsilophodon Foxii* (Huxley) from the Wealden of the Isle of Wight, and *Iguanodon Bernissartensis* from Belgium.

These were followed by a final classification of the Dinosaurs, with twelve beautifully executed figures, and a note on the Sauropoda which appeared in 1899. Marsh gave the results in 1898 of his visit to St. Petersburg, Moscow, Vienna, Munich, Paris, Caen, Havre, and London, and additional notes on Dinosaurian remains seen during his tour.

Professor H. G. Seeley wrote in 1881 on the Ornithosaurians of the Cambridge Greensand; in 1895 on *Pareiasaurus Baini* from the Karoo formation (Trias) of Cape Colony, obtained by him in 1889 at Bad, near Tamboer-Fontein; the most perfect Anomodont reptilian skeleton then known, only equalled by the specimens recently discovered by Professor Amalitzky in the Trias of Russia. In 1898 Seeley described two Rhætic Dinosaurs, *Avalonia Sanfordi* and *Picrodon Herveyi*, from Wedmore Hill, Somerset; and in the same year the skull of a Triassic Anomodont (*Oudenodon pithecops*), a small toothless reptile obtained by Mr. McKay, of East London, from the Dicynodont Beds of Cape Colony. In 1881 Seeley gave an account and figure of the Berlin *Archæopteryx*, and discussed the affinities of this second example of long-tailed Oolitic bird when compared with the original example in the British Museum (Natural History), obtained in 1861.

Henry Woodward described and figured *Iguanodon Mantelli* in 1885, and *Iguanodon Bernissartensis* in 1895; he gave in 1885 an account of "Wingless Birds," recent and fossil, with their characters, species, and distribution, both geographically and geologically.

Arthur Smith Woodward gave, in 1885, an excellent summary of the literature and nomenclature of British fossil Crocodilia, with a table of genera and species. In 1891 he noticed a tooth of an extinct Alligator from the Danian of Ciply, Belgium; a Microsaurian (*Hylonomus Wildi*) from the Burnley Coalfield, Lancashire; and noted the occurrence of *Pseudotrionyx* from the Bracklesham Beds. In 1897 he figured and described *Stereosternum tumidum*, a small lizard-like Triassic reptile from San Paulo, Brazil, related in some undetermined way to the ancestry of the Plesiosauria; and a new specimen of *Ceraterpeton Galvani* from the Coal-measures, Kilkenny, Ireland.

In 1887 G. A. Boulenger wrote, with R. Lydekker, some notes on Chelonia from the Purbeck Beds and London Clay.

R. Lydekker, in the same year, wrote on Crocodilians from Hordwell and other species from the Wealden, etc. He also published a note on *Hylæochampsa*. In 1888 he published notes on Tertiary Lacertilia and Ophidia, and discussed their affinities; he also wrote on the classification of the Ichthyopterygia; quoting from the late Sir William Flower in favour of the restriction of generic terms, and urging that their multiplication tends to make us lose sight of the mutual relationship of allied forms, a view in which the author then fully agreed, but subsequently he appeared rather to favour the creation of new species, not merely in extinct, but in recent forms of life. If a *small fee* for registration had to be paid for every new name proposed to be introduced into currency, and a *large one* imposed on the alteration of old and well-established names, in order to replace them by some lost or unknown name unearthed from the dusthole of the past, zoology would be greatly the gainer, and much time might be saved with advantage and devoted to really useful scientific work. Lydekker gave some interesting notes on Sauropterygia from the Oxford and Kimmeridge Clay, from the Leeds Collection at Eyebury. He does some useful 'lumping' of species established upon insufficient data, and mentions a delightful case in which a newly described *Plesiosaurus* presented some very striking peculiarities in its skeleton, arising from the simple mistake made by the author, who had placed the head on the extremity of the tail—the so-called cervicals being indistinguishable from the caudals of other forms. R. Lydekker, in 1889, recorded some remains of a new Cœluroid Dinosaur from the Wealden of the Isle of Wight, which he named *Calamospondylus Foxi*.

Boulenger and Lydekker called attention to a curious case of "the *un*scientific use of the imagination," in which the Abbé G. Smets, in Belgium, figured and described some remains of a new Dinosaur, which, upon examination, proved to be merely a mass of fossil wood.

Lydekker figured and described part of a left pectoral paddle of *Ichthyosaurus intermedius* from the Lower Lias of Barrow-on-Soar, in which the integument is preserved, as in a paddle figured and described by Owen in 1841. In 1891 the same author delineated and noticed a most perfect skeleton of *Ichthyosaurus tenuirostris*, obtained by Alfred Gillett from the Lower Lias of Street, Somerset, and presented by him to the British Museum (Natural History), where it still holds a premier place among its fellows.

Dr. C. W. Andrews, in 1885, gave a note on the skull of *Keraterpeton Galvani*, Huxley, a small Labyrinthodont from the Coal-measures of Staffordshire, originally described by Huxley from the Kilkenny Colliery, Ireland. In the same year he described the skeleton of a young Plesiosaur from the Oxford Clay of Peterborough, and in 1896 the pelvis of a large Plesiosaur (*Cryptoclidus oxoniensis*), also forming part of the Leeds Collection.

In 1895 Andrews discussed the *Stereornithes*, a group of extinct birds from Patagonia, and made some interesting remarks on the recurrence of flightless or wingless birds in groups, as those of South America and of New Zealand, and the Gastornithidæ in the Eocene of Europe. He contended that there seemed no reason why such groups of flightless birds should not arise at any period and in any region, providing the conditions of life were favourable. In 1896 he noticed the nearly complete skeleton of *Aptornis defossor*, a gigantic flightless rail from New Zealand, of which an excellent figure was given, followed later by an account of *Diaphorapteryx Hawkinsi*, Forbes, a large extinct rail from the Chatham Islands, 500 miles east of New Zealand. All these flightless birds shared the same fate as the Dodo and *Dinornis*, having been eaten up by man.

Another interesting insular flightless bird was described by Andrews in 1897, the *Æpyornis Hildebrandti* from Madagascar, a restored skeleton of which was set up in the British Museum (Natural History), from remains obtained by Dr. C. I. Forsyth Major at Sirabé, Central Madagascar.

Lastly, in 1899 he figured the nearly complete skeleton of *Dinornis maximus*, obtained by C. A. Ewen near Invercargill (South Island), New Zealand, one of the most genuine specimens obtained; those sent home by the late Sir Julius von Haast having been mostly composite skeletons, not belonging to one bird.

Professor Seeley gave in 1887 some interesting notes on Louis Dollo's work on the Dinosauria of Bernissart, especially in reference to the *Iguanodon Bernissartensis* and the relation of Dinosaurs to Birds. Mr. Dollo also contributed an article on some Belgian fossil reptiles, with special reference to *Hylæochampsa* and *Bernissartia*. In 1888 the same author wrote on the humerus of *Euclastes*, and discussed the relationship of the Propleuridæ with the Cheloniæ.

In 1899 Dr. G. Baur reviewed E. T. Newton's memoir on the skull of *Scaphognathus*.

The egg of a large Struthious bird (*Struthiolithus chersonensis*) found in a Post-Tertiary deposit at Kalgan, North China, was described and figured in 1898 by C. E. Eastman, of Cambridge, Massachusetts, United States. As no bones of any ostrich-like bird have been met with in China, we must receive the evidence of the egg alone with some reserve, although the account is very well authenticated.

In 1900 Eastman described a fossil bird (*Gallinuloides Wyomingensis*) from the Middle Eocene, Wyoming, with short beak, stout legs, and about the size of a gallinule, rail, or small coot, and resembling those birds in general characters.

In 1903 Professor R. Broom figured the palate of *Scylacosaurus Sclateri*, a new primitive Theriodont from South Africa, and a new Stegocephalian reptile from Ariwal North, Cape Colony.

In 1900 Professor Burckhardt gave a description and excellent figures of *Hyperodapedon Gordoni* from the Trias of Elgin; and G. A. Boulenger, in 1903, described the palate of *Hyperodapedon* and of a new genus, *Stenometopon*, also from the same deposit.

Baron Francis Nopcsa, jun., had an article in 1903 on the origin of the Mosasaurs, and discussed the question as to whether Mosasaurs were highly specialized aquatic Varanoids, or sprang from the Neocomian Dolichosaurs, or were an offshoot from some ancient Lacertilia.

Mammalia.—Professor Owen, who was among our earliest contributors, wrote in 1865 on *Miolophus*, a new genus of Eocene mammals. A year later the specimen so described by Owen proved to be the type of *Platychærops Richardsoni* (Charlesworth), (Brit. Assoc. Rep., 1854, p. 80), from the London Clay, Herne Bay (see Geol. Mag., 1866, p. 48), and was claimed for the York Museum, to which it belonged. In 1866 Owen described the lower jaw and teeth of a small Oolitic mammal from the Purbeck beds of Dorset, which he named *Stylodon pusillus*, probably a small Insectivore. He next wrote in 1869 on *Castor* and *Trogontherium*, and gave figures of the limb-bones and teeth of the gigantic beaver of the Norfolk Forest Bed series. This great beaver occurred also in the Thames Valley (see Geol. Mag., 1902, p. 385); in the Department l'Eure et Loire in France; at Taganrog, on the Sea of Azof; and near Odessa, on the Black Sea. In the same year he recorded the occurrence of the Elk (*Alces palmatus*) from the North Tyne River, Northumberland, and from the East London Waterworks at Walthamstow, Essex. A. Smith Woodward, in his "British Fossil Vertebrates" (1890), gave no fewer than thirty-two localities, to which may now be added Keiss, Caithness, and Cleveland, Yorkshire. In 1883 Owen figured and described a newly discovered skull of *Thylacoleo* from Queensland, Australia, a palatal view of which is given.

In 1865 Harry Seeley described the cervical vertebræ of a whale, *Palæocetus Sedgwickii*, from the Boulder-clay of Ely, in the Woodwardian Museum.

In the same year Dr. A. Leith Adams gave an account of the first discovery, in 1857, by Dr. S. Agius, of the bones and teeth of fossil elephants, associated with the great dormouse, *Myoxus melitensis*, in the Gandia Fissure, Malta. But the best-preserved remains of the pigmy elephant were obtained by Captain Spratt, R.N., from the Zebbug Cave in 1859.

In 1867 Professor Sir Frederick McCoy noticed the occurrence of *Squalodon Wilkinsoni*, from the Miocene Tertiary of Victoria, Australia, a primitive whale with teeth provided with bicuspid fangs. Teeth of this whale have also been found in the Red Crag of Suffolk, in Malta, France, and North America.

Henry Woodward, in 1864, described the discovery and exhumation of a skull and tusks of *Elephas primigenius* from the Brick-earth at Ilford in Essex, and in 1868 figured the skull and tusks in order to show that their normal curvature in the aged Mammoth was *inwards* at their extremities, not outwards, as had hitherto been depicted by Waterhouse, Hawkins, and others. In 1869, under the title of "Man and the Mammoth," the same writer gave an account of the animals found associated with early man in Britain during prehistoric times, in which a table was also given of the species which are extinct or have been killed, have migrated or are still living in this country. An article in the same year recorded the animals found in the fresh-water deposits of the Valley of the Lea near Walthamstow, Essex.

In 1871 Henry Woodward described the Mammoth skeleton from Lierre, Belgium, set up in the Royal Museum of Natural History at Brussels, and gave a brief account of the other objects of interest in that collection. In 1874 the same writer gave an account of the very perfect skull of *Rhinoceros leptorhinus*, from the Pleistocene Brick-earth of the Valley of the Thames at Ilford. The author pointed out that Falconer's name of *R. hæmitechus* must give place to Owen's *R. leptorhinus*, inasmuch as the species had a completely ossified nasal septum. In 1885 he recorded the addition to the British Museum of a nearly complete skeleton of Steller's sea-cow, *Rhytina gigas*, from Behring Island, and a restored skeleton of *Halitherium Schinzi*, from the Miocene of Hessen Darmstadt, and he pointed out that at present the living Sirenia were all confined within a band 30° north and 30° south of the equator, but in late Tertiary times they extended to 60° north, about 28 species being met with in North America, England, France, Belgium, Holland, Italy, Germany, and North Africa; affording additional evidence, if such were required, of the former northern extension of warmer conditions of climate in Europe in the near past.

In 1886 H. Woodward gave an account of recent and fossil *Hippopotami*. In 1898 he described the great red-deer antlers from Bakewell, Derbyshire; a year later he figured the skull and tusks of the famous *Elephas ganesa*, which forms so striking an object in the centre of the Geological Gallery of the British Museum (Natural History). In 1903 he noticed some recent cave-hunting in Cyprus by Miss Dorothy M. A. Bate.

W. Boyd Dawkins discussed, in 1868, the value of the evidence for the existence of the Mammoth in Europe in pre-Glacial times, and he concluded that the evidence forthcoming did not, in his opinion, support the contention of the pre-Glacial age of the Mammoth, which must be considered to be of later date.

In 1870 Professor Huxley contributed a paper on the milk-dentition of *Palæotherium magnum*, in which he pointed out that the genus *Paloplotherium* was founded upon a mistake, and it disappears from zoological nomenclature. Professor James Geikie described the occurrence in 1868 of *Bos primigenius* in the Lower Boulder-clay of Scotland.

E. Ray Lankester announced (1869) the discovery of a new Trilophodont *Mastodon* in the Suffolk Bone-bed at Woodbridge, and in the same year the finding of a portion of the tusk of the great sabre-toothed tiger *Machairodus* from the Forest-bed at Cromer, on the Norfolk coast. In 1899 he returned to the subject of the Trilophodont *Mastodon* from the Suffolk Crag, and refigured his *Mastodon angustidens* as var. *latidens*, the obscuring phosphatic matrix having been removed.

Professor Robert Harkness (1870) mentioned the occurrence of elephant-remains in Ireland. He concluded that there is good evidence of the Mammoth having been met with in Shandon Cave, Dungarvan, co. Waterford.

In 1871 Dr. James Murie gave figures of the skeleton and an admirable restoration of *Sivatherium giganteum*, a type of Miocene Tertiary short-necked horned ruminants, which with *Helladotherium*, *Bramatherium*, *Samotherium*, and some others belong to the Giraffidæ, and of which the long-necked giraffe and the recently discovered short-necked Okape alone survive.

William Davies (1878) recorded the animals obtained by J. J. Owles, of Yarmouth, from the Dogger Bank in the North Sea, an old Pleistocene or Post-Glacial land lying off the east coast and once a part of these Islands when they were joined to the Continent, and the bear, wolf, hyæna, the Irish deer, the reindeer, red deer, urus, bison, horse, rhinoceros, mammoth, beaver, elk, musk-ox, etc., were common British animals. He noticed a fine jaw of mammoth dredged from the Dogger Bank in 1837, and in 1879 mentioned the occurrence of the musk-ox (*Ovibos moschatus*) from the Thames Brickearth at Crayford in Kent. In 1880 Davies announced the discovery (by James Backhouse, of York) of the northern lynx (*Felis borealis*) in a cave in Teesdale, Durham. He added a new British carnivore in 1884, the civet (*Viverra Hastingsiæ*), from the Eocene of Hordwell, Hampshire.

In 1880 E. T. Newton commenced a series of papers on the Vertebrata of the Pre-Glacial Forest Bed series of the East of England. In his first paper he recorded the wolf, fox, *Machairodus*, *Felis*, marten, glutton, bear (two species), walrus, and a seal. In his second paper he gave the horse, the ass, four species of *Rhinoceros*, *Hippopotamus*, two species of pig, ox, bison, sheep, goat, thirteen species of deer, and the reindeer (*Rangifer tarandus*). In 1882 he noticed the occurrence of the marmot, *Spermophilus*, beneath the Glacial Till of Norfolk. In 1883 he described the teeth of *Hyæna crocuta*, var. *spelæa*, from the Forest Bed at Corton, Suffolk. In 1887 he figured remains of the otter, the eagle, owl, shoveller duck, and cormorant, all from the Forest Bed series. E. T. Newton added, in 1889, descriptions of *Cervus rectus, Bison bonasus, Phoca barbata, Delphinapterus leucus*, and *Phocæna communis*. In 1890 the same author noticed the occurrence of Lemmings and other rodents in the Brickearth of the Thames Valley, Crayford. Lastly, in 1902, he recorded the discovery of *Trogontherium*, the giant beaver, from near Greenhithe, Kent, in the valley of the Thames.

Sir Henry Howorth wrote in 1880 on the Mammoth in Siberia, giving a number of interesting facts to prove the very early date in history when, by the trade-routes, Mammoth ivory was brought south-west into Europe from Siberia. In 1901 he wrote of "the earliest traces of Man," taking as his text the evidence of Palæolithic Man in Africa, by Sir John Evans, H. O. Forbes on the stone implements from Egypt and Somaliland, Ashington Bullen on Eolithic implements, etc.

Richard Lydekker had a series of three papers on the Artiodactyla, etc., in 1885, and on the teeth of *Hyænodon* in 1890.

Professor O. C. Marsh (in 1887) wrote on American Jurassic mammals, and figured and described many forms closely resembling our Purbeck and Jurassic microtheres, of which he made us acquainted with no fewer than 26 species. In 1889 he illustrated the skeleton of the great *Brontops* (*Titanotherium*), a huge *bony-horned* *Rhinoceros* with two blunt *bony* prominences on its snout near the extremity, placed side by side. He figured *Coryphodon hamatus* in 1893, a huge Amblypodous ungulate allied to *Dinoceras*, from the Lower Eocene of Wyoming, U.S.A. In 1894 he gave a restoration of *Elotherium crassum*, a pig-like animal from the Miocene of North-Eastern Colorado, only surpassed in bulk by the Rhinoceroses and Titanotheres, its contemporaries. In 1899 Marsh published his Address on the Origin of Mammals (delivered at Cambridge August 25th, 1898). On the 18th March he passed away in his 68th year, having done a day's work and done it well.

Dr. C. I. Forsyth Major wrote in 1890 on the Pliocene Mammalian Fauna at Olivola in the Carrara Mountains, and recorded *Felis, Machairodus, Hyæna robusta, Canis, Ursus etruscus, Rhinoceros etruscus, Equus stenonis, Mastodon arvernensis, Sus Strozzi, Cervus dicranius, Leptobos elatus, Castor*, etc. In 1899 he described *Sciurus Bredai* and *S.* sp., *Lagopsis verus*, and *Cricetodon minus*, from the Middle Miocene of Oeningen; fossil dormice, *Muscardinus sansaniensis*, and *Eliomys Hamadryas*, from Sansan and La Grive Saint-Alban, and on *Pliohyrax græcus* from the Upper Miocene of Samos and Pikermi.

In 1900 Forsyth Major gave a summary of what was known of the extinct primates of Madagascar—*Megaladapis, Palæochirogalus, Nesopithecus*, and *Hadropithecus*; and in 1901 an interesting article on the transference of secondary sexual characters of mammals from males to females, the horns of the Giraffidæ, the antlers of the deer tribe, and the horns in the Bovinæ and Capridæ being considered, the reindeer and roedeer and sometimes the red-deer having antlered females, and the tusks also in the Suidæ (in the *Potamochœri*) being almost equal in size and shape to those of the males. Also he wrote on a supposed camel and a nilghai (*nylghau*) from Samos; the former proved to be a hornless skull of the female *Palæotragus Rouenii*, a small Giraffoid form, and the nilghai to be another of the Giraffidæ, *Palæotragus vetustus*.

During his visit to Madagascar, in 1895, Forsyth Major was fortunate in obtaining a nearly complete skeleton of *Hippopotamus madagascariensis*, which is now set up in the British Museum Geological Gallery, and was photo-engraved in 1902 and described by the discoverer. Like *H. liberiensis*, it is a pigmy form of the great *H. amphibius* of Africa. Besides the above there are in the Mediterranean islands *H. Pentlandi*, *H. melitensis*, and *H. minutus*, all pigmy forms. In 1903 the same author wrote on some new Carnivora from the Middle Miocene of La Grive Saint-Alban, Isère, France, and defined *Progenetta certa*, *Leptoplesictis* sp., *Trocharion albanense*, and *Trochictis Depreti*.

Numerous mammalian remains from Egypt have from time to time been sent by Captain Lyons, the Director-General of the Geological Survey, to the British Museum for determination, and Dr. C. W. Andrews during the last five years visited Egypt several times in order to collect further material, which he has described in a series of papers. In 1899 he noticed and figured *Brachyodus africanus*, a large anthracotheroid ungulate, of which a number of allied forms have been described from European deposits; he also mentions the remains of a small species of *Rhinoceros*.

Dr. Andrews made numerous expeditions with H. J. L. Beadnell to the western desert, which resulted in the discovery of a number of important mammalian remains of Zeuglodonts, Sirenians, and Proboscidea; of these may be mentioned *Eotherium ægyptiacum*, *Zeuglodon osiris*, *Palæomastodon Beadnelli*, *Mœritherium Lyonsi*, *M. gracile*, *Bradytherium grave*, and *Eosiren libyca*. Also from the Wadi-Natrun remains of a small hippopotamus, a hipparion, a small pig-like animal; various antelopes were also obtained, likewise remains of *Hippotragus Cordieri*.

In 1903 Andrews offered suggestions on the evolution of the Proboscidea, and described the gradual increase in the complexity of the molar teeth, the loss of incisors Nos. 1 and 3, and the great increase in size of incisor No. 2, which eventually formed the tusk; the canines are also early lost; in the earliest forms some of the cheek-teeth (milk-molars) are replaced by premolars in the usual manner from beneath, and these teeth remain in wear simultaneously with the true molars. In later forms no vertical succession takes place; as the milk-molars are worn they are shed, being replaced *from behind* by the forward movement of the molars. Of these also the anterior may be shed until, in old individuals of the later types, the last molar is alone functional. The molar teeth increase in complexity from the earliest to the latest type, beginning as simple quadritubercular molars in *Mœritherium* and ending with the complex tooth found in *Elephas*; in *Palæomastodon* the molars are trilophodont, as are the first and second molars in *Tetrabelodon*. In the Stegodonts a further increase in the height of the crests of the molars takes place, the teeth being covered by a thick coat of cement; in still later forms these crests become highly compressed laminæ united by cement; as many as twenty-seven plates being present in one tooth in the Indian elephant.

By these researches we are made acquainted with a series of forms in the direct ancestral line of the Proboscidea, taking as (1) *Mœritherium*, Middle Eocene; (2) *Palæomastodon*, Upper Eocene; (3) *Tetrabelodon*, Miocene; (4) the Stegodonts, Pliocene; (5) the Mammoth, *Elephas primigenius*, Pleistocene; and (6) the living Indian elephant.

In the same year Andrews gave an account of further discoveries in the Fayûm, Egypt. The commonest forms met with were *Palæomastodon* and *Arsinoitherium*. A fine skull of the latter and of *Mœritherium* were obtained; the author also described and figured *Megalohyrax eocænus* and *Pterodon africanus*.

Professor E. D. Cope gave an account of a new type of Perissodactyle Ungulate, *Phenacodus primævus*, from the Eocene of Wyoming, U.S.A., believed to be a primitive ancestor of the horse. In 1899 Cope discussed the development of the Proboscidea, but the discoveries made by Andrews more lately in Egypt give us fuller information on this subject.

P. M. C. Kermode gave in 1898 some interesting particulars of the exhumation of the gigantic Irish deer in the Isle of Man; the first specimen, having been obtained at Ballaugh in the Isle of Man, was in 1819 and is now preserved in the Edinburgh Museum; the recently discovered specimen has been set up in Douglas Castle.

Should our retrospect of the life-history of the GEOLOGICAL MAGAZINE in the past forty years seem hardly to justify so large a space having been devoted to it, nevertheless we may plead that it serves to show what an important part this journal has taken, and still takes, in the progress of geology and palæontology, not only in this country and in our colonies but abroad generally, whilst the splendid list of eminent men among its contributors still stands unrivalled. In the matter of illustrations we have a right to feel proud. Seven hundred excellent plates adorn the journal, and seventeen hundred illustrations will be found in the text.

The increase in recorded fossil remains has been enormous, but the increase in names and the changes brought about in their application have been even far greater. We have only to compare A. S. Woodward and Sherborn's Vertebrata with that part of Morris's Catalogue (1856), or to consider for a moment the great additions made to our Oolitic species of Gasteropoda recorded by Hudleston of late years since Professor Morris's time.

After all, it is not the length of the palæontological road which is so trying, but its inequalities. For example, how can the perplexed student follow the zigzag and tortuous nomenclature of the Ammonites, as he views them to-day by the light of modern writers on this group? Or, to take a less perplexing branch, the British non-marine Mollusca (as recorded by B. B. Woodward, 1903). What becomes of our knowledge, derived from the past, if out of 167 names defined by Forbes and Hanley, only 51 remain intact? Such metamorphoses are too startling.

One pressing matter remains to be mentioned, that is, a General Index to the forty annual volumes of the Geological Magazine.

The Index is prepared in MS. by Mrs. Woodward. The question is, *shall it be printed?* If, say, 300 of our readers are prepared to subscribe one guinea each for a copy, this work of reference might be published. It would unquestionably prove of the greatest value to all workers in geology and palæontology.

Every year Time strikes off some name from our list of old and valued friends, and each year gives us some new ones to add, but we crave *more* subscribers in order to be able to give more illustrations and so add new interest to our journal. In conclusion, we trust that the fifth decade may be brighter and more successful than the four already completed, for our readers and subscribers as well as for our kind-hearted and always encouraging and helpful friend the Publisher, and lastly for ourselves that we may be permitted to witness the Jubilæum of the Geological Magazine.

H. W.

II.—Further Notes on the Mammals of the Eocene of Egypt.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

Part II.

(PLATE VI.)

Arsinoitherium.

The *skull* of one species (*A. Zitteli*) of this remarkable ungulate has already been figured by Mr. Beadnell, and also in this Magazine (December, 1903), where its general form is well shown. Details of the structure of the skull and skeleton will be given in the monograph, so that only a few of the more important characters need be referred to here.

The pedunculate occipital condyles are very large and prominent; the occipital surface slopes strongly forwards and is bordered by a massive lambdoidal ridge, which on either side (in old animals at least) rises into a prominent backwardly directed boss of bone, almost like a blunt horn. The parietal region of the cranial roof is flat and is at right angles to the side walls of the skull, being sharply marked off from them by well-defined ridges, which form the upper limits of the temporal fossæ. The suture between the parietals is obliterated in the youngest skull examined. The pair of small posterior horns over the orbits are borne exclusively by the frontals, while the great anterior pair seem to be formed entirely by the enormously developed nasals.

The squamosal takes a large share in the formation of the side wall of the cranium. It bears a large post-tympanic and also a large post-glenoid process, the two approaching one another, though not meeting, beneath the auditory meatus. The glenoid surface is very broad from side to side, but narrow and deeply concave from before backwards. The orbits are not marked off in any way from the temporal fossæ; there are large antorbital foramina. The pre-nasal buttress of bone, running from the pre-maxillæ to the nasals and helping to support the front of the great horns, seems to be formed mainly by the premaxillæ. The pterygoids form extremely large palatine plates, and the palate is very deeply concave from side to side, particularly in front.

In the *mandible* the ascending ramus is high, and the coronoid process rises considerably above the transversely elongated condyle.

The *teeth* (Plate VI, Figs. 1–3). The dental formula is i. $\frac{3}{3}$; c. $\frac{1}{1}$; pm. $\frac{4}{4}$; m. $\frac{3}{3}$. The tooth series is closed, and in the mandible at least the crowns all wear to a common level, and there is no clear line of distinction between the premolars, canines, and incisors; but, on the other hand, in both upper and lower jaws the difference between the premolars and molars is most striking. The molars are especially remarkable for the height of their crown, particularly on the outer side. Each molar (see Figs. 1 and 3) consists of two columns (*pc.* and *ac.*) flattened antero-posteriorly, and with the posterior face slightly concave from side to side. The enamel-covered portion of the outer side of these elements is very much higher than on the inner side. These main columns are united on the inner side of the tooth only, where also are developed the smaller accessory crests marked x and y in the figures. In wear (see m. 2 of Fig. 1) these accessory elements, together with the inner ends of the main columns, unite to form an inner wall, which, except just at first, is not covered with enamel (Fig. 1). The premolars present a totally different appearance. In them there is an outer wall covered with enamel and consisting of two, or more probably three, united elements. There are two inner cusps, the anterior of which soon becomes united with the ectoloph, as in very worn teeth the posterior one does also; anteriorly the element marked x in the molar is present. The peculiar arrangement of the roots in the cheek teeth and the probable homologies of their cusps will be described later. It seems probable that we have here an extreme modification with great hypselodonty of one of the types occurring among the earlier Amblypoda. The canines and two posterior incisors are simple columnar teeth with a cingulum on the inner side, wearing to a flat surface continuous with that of the cheek teeth. The anterior pair of incisors are not well known to me, but they appear to have been separated by a considerable interval in the middle line, and to have possessed curved and pointed crowns with a shelf-like development of the cingulum posteriorly.

The lower molars are at first bilophodont, each consisting of a pair of obliquely transverse crests, the anterior faces of which are slightly concave from side to side and not covered by enamel. The outer angle of the posterior crest is united by a ridge with the inner angle of the anterior one, from the outer angle of which another ridge runs forwards and inwards to the anterior face of the tooth. The pattern assumed in wear is shown in Fig. 2. These molars in some respects resemble those of some species of *Coryphodon* (e.g. *C. simus*[1]), but are more hypselodont.

The premolars are much more compressed laterally than the molars; they seem to consist essentially of a pair of crescents, but the details of their structure cannot be discussed here. The canines and incisors are simple columnar teeth wearing to a common level and forming a closed series both in the middle line and with the premolars. Altogether the dentition in this genus seems to be one of the most remarkable known, at least among the Ungulata. The teeth here specially referred to and figured are those of the type-specimen of *Arsinoitherium andrewsi*, Lankester.

The skeleton is almost completely known, but in the case of some of the bones there may be some danger of confusion with those of *Palæomastodon.*

The axis has a blunt peg-like odontoid process; its centrum and still more those of the cervical vertebræ behind it are very broad and short, so that the neck must have been nearly as short as in the elephants.

The scapula is much like that of *Dinoceras* as figured by Marsh in his monograph of the Dinocerata.

The humerus differs considerably both from that of *Elephas* and of *Dinoceras.* It is especially remarkable for the extreme antero-posterior compression of the lower part of its shaft and distal end, and for the presence of a very prominent deltoid process.

The radius and ulna are very short and stout, and do not differ widely in their main features from those of *Elephas*, while in some points, e.g. the distal articulation of the radius, they are unlike the corresponding parts of *Dinoceras.* The distal articulation of the ulna is still larger in proportion to that of the radius than in the elephants. In these latter, in some cases, the lunar has a surface for the trapezoid as well as for the magnum, there being apparently some displacement of the proximal row of carpals to the pre-axial side, instead of post-axially as usual. Whether this is so in *Arsinoitherium* or not in the case of the lunar is not known at present, but there is some evidence that the cuneiform extended pre-axially a short distance over the magnum. Weithofer ascribes the peculiar displacement in the elephants to the preponderating size of the ulnar articulation, and the same cause may have been efficient here.

The short stout metacarpals are somewhat displaced outwards; the third has a small contact with the unciform which entirely supports the fourth and fifth.

The femur is chiefly remarkable for the great antero-posterior compression of its shaft, the outer border of which is a thin sharp edge without any distinct projection representing the third trochanter. The distal articulation is much as in *Dinoceras.*

[1] See Osborn, "Evolution of the Amblypoda," pt. i: Bull. Amer. Mus. Nat. Hist., vol. x (1898), p. 192, fig. 16.

The tibia is extremely similar to that of *Dinoceras.*

It is in the tarsus that the relationship with the Amblypoda is most apparent. The astragalus in general shape is much like that of an elephant, but closer examination shows that its distal articulation is divided by a well-marked ridge and angle into two surfaces, one, much the larger, for the navicular, the other for the cuboid. Internal to the navicular surface there is a small facet which seems to indicate the presence of a distinct *tibiale.* In all essential respects the astragalus is very nearly like that of *Coryphodon* or *Dinoceras.* The calcaneum is very short and stout; there is a large fibular facet, and the surface for the cuboid is small. A navicular attributed to this animal is very similar to that of *Coryphodon.* Detailed descriptions and figures of the foot-bones and other parts of the skeleton will be given in the monograph.

The dimensions of the figured specimens (Figs. 1 and 2) are:—

Length of upper molar series	23·5 cm.
Length of the three posterior upper premolars ...	11·5 ,,
Length of lower molar series	23 ,,
Length of lower premolar series	14 ,,

All that is at present known of the structure of *Arsinoitherium* leads me to believe that it is a highly specialised, probably terminal, member of a subdivision of the Amblypoda, probably most nearly related to the Coryphodontidæ, though belonging to a separate family, the Arsinoitheriidæ. I am also inclined to think that *Barytherium,* though widely different in many respects, may have somewhat similar relationships, and may belong to still another family of the same sub-order.

Geniohyus mirus, gen. et sp. nov.

During the season 1902–3 a large part of the right ramus of the mandible of a pig-like animal was collected by Mr. Beadnell. This specimen, which is the anterior part of the right ramus of the mandible together with the symphysis, presents some very remarkable characters. The symphysial region is narrow both from side to side and from above downwards and behind it, just where the rami begin to diverge; the ventral border of the jaw is produced downwards on either side into a long decurved and backwardly directed process of bone, quite unlike anything I am acquainted with in any other animal. The hinder border of the base of this process is connected with the outer edge of the ramus itself by a thin plate of bone. The ramus is incomplete ventrally, but was evidently very narrow from above downwards. The function of this remarkable paired ventral process is very doubtful, but possibly it may have served as a protection for the projecting portion of a long upper tusk like the similarly situated process on the mandible of the *Dinoceras.*

The molars and premolars are in an excellent state of preservation, the only part wanting being the greater portion of the talon of m. 3. The characters of the molars are those of a primitive member of the Suidæ in which the selenodont character of the outer cusps is very well marked. Each molar consists of two pairs of cusps, the outer one of each pair being distinctly selenodont. In the first molar the antero-external cusp is somewhat worn. It consists of the main tubercle, which is the apex of a V of which the arms are slight ridges, which rise at their ends into small tubercles; of these the anterior is situated on the anterior border of the tooth, while the posterior is connected by a slight ridge with the postero-external angle of the inner cusp. The postero-external cusp shows the selenodont character still more plainly: its small anterior accessory tubercle partly closes the main transverse valley; the posterior accessory tubercle is on the hinder border of the tooth. The internal cusps are trihedral in form, so that in wear they also show a tendency to a V-shaped surface, the opening of the V of the anterior cusp looking backwards and outwards, that of the posterior forwards and outwards. There is a slight development of the cingulum on the outer side of the tooth, most marked opposite the opening of the transverse valley and near the anterior end of the tooth. The next molar is similar, except that on the hinder border there is a minute additional tubercle lying internal to the posterior accessory tubercle of the posterior cusp. In the last molar the structure is similar as far as it is preserved, but the talon is almost entirely wanting.

The *premolars.* The anterior premolar is a compressed tooth consisting of small anterior and posterior tubercles and a high main cusp. In the next there is a small cingular ridge in front of the tooth, and the main cusp is much larger and shows a tendency towards division into an outer and an inner tubercle. In wear it gives a triangular surface, from the outer angle of which a ridge runs down the outer face of the tooth, while from its front angle there is a small ridge connecting it with the anterior cusp, and similarly posteriorly a small crest unites it with the posterior cusp. The next tooth is similar, except that the posterior lobe is larger and shows a tendency to give a V-shaped surface in wear. In pm. 4 the division of the main cusp is complete; the inner element is small and rounded, the outer larger and V-shaped in wear. From the anterior point of the V a ridge runs to the small anterior cusp, while from the posterior a low ridge unites it with the anterior limb of the V-shaped hinder lobe. To the inner side of this last there is a trace of an inner cusp corresponding in position to the postero-internal cusp of the molar. This remarkable mammal is clearly entitled to generic distinction, and it may be called *Geniohyus mirus* in allusion to the remarkable character of the process on its mandible.

The dimensions of the teeth in the type-specimen are:—

	Length.	Breadth.
pm. 1	12 mm. ...	7 mm.
pm. 2	12 ,, ...	9 ,,
pm. 3	13 ,, ...	10 ,,
pm. 4	13 ,, ...	11 ,,
m. 1	15 ,, ...	11 ,,
m. 2	17 ,, ...	13 ,,
m. 3	? ,, ...	15 ,,

Geniohyus fajumensis, sp. nov.

Another specimen, consisting of a portion of the mandible containing the premolars in a perfect state of preservation, was also collected. This may be taken as indicating the existence of a second species of *Geniohyus*, since the teeth, though similar in general form, differ considerably in many details. The chief of these differences are that the main cusp is already distinctly divided in pm. 2, and the hind lobe in all the teeth is much larger and more distinctly selenodont.

The structure of the teeth is as follows :—Pm. 1 is strongly compressed with a very small anterior cusp and a high main cusp, from which three ridges diverge posteriorly, one running down the outer face of the tooth, a second back to the anterior arm of the V-shaped posterior cusp, the third inwards down the inner face of the tooth. The posterior lobe is distinctly selenodont.

In pm. 2 the anterior cusp is larger, and the ridge running inwards from the main cusp bears a small tubercle at its inner end. The posterior lobe is larger than in pm. 1. Pm. 3 has a larger anterior tubercle, and the cusp on the inner side of the main cusp is now nearly as large as that element and is clearly separated from it. The posterior V is still larger. Pm. 4 is similar, except that the small anterior cusp is doubled, the posterior lobe is still larger, and there are traces of a small postero-internal cusp.

The dimensions of the premolars are :—

	Length.		Breadth.
pm. 1	13 mm.	...	7 mm.
pm. 2	13 ,,	...	8 ,,
pm. 3	15 ,,	...	10 ,,
pm. 4	16 ,,	...	12 ,,

EXPLANATION OF PLATE VI.

Fig. 1.—Left upper molars and premolars of *Arsinoitherium andrewsi*, Lankester.

,, 2.—Left lower molars and premolars of the same.

The two specimens figured belong to one individual, which is the type of the species. About one-fourth nat. size.

,, 3.—Outer face of last upper molar of the left side of *Arsinoitherium zitteli*, Beadnell.

In Figs. 1, 2, and 3: *a.c.* anterior column of molar; *p.c.* posterior column of molar; *x*, anterior inner cusp; *y*, posterior inner cusp.

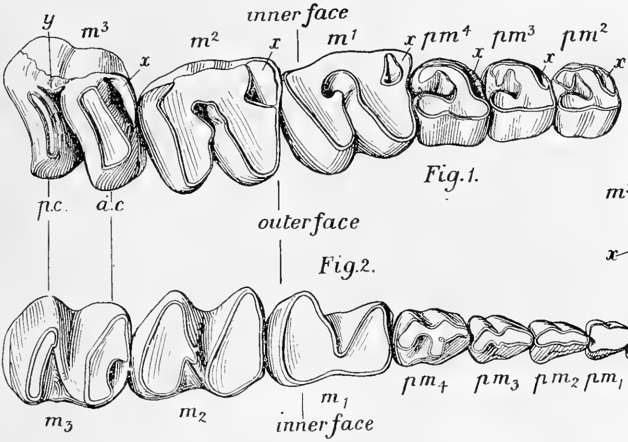
,, 4.—Upper and side views of part of the mandible of *Geniohyus mirus*, gen. et sp. nov. Type-specimen. About two-thirds nat. size.

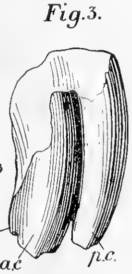
sym. symphysis of mandible; *x*, backwardly directed process on lower border of mandible.

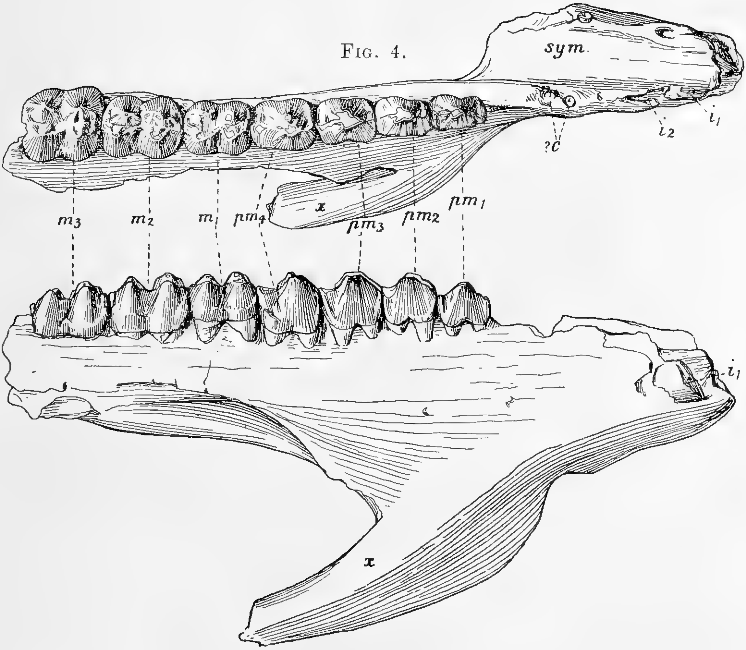
III.—Note on the Species '*Am. plicatilis*' and '*Am. biplex*' of Sowerby.

By Rev. J. F. Blake, M.A., F.G.S.

THE old question of the proper interpretation of these names, which was raised by Professors Nikitin and Pavlov, after their visit to this country for the Geological Congress in 1888, to whom no reply was made, for their conclusions could scarcely be denied, has been raised again by Miss Healy in a communication







G. M. Woodward del.

Mammals of the Eocene of Egypt.

to the Quart. Journ. Geol. Soc., Feb. 1904. As these conclusions do not appear to be well known, it may be as well to quote them. Nikitin[1] says: "Having found in the British Museum the original of *Am. biplex*, Sow. (tab. 293, fig. 1), I assured myself that that original presented absolutely the Oxfordian form of *Perisphinctes* of the group of *P. plicatilis*, by the character of its numerous straight rounded ribs, by the mode of enrolment, by the constriction of its perfectly visible whorls, and lastly by the matrix; it showed no resemblance to the Kimmeridgian and Portlandian forms described in France and England under this name . . . Mr. Loriol had not seen the original of Sowerby . . . but having received from England, under the name of *A. biplex*, Sow., the Portlandian forms, he was justified in giving this name to the same form from Boulogne. On studying the English Kimmeridgian forms placed in the museums of England under the name of *A. biplex* I found amongst them the typical form of *A. Pallasi*, D'Orb."

Professor Pavlov deals only with the latter species,[2] saying, "*Perisph. biplex* (*Pallasianus*) is the commonest form of our *virgatus*-beds, and its synonymy with the English form has for a long time been recognized"; and again, "Amongst these fossils [enumerated by Phillips] *Am. biplex* can, according to all appearances, be placed in synonymy with our *Perisph. Pallasi.*"

These, then, by the concurrence of two well-qualified observers, may be considered settled points in any revision of our Upper Jurassic Ammonites. But it may well be asked how came so many English geologists thus to misname their own species. It would appear to have been in this way. Geologists of old cared less for the names than for the specimens themselves, and when Fitton[3] submitted his fossils to J. de C. Sowerby, the son of J. Sowerby and successor in the Min. Con., and was told that the characteristic Ammonite of the Kimmeridge Clay and Lower Portland was called *Am. biplex*, it became so to him, and to all who followed him, without inquiring into the name. This name being thus occupied, Phillips used for the common Malton fossil the other name,[4] as the only one unoccupied, referring to a somewhat similar and not well-distinguished Ammonite. It thus became '*Am. plicatilis*,' and was so understood even by Nikitin himself.

Leaving, however, names alone, which, though useful, may sometimes mislead us, it is common knowledge that one species figured by Loriol, Damon, Phillips (Geol. Oxf., pl. xv), and Woodward, is characteristic of the Upper Kimmeridge, while another species, figured by Sowerby in pl. 293, figs. 1, 2, is the characteristic fossil of the Coralline Oolite; but as to the species figured by him in pl. 166, it has never to my knowledge been found *in sitû*, so that its exact horizon is not known. This being the state of affairs, we will see how much further we are carried by the observations of Miss Healy.

[1] "Excursions dans les Musées, etc., de l'Europe occidentale": Bull. Soc. Belge Géol., tom. iii.

[2] "Etudes sur les couches Jurassiques et Crétacées de la Russie."

[3] "Strata between the Chalk and the Oxford Oolite."

[4] "Geology of Yorkshire," p. 102.

With regard to Sowerby's *Am. plicatilis,* we seem as much in the dark as ever. We cannot be sure that the type has been found. The specimen figured by Miss Healy is one which "bore no label," and it by no means appears to be the original specimen when we can "compare it with Sowerby's original figure"; though perhaps the presence of "a few crystals of carbonate of lime about it" could prove that it *is* the type; nor can we even be certain that it belongs to the same species, though this may be probable. If there is one thing on which Sowerby may be depended, it is to give indications by which his specimens may be recognized. He seldom, if ever, 'restores' his pictures; but in this case we find a broad band along the periphery which he would have to imagine, he has made the bifurcations originate often towards the inner half of the whorl, he has run them quite across some suture-lines and has omitted all suture-lines except those at the end, even omitting to mark two deep holes which are left by them, and he has added even a projecting keel beneath the siphuncle, though this may be from another specimen. Nevertheless, the description is also at variance with the figure, but agrees better with the description of *A. biplex,* as shown by placing the latter in italics beneath it.

Discoid radiated, sides flat, front round, plain in the centre,
Discoid costated, sides depressed, front is round,

volutions exposed, radii numerous, equal, straight,
volutions exposed, costæ numerous, small, nearly straight,

furcate, aperture square with rounded angles.
split over the front, aperture oblong, narrower near the front, which is round.

The radii do not branch till they begin to turn over the front,
Costæ are divided into two branches a little before they pass over the front.

in the centre of which they are nearly obliterated.

It is seen that the main difference indicated is in the character of the centre of the periphery, but somewhat similar features may be seen in some of those corresponding to tab. 293. I think, however, they are specially characteristic of shells of the type of tab. 166 (though they seem to be referred by Miss Healy to wearing only); for the ends of the half ribs are obscurely seen in the photograph to be swollen on each side of the median line; the other differences are mismatched, as:—'small' for 'equal,' 'nearly straight' for 'straight,' and 'a little before' for 'not till they begin.'

We shall never know for certain where Sowerby's figured specimen came from till one like it has been discovered *in situ* in the same sandy stratum at Dry Sandford or Marcham with the several associates recorded, including '*Am. excavatus,*' but Phillips says nothing about that locality, and speaks only of Headington. Meanwhile the new figure most resembles two specimens in my collection from the summit of the Trigonia-beds of Weymouth (whence, in fact, Buckland may have brought his unlabelled specimen), in which case it represents the highest zone of the local Corallian. Its nearest foreign equivalent, already recognized in the British Islands, is *Am. Achilles* of D'Orbigny (Terr. Jurass., pl. 206), which shows when young the same peculiarity of the periphery, and whose sutures, as drawn in the adult, show the same kind of development as one might expect from the smaller examples, provided that both figures really belong to one species. With regard to Sowerby's figure on tab. 293, fig. 1, matters are plainer: it represents, as already stated, the typical form of the Yorkshire fossil known as *Am. plicatilis*, acknowledged to be so from the intended representation of it in pl. iv, fig. 29 of the 3rd edition of the "Geology of Yorkshire," revised by R. Etheridge; it corresponds also to Sowerby's *description* of *A. plicatilis* of tab. 166, which, as already noted, so far agrees with that of tab. 293, fig. 1. It was for this reason I supposed Sowerby's specimens had probably been interchanged, being guided by Agassiz's translation of his work, but Miss Healy has drawn attention to the character of the matrix, which I had entirely overlooked, which puts an end to this idea and at the same time opens up new considerations. By no possibility could any fossil in such a matrix be found in any bed at Dry Sandford, nor in any of the Corallian beds at Headington. The fossil in itself is, however, perfectly normal, but it has been separated septarially along a calcite-filled crack running principally nearly parallel to the median plane. This has raised the upper surface and separated the lower, as pointed out to me by Mr. Crick; but the small central portion is quite continuous with the outer whorls, on the upper side at least.

But the problem is, where to find a septarian matrix containing a Corallian fossil. Looking over all the fossils referred to Corallian or Oxfordian strata in the British Museum, one only was noted with a similar, very similar, matrix. It was the matrix of '*Am. varicostatus*,'[1] and the locality given was "Hackleton," which is in a drift-covered district about 5 miles from Northampton towards Bedford or 15 miles from Hawnes. My own purchased specimen, locality unknown, but horizon stated as "Oxford Clay," and perfect to the centre, has also been preserved in a septarium.[2] The specimen of Sowerby's pl. 293 has evidently been knocked out of a similar rock, and the second fragment has a similar matrix.[3] On the other hand, we may naturally look for such specimens in localities where Corallian rocks are represented by clays, and especially where septarian doggers are recorded as occurring. Such are found near the summit of the Corallian clays at Ampthill (see Woodward, "Jurassic Rocks of Britain," vol. v, p. 136).

From these considerations we may safely conclude that the fossils figured as *A. biplex*, but usually called *A. plicatilis*, are the inside whorls, very likely broken out of the middle, of larger specimens called *A. varicostatus*. The latter retain the old age characters, though such characters are common to several species. There

[1] The spelling of Buckland, probably an oversight, as corrected by Phillips.
[2] Supposed at first to be from Osmington, but this shows that it was not so.
[3] After the proof afforded by Mr. Crick of the Cornbrash age of *Nautilus truncatus*, stated by Sowerby to be from the Lias of Keynsham, we cannot place too much reliance on the localities given by the latter.

is the same association of inner and outer whorls at Headington, Malton, Pickering, and elsewhere, at least in different specimens. The most perfect representation of this species is the figure given by D'Orbigny under the name *A. biplex* on tab. 191, 192 of the Terr. Jurassique, corresponding in every respect down to the smallest size with my own specimen.[1] It corresponds also with the sutures as drawn by Miss Healy, if these were taken from the opposite side of the shell, were drawn in the usual manner with the lobes pointing downwards, and shaded dark in contrast with the saddles. The suture-line is rather remarkable for the breadth of the dorsal saddle, and I doubt it would ever broaden out from such as characterize *A. plicatilis* of Sowerby, though we must allow *some* liberty to the poor Ammonites while growing.

As to the name that is to be applied to this fossil, I must leave that to those who are more interested in the question, for there is plenty of choice. If we could be sure that *Nautilus colubrinus* of Reinecke, which came from Staffelstein, had an old age like that of ours, its name might be the earliest (1818); on the same condition *A. planulatus* of Schlotheim might be the next (1820). Sowerby's name of *biplex* was the earliest English name (1821), but it included only the earlier whorls. *Am. instabilis* of Phillips (1829–35) was the next, but it was not very fully described and it was unaccompanied by a figure.[2] Buckland in 1836 gave the first complete description and figure as *A. varicostatus*. D'Orbigny, in 1846 (?), figured it as *A. biplex*, but described it in the text as *A. plicatilis*; and finally Oppel in 1862 divided it and gave the name *A. Martelli* to the perfect form. For myself I think that the use of Buckland's name, though it has not the priority, would cause the least confusion, in which case both of Sowerby's names might become obsolete, as ill-distinguished and of doubtful reference. Possibly the object of nomenclature may not be, after all, the establishment of the earliest and least understood names, but the prevention of confusion as to what you are talking about.

IV.—Further Notes on the Trias of Devonshire, with special reference to the Divisional Line between the Bunter and the Keuper in that region.

(Reply to some Criticisms by Mr. Alexander Somervail.)

By Alexander Irving, D.Sc., B.A.

Mr. ALEXANDER SOMERVAIL has been so good as to send me lately a paper read by him before Section C of the British Association at Southport, September, 1903, and printed in the Geological Magazine, Dec. IV, Vol. X, No. 472, October, 1903. The paper contains certain criticisms on the published work of

[1] It is marked as triplicate, but obviously it is usually biplicate.

[2] In 1874, in the 3rd edition of the "Geology of Yorkshire," this name was abandoned for Buckland's, reference being made to "pl. xiv, fig. 10," but the reference is obviously to the "Geology of Oxford," where it is figured with Buckland's name in the legend.

Professor Hull, F.R.S., and myself among the Red Rocks of the South Devon coast, with especial reference to "the Base of the Keuper in South Devon." I desire to reply here to Mr. Somervail, and in so doing shall have to refer frequently to the three papers of my own published in the Quarterly Journal of the Geological Society in the years 1888, 1892, 1893, and to the paper by Professor Hull in the same Journal in the year 1892. For the sake of convenience and brevity I will refer to these papers by certain letters, as below.[1]

Mr. Somervail states (p. 460): "There is only one point in which I differ from these authors; it is in relation to the rocks forming the base of the Keuper in this area." He states further that "in the last of these papers both authors agree to regard certain breccias occurring at the mouth of the river Otter, and again at the mouth of the Sid on its eastern side, as the basement beds of the Keuper." This is not quite an accurate statement, seeing that the base of the Keuper along the Otter Valley was definitely worked out by me after Professor Hull's paper (H) was published, and the results given in paper C a year later. In the discussion which followed the reading of paper C at the Geological Society Professor Hull repeated his assent to my reading of the district so far as the basement-line of the Keuper was concerned; and at the same time gave up his previous contention that the great marl series of the district further west, and below the Budleigh Salterton Pebble-bed, was the representative in the Devon area of the Lower Bunter of the Midlands and the Severn country.[2]

Mr. Somervail tells us that I have described the breccias near the mouth of the Otter "as calcareous or dolomitic breccias or conglomerates." Here there are two slight inaccuracies; for (1)

[1] (A) A. Irving, "The Red Rocks of the Devon Coast-Section": Q.J.G.S., vol. xliv (May, 1888).

(B) ——— "Supplementary Note on the Red Rocks of the Devon Coast-Section": Q.J.G.S., vol. xlviii (Feb. 1892).

(C) ——— "The Base of the Keuper Formation in Devon": Q.J.G.S., vol. xlix (Feb. 1893).

(H) E. Hull, F.R.S., "A Comparison of the Red Rocks of the South Devon Coast with those of the Midland and Western Counties": Q.J.G.S., vol. xlviii (Feb. 1892).

[2] In a letter to me afterwards Professor Hull went even further, and declared himself inclined to view, in the light of these later facts, all the so-called Lower Bunter of the Midlands as more closely related to the Permian than the Trias. For my part, I should, in the light of my work in Central Germany in 1883 (see Q.J.G.S. for August, 1884), hesitate to go so far as that. It would tend to drag us back into the Murchisonian confusion of thought, arising from insufficiency of observation, which it was the definite purpose of that paper (and of one supplementary to it in the Geol. Mag. of that year) to clear away. My contention was, and is, simply that the marl series of Devon are the equivalents of the identically similar marls, which are interbedded with the Magnesian Limestone beds of the Permian in the regions to the east of the Pennine Chain, and conspicuously so in Notts; and that the Lower Bunter of the Midlands is wanting in the basin south of the Mendip Axis, even as Professor Hull, in his work on "The Permian and Triassic Rocks of the Midland Counties," has shown it to be wanting in various successions in the Severn country, to which references are given in my papers. See further my paper "Twenty Years' Work at the Younger Red Rocks" (Geol. Mag., August, 1894).

I have never described (I believe) the breccias as 'dolomitic,' and (2) I am not aware that I ever spoke of them as 'conglomerates'; on the contrary, I took particular pains in recording my close observations of the *breccia* at the Otter mouth (A, p. 153) to show that it could not be called a conglomerate, on account of the extreme paucity of rounded included fragments. Further, I had no evidence of the presence of magnesium carbonate in the rock, without which the term 'dolomitic' would not be justified.

We come now to the main point. Mr. Somervail goes on to say: "This description *certainly does not* apply to the alleged breccias on the left bank of the Sid," emphasizing by italics this categorical denial. This requires severe examination.

Mr. Somervail's caricature of my description of the breccias (*supra*) does not apply with scientific precision to either of them at the mouth of the Sid or the mouth of the Otter; but my description applies to them at both places, although at the Sid there is just this difference, that the breccia is not so massively developed, and is not quite so strongly calcareous, owing probably to the fact that the carbonate of lime has been partly leached out from the matrix by longer exposure. I have, as I write, lying before me *six specimens of the breccias in question*,[1] which were labelled at the time when my work in Devon was done, and have only lately been again brought to light. Four of these are labelled "Basal Breccia of the Keuper, left bank of the Otter," and on two of these is written the reference "Q.J.G.S., vol. xliv, 153" (paper A); the fifth is labelled "basal breccia of the Keuper at Harpford"; and the sixth is labelled "Calcareous breccia, base of the Keuper, mouth of the Sid." Of these specimens, as judged by the rough test of the same dilute acid, the one from Harpford and two of those from the Otter mouth are very strongly calcareous (one, indeed, to such an extent that the matrix is in places macrocrystalline); the specimen from the mouth of the Sid effervesces rather less strongly with the acid than those, but more strongly certainly than the remaining two specimens from the Otter mouth. Again, a comparison of them reveals the fact that while the breccia-structure of the specimen from Harpford and of two of those from the Otter is more conspicuous than in that from the Sid (owing to the larger size of the contained fragments), in the remaining two from the Otter that is not the case. I need not repeat here what I wrote some fifteen years ago as to my hesitation to fix upon the Sid breccia as the base of the Keuper at that spot, until confirmed in that view by so experienced an observer as Professor Hull, who brought to the subject his trained experience of more than twenty years' work in the Red Rock Series of the Midlands and the Severn country. But I may add that, in my annotated copy of paper A, I find the following marginal note, made at the time of my visit with Hull:—"There is a more definite breccia (true base of the Keuper) forming the shelf of rock, on which the ladder rests at the eastern end of the foot-bridge across

[1] These were exhibited at the meetings of the Geological Society when my papers were read.

the Sid. It contains fragments of grit and quartzite, and is calcareous."[1]

So the bed described by Professor Hull (H, fig. 2) as "a basement-bed of hard calcareous breccia" may be seen to be no fiction, as is implied in Mr. Somervail's remarks. The hammer told me it was *hard* as compared with these red rocks in general. Recollecting that the rocks which furnished the fragments lay probably to the westward, we should expect to find the brecciated structure less pronounced, and the rock itself more feebly developed, as we work eastwards.

Mr. Somervail makes a remark in his paper (p. 460) as to difference of the line of strike of the beds in the Otter and the Sid valleys. That is, however, but a glimpse of the obvious, it adds nothing to evidence either way and need not detain us.

He goes on to say: "The Otterton breccias are not again brought up . . . . at the fault at the Chit rock." Of course they are not found there on the east side of the fault, but that rock—as both Hull and I have recognised, and as sections in and about Sidmouth show to an unprejudiced observer—*is Bunter*, and therefore at a lower horizon in the series. They do not, however, "occupy a much lower horizon," though they are hidden (doubtless) underground some distance below sea-level, as my reading of the section implies, on the western side of the fault; and they crop out in the Otter Valley two miles to the west at about 70 feet O.D. at places mentioned in paper C, just as we should expect, when the faulting visible in the cliff-section (to which I have drawn attention in my three papers) and the slight easterly dip of the Lower Keuper beds between the Chit Rock fault and the Otter are allowed for. Mr. Somervail appears to have overlooked the faulted synclinal (A, p. 152) visible in the Keuper strata to the west of the Chit Rock fault; but even allowing for that, I do not think I have greatly over-estimated the fault-throw at the Chit itself, with its mural western face; the estimation being based on a comparison of what is seen at the Chit Rock and to the west of it, with what is seen in the open daylight succession in the cliffs to the east of the Sid; and I venture to say there need be no great difficulty in establishing the identity of horizons on both sides of the valley in which Sidmouth lies if the observations recorded in my paper A (pp. 150, 152) are duly considered. It is extremely unlikely that, if we could restore the strata which have been destroyed in the erosion of the intervening valley of the Sid, and restore the rocks on either side of the fault to their original planes of deposition, we should find the 150 feet or so of strata marked by calcareous concretions (A, p. 150) thinning out in such a series of strata to the

[1] I recollect noticing at the time how the mouth of the Sid was blocked by a dam of shingle, through which the water percolated in reverse directions at high and low tide. Is it worth while to ask if, in the course of fifteen years or so, this shingle-bank may not have been driven by tidal action further east, and covered up the lower portion of the section as Hull and I saw it, with the obliquely bedded Bunter Sandstone below the breccia? That question any resident in the locality can answer for himself.

few feet which Mr. Somervail's computation requires in a distance of less than half a mile, unless we assumed some great unconformity and overlap, of which there is no evidence so far as I know.

Mr. Somervail's statement (p. 461) "From Otterton Point *eastwards* these [the Otterton] breccias are overlain by a series of red sandstones," etc., is misleading. No such succession exists, since from Otterton Point the coast trends *nearly due north*, and therefore nearly along the line of strike of the beds. To truly estimate the thickness of that series—in which I have definitely recognised (paper C) the basement beds of the Keuper, with the Otterton breccia marking their downward limit—we must take a *section due west from the Chit Rock fault to the Otter*, a distance of only two miles, instead of that of four or five miles along the line of coast. No one has thought of applying (as he seems to suppose [1]) "the term breccia" to these sandstones, but near their base, in sections described by me in the Otter Valley (paper A, p. 153, and paper C, pp. 80, 81), they have the character, not of breccias, but of "brecciated sandstones," the contained fragments being sparsely scattered in the rock, while even the basal breccia itself is here and there repeated in them for a short distance in the upward succession. I have also noted (paper A, p. 149) that on the eastern escarpment of the Sid (above the breccia at that place) the same current-bedded sandstones (which in paper A were erroneously referred to the Bunter, but in paper C were referred to the Keuper basement beds) are "slightly brecciated," and contain subordinate "current-bedded breccias in a marly matrix, the contained fragments being mostly of indurated red marl." [2] These fragments may with little doubt be considered as derived from the red marls of the Permian; and their presence (if that derivation be admitted) tends to emphasize the stratigraphical break, as I have maintained in my papers as existing below the great pebble-bed, which runs inland from Budleigh Salterton, and constitutes the *terrain* of the Aylesbere Hills.

It is not clear to my mind what Mr. Somervail may mean when he says (next paragraph), "The effect of the fault at the Chit rock is to bring up . . . . the higher portion of these current-bedded sandstones." If he means that the Chit Rock is a portion of them, both Hull and I are at direct issue with him; if he does not mean that, it is difficult to see the logical force of the remark. Of course, the beds on the east of the Sid are "higher in the series" than those of the Chit Rock, according to the recognised succession of the Bunter and Keuper everywhere. At the bottom of p. 461 he seems to dogmatise as to the thickness of the sandstones east of the Sid, without, so far as I can see, any data as to the limit of their downward extension. Perhaps it may be useful to append here the

[1] Had he weighed the meaning of the footnote to p. 153 of paper A, he might have seen that it was intended to suggest an explanation of the "nobbly and concretionary structure" of which he makes mention. I observed it as a later development on the face of the cliff (?). Those familiar with the splendid natural sections of the Himlack Stone (Notts) will see the force of this all the better.

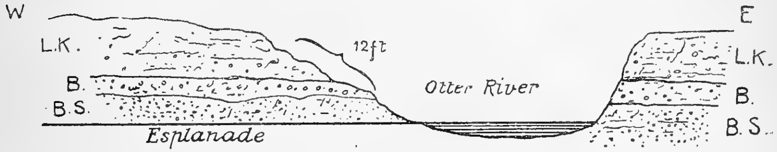
[2] From my notebook.

following note (transcribed from my notebook) made on the spot in September, 1887:—

"*Escarpment of the Sid.*—Massive false-bedded sandstones; intercalated marly beds, very strongly false-bedded and brecciated (mainly with indurated fragments of red marl). Just east of the Sid [in the coast-section] the same (marls more developed with pale-green layers); next sandstone of pale-grey colour (though reddened on the cliff-face by rain-wash) containing angular fragments of dark-red marl, the surfaces of these being grey, from the leaching out of the irony colouring matter."

Here we have a record surely of evidence indicating the gradual transition from shallower to deeper water at the time of deposition of the beds in question. These more or less brecciated false-bedded sandstones I take to be on the same horizon as those near the base of High Peak Hill, where in the Lade Rock they visibly underlie the more compact and massively bedded sandstones, so characteristic of the Lower Keuper, both in the Devon sections and in the Midlands (see paper A, pp. 150,[1] 151), and are in one or two places bored through by the surf. The same succession may be observed at Badfield's Point, beyond which, as we follow the coastline (trending in a S.S.W. direction), these irregularly bedded soft sandstones form

Section across the River Otter near Otterton Point, Devon.



L.K. Lower Keuper basement-beds, in which pebbles and fragments are sparsely scattered. B. Breccia. B.S. Bunter Sandstone.

the cliff-face all the way to Otterton Point. There we recognise below the breccias the reappearance of the Bunter beds, which are faulted up at the Chit Rock and described by me (see paper A, p. 153, and C, p. 81). Mr. Somervail (p. 462) speaks of these breccias as "only a small portion of still lower beds of the same nature seen on the west side of that [the Otter] river, and extending along the Promenade" at Budleigh Salterton. In this I am unable to follow him. In my notebook I find the accompanying sectional drawing across the Otter, made on the spot, which represents the breccia with the overlying brecciated sandstones as exposed on the same horizon in the Esplanade section. The beds below these I have already relegated to the Bunter of the section further to the west (paper A, p. 153). It reminds one of sections in the Nottingham district.

In conclusion, I cannot admit that Mr. Alexander Somervail has attained the object of his paper in showing "sufficient evidence for the conclusions that the Sidmouth section has been misread by

[1] There is a misprint in line 10, p. 150, where "more fully developed" should read "more feebly developed."

Professor Hull and Dr. Irving." By the irony of fate he has chosen for the reading of his paper the very place (Southport) at which a paper by the present writer (after a Summer's work in Germany) carried conviction to the mind of Professor Hull as to the true divisional line between the Permian and the Trias in England and on the Continent. See Report of the British Association, Southport Meeting, 1883.

Mr. Somervail has been good enough to send me also a copy of a paper read at Sidmouth last Summer.[1] There is much in that paper that one appreciates, and not much to criticise beyond what one has already dealt with. He seems, however, to speak of the 'Waterstones' as forming the base of the Keuper in the Midlands, which scarcely harmonises with the use of that term by previous writers, and notably by Professor Hull in his classic memoir on the Permian and Trias, to which reference has been made above. It does not reveal any intimate acquaintance on the writer's part with the Midland Red Rocks, or even with inland sections of the Devon series.

As to Mr. Somervail's failure and that of his "friend who was visiting Sidmouth" to find the breccia east of the Sid, no more remains to be said here, each reader being left to draw his own inferences. I must, however, traverse his statement that "the succession of beds above it" is not the same in both sections (of the Otter and the Sid). A perusal of the remarks in the foregoing paper will show why here I am also at issue with him. I admit that there is not such a full development of the false-bedded basement beds of the Keuper in the Sid section as in the Otter sections $2\frac{1}{2}$ miles further west; but that is only a *quantitative* difference, not at all surprising in these red rocks considering the conditions under which they were deposited. He speaks of an "alleged fault" at the Chit Rock, when the existence of the fault is "as plain as a pike-staff" (or was 15 years ago) to any unprejudiced observer. Of course, the sequence east of the Sid is not repeated at the Chit, because the beds have been destroyed by the erosion of the valley in which Sidmouth lies.

V.—The Upper Chalk of North Lincolnshire.

By Arthur Burnet.

In the Summer of 1902 I commenced an exploration of the chalk-pits on the eastern border of the Lincolnshire Wolds, starting at Louth and working northward. Mr. W. Hill had previously visited this locality, and had proved the existence of the zone of *Holaster planus* at Boswell, three miles north-west of Louth, and also at Kirmington, much farther north.[2] Mr. Jukes-Browne

[1] "The Red Rocks of the South Devon Coast," by Alexander Somervail (Transactions of Devonshire Association for the Advancement of Science, etc., vol. xxxv, pp. 617–630).

[2] W. Hill, "Note on the Upper Chalk of Lincolnshire": Geol. Mag., Dec. IV, Vol. IX (1902), p. 404.

suggested to me that I should try and obtain fossils from the intermediate pits, and thus extend the work commenced by Mr. Hill. As the result of visits to about thirty pits, ranging from near Louth to Barrow-on-Humber, I have obtained further evidence of the zone of *Holaster planus*, and also some indications of the zone of *Micraster cortestudinarium*.

I was unable to find any other sections showing beds which could be regarded as the exact equivalent of those seen at Boswell. These latter probably belong to the lowest part of the *Holaster planus* zone, and the palæontological evidence now available seems to show that the outcrop of the base of this zone lies further west than was originally supposed to be the case. In the quarry at Boswell (from which Mr. Hill obtained *Holaster planus, Micraster Leskei*, and *Ananchytes scutatus*) I found a good specimen of *Holaster placenta* and a *Micraster* (species doubtful).

The quarry at Acthorpe, a mile and a half north-west of Louth, is the most southerly point in Lincolnshire from which Upper Chalk fossils have been obtained. There I found the following:—*Inoceramus Cuvieri, Rhynchonella limbata, Rhynchonella Cuvieri*, and *Terebratula carnea. Infulaster eccentricus, Echinoconus globulus*, and *Rhynchonella limbata* had been previously found here by Mr. Rhodes, of the Geological Survey.

The beds exposed in the quarry three-quarters of a mile west-south-west of Fotherby are typical of those seen in most of the pits to be afterwards mentioned in this article. The section is as follows:—[1]

	ft.	in.
Broken white chalk	4	0
Layer of grey fuller's earth	0	3
Hard white chalk with flint nodules	6	0
Course of continuous flint	0	6
Hard creamy chalk without flints	8	6

Here I found several fossils, viz.:—

Serpula, sp. (small spiral).
Holaster planus.
,, *placenta*.
Goniaster (ossicle).
Cyphosoma (spine).
Terebratula carnea.
Terebratulina lata.
Kingena lima.
Rhynchonella Cuvieri.
Ostrea normaniana.
,, *vesicularis*.
,, sp.
Inoceramus Brongniarti?
Plicatula sigillina.
Septifer lineatus.

A pit near Fotherby Grange, and about three-quarters of a mile north of the above, yielded the following:—

Serpula, sp. (small spiral).
Terebratula carnea.
Terebratulina lata.
Rhynchonella Cuvieri.
Holaster planus?

A pit half a mile north-west of Lambcroft shows white chalk with flint bands of a peculiar nature, the flint being intermingled with lumps of white chalk. I found here *Rhynchonella Cuvieri, Kingena lima*, and a spine of *Cidaris perornata*.

[1] "Geology of part of East Lincolnshire," p. 69.

Similar beds also occur in the upper part of a pit a quarter of a mile south-west of North Ormsby. At the base of the pit, below the lowest band of imperfect flint, there is a bed of cream-white chalk, which yielded *Micraster Leskei.* Other fossils found in this pit were:—

Holaster, sp.
Magas pumilus.
Rhynchonella Cuvieri.
Terebratulina lata.
Ostrea vesicularis.
,, sp.
Inoceramus, sp.

It is not improbable that the upper beds of this pit, together with those seen at Lambcroft, belong to the zone of *Micraster cortestudinarium.*

A quarry half a mile east-south-east of North Ormsby yielded the following:—

Terebratula carnea.
Kingena lima.
Terebratulina lata.
Rhynchonella Cuvieri.
Inoceramus Cuvieri.
Holaster placenta.

Another quarry in the same village, to the north of the church, showed a similar section to that seen at Fotherby, with the following fossils:—

Terebratula carnea.
Rhynchonella Cuvieri.
Serpula, sp. (small spiral).
Ananchytes scutatus.
Inoceramus, sp.

The same lithological features were visible in a large quarry about half-way between North Ormsby and Wyham, from which I obtained *Rhynchonella Cuvieri, Kingena lima, Holaster planus* (or *placenta*), and a spine of *Cidaris.* I also found spines of *Cidaris sceptifera* in a small pit at Wyham.

There are two quarries at Cadeby, both of which show a course of the imperfect flint previously mentioned. The only fossil that I could find was *Ostrea vesicularis*; the lithological character of the beds, and their extremely unfossiliferous nature, suggest the possibility that they belong to the zone of *Micraster cortestudinarium.*

Further west, in a quarry at Wold Newton, I found *Magas pumilus, Rhynchonella Cuvieri, Holaster planus*, and *Inoceramus*, sp.

Few fossils could be found in the pits at Hawerby, Ravendale, and Hatcliffe. At Hawerby I found *Terebratula carnea, Ostrea vesicularis*, and *Inoceramus*, sp. From East Ravendale I obtained a broken echinoderm, which is possibly *Ananchytes scutatus.*

The quarry near Beelsby Church yielded *Terebratula carnea, Rhynchonella Cuvieri*, and a species of *Inoceramus.*

The quarry half a mile south-west of Irby Church shows a section of hard chalk with tabular flints, and scattered flint nodules. Here I found:—

Holaster planus (or *placenta*).
Terebratulina lata.
Rhynchonella Cuvieri.
Spondylus latus.
Inoceramus Cuvieri.

Continuous bands of dark flint are also seen in a pit to the south-east of Riby. The fossils found here were *Holaster planus* (or *placenta*) and *Rhynchonella Cuvieri.* Judging from the easterly position of this quarry, and also that at Irby, it seems possible that they are in the zone of *Micraster cortestudinarium.*

The quarry a quarter of a mile west of Great Limber Church is of interest, as it yielded some rather striking specimens, viz.:—*Infulaster eccentricus, Parasmilia centralis, Rhynchonella octoplicata,* and *Rhynchonella Cuvieri.* The *Infulaster* is a fine well-marked specimen, and is the second which has been found in Lincolnshire, confirming the occurrence of the species at this low horizon.

In another pit about half a mile east-south-east of the same village I found *Spondylus latus, Terebratula carnea,* and *Ananchytes scutatus.*

From the quarry at Limber Parva I obtained *Holaster planus* (or *placenta*) and *Serpula*, sp. The section here is very much overgrown, and a better exposure of the same beds is to be found in the quarry half a mile south-east of Kirmington, where Mr. Hill obtained *Holaster planus.* I also found here a specimen of that echinoderm, together with *Inoceramus Cuvieri, Kingena lima,* and *Rhynchonella Cuvieri.*

In a quarry three-quarters of a mile south of Ulceby I found *Magas pumilus, Terebratula carnea, Rhynchonella Cuvieri* (or *reedensis*), and *Ostrea vesicularis.*

The quarry a mile west of Ulceby shows soft white chalk with flint nodules and several layers of imperfect flint similar to those seen at Lambcroft and Cadeby. The fossils obtainable here have consequently a special interest, and those I found were:—

Micraster cortestudinarium.
Holaster planus (or *placenta*).
Ostrea vesicularis.
Rhynchonella reedensis.
Terebratulina lata?
Rhynchonella Cuvieri.
Terebratula carnea.

It is probable that this pit and the tract of chalk which lies between Ulceby and Barrow is in the zone of *Micraster cortestudinarium.*

Similar beds with tabular flints are seen at Wootton, and also in a large quarry three-quarters of a mile west of Thornton, but the only fossils found were:—*Inoceramus Cuvieri, Rhynchonella Cuvieri, Rhynchonella reedensis?* and *Terebratulina*, sp.

From a large quarry south of Barrow I obtained a number of fossils as follows:—

Terebratulina lata.
Terebratula, sp.
Magas, sp.
Kingena lima.
Rhynchonella Cuvieri.
Rhynchonella reedensis.
Holaster placenta.
Echinocorys (*Ananchytes*) *scutatus.*
Inoceramus, sp.

Although the exact correlation of these beds with the chalk zones in other parts of England is necessarily a matter of some difficulty, Mr. Jukes-Browne considers that the palæontological evidence which I have obtained establishes the existence of the zones of *Holaster planus* and *Micraster cortestudinarium* in North Lincolnshire. The extreme rarity of fossils, and the fact that we have to deal with isolated exposures separated from each other by a distance of a mile or two, renders it an extremely difficult task to fix the dividing lines between the two zones and between the Middle and Upper Chalk. Further research in this district will no doubt throw additional light upon this subject and help to solve some of the still doubtful problems respecting the Lincolnshire Chalk.

All the fossils referred to in this article have been examined and named by Mr. Jukes-Browne, to whom I am in many ways greatly indebted for advice and assistance.

CLASSIFIED LIST OF FOSSILS.

Lamellibranchiata.

Inoceramus Cuvieri, Sby.
,, *Brongniarti*, Sby.
,, (an unnamed species).
,, sp.
Spondylus latus, Sby.
Plicatula sigillina, Woodw.
Septifer lineatus, Goldf.
Ostrea vesicularis, Lam.
,, *normaniana*, d'Orb.
,, sp.

Brachiopoda.

Rhynchonella Cuvieri, d'Orb.
,, *limbata*, Schloth.
,, *reedensis*, Eth.
,, *octoplicata*, Sby.
Kingena lima, Defr.
Terebratula carnea, Sby.
Terebratulina lata, Eth.
Magas pumilus, Sby.

Echinodermata.

Micraster Leskei, Desm.
,, *cortestudinarium*, Goldf.
,, sp.
Cyphosoma, sp.
Goniaster, sp.
Infulaster excentricus, Forbes.
Holaster planus, Mant.
,, *placenta*, Ag.
Ananchytes scutatus, Leske.
Cidaris sceptifera, Mant.
,, *perornata*, Forbes.
,, sp.

Annelida.

Serpula, sp. (small spiral).

Actinozoa.

Parasmilia centralis, Mant.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom.

The Cretaceous Rocks of Britain. Vol. II: The Lower and Middle Chalk of England. By A. J. Jukes-Browne, with contributions by William Hill. 8vo; pp. xiii, 568, map, 8 plates, illustrated. (London, 1903. Price 10s.)

The first volume of this series of memoirs on the Cretaceous Rocks was reviewed at considerable length in the Geological Magazine for February, 1901. In that review some idea of the plan of the work was given, and it will now only be necessary to sketch the contents of the present volume, which brings the subject-matter up to the zone of *Terebratulina gracilis* in the White Chalk.

The volume opens with a general account of the Chalk as a whole and a history of its subdivision into parts; an account of considerable historical interest and valuable as defining the position taken by the authors in dealing with their subject.

Defining next the 'Lower' Chalk, the authors point out that this is divided into two zones, that of *Ammonites varians* and that of *Holaster subglobosus.* They also include in the latter the *Actinocamax plenus* marls, which "do not constitute a zone, and have no distinct zonal fauna," and they follow with a description and lists of the fossils which are characteristic of the beds.

Chapter iii deals with the 'Lower' Chalk of the Kentish coast, the classical section of which is to be found between Folkestone and Dover, and was the subject of the especial study of Mr. Hilton Price, who divided the two zones up into nine beds. Some slight modifications of Mr. Price's work is suggested; beds 3 and 4 are united, but the rest seem to have stood the test of recent research. Leaving the coast, a general description of these beds in the inland parts of Kent and Surrey is given, and Hampshire and Sussex are similarly treated, attention being called to the section between Beachy Head and Eastbourne, the beds in which are, however, too much disturbed to allow of a definite section being given.

Chapter vii introduces us to the Isle of Wight, and includes several important observations both as to the sections and the fossils, made since the second edition by Strahan and Reid of the memoir on that island, which was published in 1889. It is pointed out that the use of the words "Chloritic Marl" is continued because it is convenient and has been so long in use, but at the same time the green grains are not chlorite and the matrix is not a marl.

Chapters viii–xix deal in similar manner with the counties of Dorset, Somerset, Devon, Wilts, Berks, Oxford, Bucks, Beds, Herts, Cambridge, Suffolk, Norfolk, Lincolnshire, and Yorkshire; and Chapters xx and xxi provide a useful sketch of the beds of similar age in the north-east and north-west of France.

The Middle Chalk (the lowest beds of the White Chalk) is defined as consisting of the zones of *Rhynchonella Cuvieri* and of *Terebratulina.* This latter zone has long been known as the zone of *Terebratulina gracilis,* but Dr. Kitchin is quoted as pointing out that the true *gracilis* is confined to the higher beds of the White Chalk, and that the form so common in the *Terebratulina* zone seems to be that called *T. gracilis,* var. *lata,* of Etheridge. The 'Middle' Chalk is then described in similar detail to the 'Lower' Chalk, the authors proceeding county by county and tabulating a vast amount of valuable material in the several chapters. We see here for the first time the influence of the careful zoological work done in recent years by Dr. Rowe, of Margate, whose collecting has more definitely proved the boundaries of the several zones of the White Chalk. The 'Middle' Chalk portion of the memoir closes with a chapter on the French equivalents, allowing a comparison to be made at once useful and convenient.

Chapters xxii, xxiii and xlii, xliii are written by Mr. Hill, and treat of the microscopical structure of the rocks described in the memoir. Mr. Hill describes the macroscopic aspect of the rocks and the microscopic aspect of thin sections, giving photomicrographs on pls. iv–viii. He describes the examination of the residues after washing, lists the minerals found, and tabulates the results. He gives a summary of the chemical analyses, and lists the Foraminifera, the species of which were determined by Mr. Chapman. The amount of valuable information thus brought together enables the authors to discuss the "Evidence of current action at the base of the Chalk," "Limits of the Chalk Sea," "Sedimentation," and the "Depth of Water" beneath which the several zones were accumulated. This last consideration is naturally a difficult problem, and no definite statement is possible. But the general considerations drawn from recent sources and the internal evidence available for observation "make it probable that the Chalk marl of the south-eastern and south-central counties was formed at a depth approaching, but probably rather less than 400 fathoms." Quoting Dr. Hume's conclusions, the authors continue—"it would seem that in passing upwards from the Chalk marl to the beds of nearly white chalk which underlie the Belemnite Marls, we are tracing the effects of a subsidence which carried the area through the bathymetrical limit of 400 fathoms, and that the zone of *Holaster subglobosus* was formed in water which finally approximated to a depth of 500 fathoms." Passing on to the lower beds of the White Chalk, the authors admit that the difficulties are greater. "No inference as to depth can be drawn from consideration of the mineral particles," beyond that "it [the 'Middle' Chalk] was formed in clear water of some depth at a considerable distance from land and in a region where there were no volcanoes." The evidence of the animal life seems to be conflicting, according to our present-day knowledge, and "it is very probable that during part of the Middle Chalk time the depth exceeded 500 fathoms; but . . . . there seems to have been a recovery by upheaval during the formation of the Chalk rock (zone of *Holaster planus*), consequently the time of greatest depth was probably that when the lower part of the *Terebratulina* zone was being accumulated."

II.—Grundzüge der Paläontologie (Paläozoologie), von Karl A. von Zittel, Professor an der Universität zu München. Abtheilung I: Invertebrata. Zweite verbesserte und vermehrte Auflage. Mit 1405 in den Text gedruckten Abbildungen. München und Berlin, Oldenbourg, 1903.

Textbook of Palæontology (Palæozoology). By K. A. von Zittel, Professor at the University of Munich. Part I: Invertebrata. Second edition, revised and enlarged, with 1405 figures printed in the text. 8vo; pp. viii, 558. (Price 16*s.* 6*d.*)

THAT a second edition of a work so valuable to all students of Palæontology as the "Grundzüge" of the late Professor von Zittel should be called for, after the lapse of nine years since the issue of the original, is not a matter of surprise. It is greatly to be lamented that the author should have been snatched away by his fatal malady whilst the revision was in progress, so that he was only able to complete the first part, relating to the Invertebrate fossil fauna, and see it through the press. On account of the increased amount of subject-matter this new edition is to be brought out in two volumes, the first of which is now before us; it is furnished with an index so as to be complete in itself.

It is well known that about four years ago an English translation of the "Grundzüge" appeared under the title of "Textbook of Palæontology." It was edited by Dr. C. R. Eastman, of Harvard University, a former student of von Zittel, assisted by several collaborators, who were, with two exceptions, American authorities of special eminence in their respective subjects. By these authors most of the fossil groups in the "Grundzüge" were revised to such an extent that the system of classification in the new Textbook could not rightly be claimed as the same as that in the "Grundzüge." And that it was so regarded by American palæontologists is shown in a published review of it, by one of their number, from which the following is an extract:—

"Palæontological science is certainly beholden to Wachsmuth, Sladen, Ulrich, Schuchert, Dall, and others for their labours of love in trying to make this an authoritative and trustworthy textbook. How well they have succeeded remains to be determined after the book has been used in the laboratory. The improvement is so marked over the German edition, the 'translation' contains so little from the original, and the 'revision' is so complete, that the question naturally arises whether Dr. Eastman could not just as well have gone a little further in his work and made it a textbook by American authors, which would have held the same place among English-speaking people as the original Handbuch does among Europeans."[1]

That Professor von Zittel did not agree with the extensive and important alterations introduced in the translation (so-called) of his "Grundzüge" is shown in his preface (in German) to the Textbook, in which he points out some of the difficulties and discrepancies resulting from the collaboration of a number of specialists whose views on systematic classification agreed neither with his own nor with each other. As a specially unfortunate instance he quotes the fact that in the Textbook the Chætetidæ and Fistuliporidæ are in one part treated as belonging to Corals and in another referred to the Bryozoa! In this new edition, moreover, von Zittel rejects most of the alterations made in the Textbook, and holds fast to the classification of the first edition of the "Grundzüge," which is more in accord with the views of German palæontologists than with those of America.

Without pretending to any detailed criticism, a few remarks may be made on the contents of this volume. And, first, it is noticeable that no addition or alteration appears to have been made in the description and distribution of Foraminifera, Radiolaria, and Porifera, which remain the same as in 1895, though we should have looked for some reference to the fresh discoveries of Radiolaria in the

[1] Journal of Geology, Chicago, vol. iv, 1896, p. 738.

Palæozoic rocks of this country and other regions in the interval; and no mention is made of the occurrence of fossil representatives of the Lithonine Calcisponges.

In the chapter on the Corals a valuable addition has been made by the very clear description of the microscopic structure of their skeleton, accompanied by excellent figures, which has been contributed by Mrs. Dr. Ogilvie Gordon. Von Zittel still retains the Tetracoralla or Rugosa as a distinct order of the Madreporaria sclerodermata, on the ground of its possessing a combination of characters, including that of the feather-like arrangement of the septa, which never occur in the Hexacoralla. The classification of the Hexacoralla follows the system of Dr. Ogilvie Gordon, and the Aporosa and Perforata are not continued as independent groups.

The families of the Favositidæ, Chætetidæ, and Monticuliporidæ are placed, with some others, near the Alcyonaria, but their systematic position is considered doubtful. The Monticuliporidæ and its allies are treated very briefly, in strong contrast to the elaborate description of the group by Ulrich in the Textbook, where they are referred by him to the Bryozoa, and the evidence strongly supports this view of their position.

The recent work of Bather and of Jaekel on the Cystoidea has necessitated a rearrangement of this division, which is now placed in the orders of Thecoidæ, Jaekel, Carpoidæ, Jaekel, and Hydrophoridæ, Zittel.

The classification of the Brachiopoda in the first edition of the "Grundzüge" was based on that of Thomas Davidson, and it is continued substantially the same in the present one, though, of course, due mention is made of the systems of Beecher and of Schuchert, which depend mainly on the embryological features of these organisms.

Also with respect to the Cephalopoda, in the description of which the author was assisted by his friend Dr. Pompeckj, the classification of 1895 is retained with some needful modifications, and that of the late Professor Hyatt in the Textbook is passed over, the author remarking that it might be considered as an original treatise, much of which related to facts which had not previously been published.

In conclusion, we venture to think that apart from its own merits this volume will be highly valued by palæontologists as the final work of a great master of the science, who spared no efforts in his devotion to it, and died, as he had lived, in its service.

III.—The Fossil Plants of the Carboniferous Rocks of Canonbie, Dumfriesshire, and of Parts of Cumberland and Northumberland. By R. Kidston. Trans. Roy. Soc. Edinburgh, vol. xl, pt. 4 (No. 31), pp. 741–833, with 5 plates.

In the February number of the Geological Magazine (p. 82), a notice appeared of a memoir by Messrs. Peach and Horne on the geological structure of the Canonbie Coalfield of the Scottish borderland. The present paper by Mr. Kidston forms an important contribution to the fossil flora of the same district. The succession of Carboniferous rocks, both Upper and Lower, is here very perfect, ranging from the Calciferous Sandstone to the Upper Coal-measures. The presence of true Upper Coal-measures in this coalfield, with its characteristic flora, is especially remarkable. This horizon has previously only been found in Britain in the three Southern coalfields of South Wales, Somerset, and the Forest of Dean.

Mr. Kidston's paper also contains the most important contribution to the Lower Carboniferous flora of Britain which has so far been published. A large number of species are described from the Calciferous Sandstone series, or its geological equivalents, of Dumfries, Cumberland, and Northumberland. Figures of several of these plants are given, in addition to new species of *Sigillaria, Stigmaria, Pinakodendron,* and *Palæostachya,* and a new genus *Eskdalia* from various horizons.

IV.—An Attempt to Classify Palæozoic Batrachian Footprints. By Dr. G. F. Matthew. Trans. Roy. Soc. Canada, ser. II, vol. ix, sec. iv, p. 109.

New Genera of Batrachian Footprints of the Carboniferous System in Eastern Canada. By G. F. Matthew, LL.D. Canada Rec. Sci., vol. ix, No. 2, p. 99, 1903.

THESE two articles are complementary. The first is a survey of the described Carboniferous and Devonian footprints of America, with an attempt to classify them under generic heads. It was found that diverse genera had been described under one generic name, and that closely related tracks had been described under different generic names by various authors. A table is given to exemplify this; in the table the genera are divided into related groups, based on the number of toe-marks and the general aspect of the footprint. The principal authors who have described these tracks are King, Leidy, Lea, Butt, Marsh, and Dawson. The chief places where these footprints have been found are the coalfields of Eastern Pennsylvania, of Kansas, and of Nova Scotia. Some of the types are common to several of these regions.

In his second article Dr. Matthew gives figures and descriptions of a number of new genera of Batrachian footprints from the Lower Carboniferous and the Coal-measures of Nova Scotia. The smaller forms are from the Joggins Coalfield, a larger one from the coalfield of Sydney, Cape Breton, and another large one from the Lower Carboniferous of Parrsboro', N.S. The figures show great diversity of type, and justify the reference to different genera.

The material described is mostly in the Redpath Museum of McGill University, Montreal, and is a part of the large collections made by the late Sir J. W. Dawson. Three plates of figures accompany the first article and one the second.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 19th, 1904.—Sir Archibald Geikie, Sc.D., D.C.L., Sec. R.S., Vice-President, in the Chair.

Annual General Meeting.

The Chairman read the following letter which had been addressed to him by the President:—

February 9th, 1904.

"Dear Sir Archibald,

"Please kindly convey to the Council, the Officers, and the Fellows of the Geological Society my sincere regrets that I am not yet well enough to attend the Anniversary Meeting, and personally thank them for the honour they paid me in making me their President, and for their unfailing goodness to me during my tenure of office.

"I shall also be grateful if you will congratulate on my behalf the new President and the recipients of Medals and Awards; and assure the Fellows of my constant sympathy with, and faith in, the continued progress of the Society, and of my hope to be soon once more amongst them as a fellow-worker.

"Thanking Mr. Teall and yourself for your great kindness in taking over my Presidential work for me during my illness, and so relieving me of all responsibility,

"I remain, dear Sir Archibald,
Sincerely yours,
Charles Lapworth.

"Sir Archibald Geikie, D.C.L., Sec.R.S."

A telegram expressing the Society's sympathy with Professor Lapworth and good wishes for his prompt convalescence was, with the approval of all the Fellows present, despatched to him.

The Reports of the Council and of the Library and Museum Committee for the year 1903, proofs of which had been previously distributed to the Fellows, were then read.

The reports having been received and adopted, the Chairman handed the Wollaston Medal, awarded to Professor Albert Heim, of Zürich, to Mr. J. J. H. Teall, M.A., F.R.S., for transmission to the recipient, addressing him as follows:—Mr. Teall,—

The Council of the Geological Society of London have awarded to Professor Heim the highest honour which they have to bestow, the Wollaston Medal, in recognition of the value of his researches concerning the mineral structure of the Earth, and more especially of his contributions towards the elucidation of the structure of mountain-masses, as illustrated in the chain of the Alps. In his great monograph, the "Mechanismus der Gebirgsbildung," he traced with remarkable skill the influence of plication in the terrestrial crust, following this influence step by step from the distortion and fracture of organic remains in hand-specimens up to the most gigantic foldings which have comprised a vast mountain-chain in their embrace. His researches, however, have not been confined to the internal structure of the Alps. He has devoted himself with not less enthusiasm and success to the study of their glaciers and their landslips. Gifted with no ordinary artistic power, he has been able to enrich geological science with a valuable series of landscape drawings and sections, in which the intimate relations of geology and topography are admirably delineated. His latest achievement in this department is a large model of the massif of the Hohe Säntis, which was exhibited at the recent meeting of the International Geological Congress in Vienna. It was admitted by the assembled geologists to be probably the most accurate and beautiful model of a mountain-group that had ever been constructed. We may judge of the labour and enthusiasm spent on it from the fact that, besides climbing to every crest of that rugged tract, Prof. Heim made many ascents in a balloon, so as to obtain detailed and comprehensive bird's-eye views of the whole region which he wished to depict. In asking you to be so good as to transmit to him this Medal, I would request you to convey with it an expression of our warmest wishes for a long continuance of the mental and bodily activity which he has so unsparingly devoted to the interests of our science.

Mr. Teall, in reply, read the following translation of a letter which had been forwarded by the recipient:—

"I much regret that my duties here make it impossible for me to be present at your annual meeting, and that I am therefore unable in person to express my thanks for the honour which you are conferring upon me.

"It may perhaps interest you to know the circumstances which led me to turn my attention to geology. When, at the age of nine years, I visited the Alps for the first time, in company with my father, the mountains appealed to my youthful imagination, and I then conceived the idea of representing them not only on paper but also in relief. I accordingly attempted to model them in clay, working at first directly from nature, and afterwards by the aid of the topographic maps which were then appearing. I soon found that one can only represent correctly that which one understands, and I was thus led to study the internal structure as well as the external form of the mountains.

"At the age of sixteen years I had prepared a model of the Tödi group on a scale of 1 : 25,000. Arnold Escher von der Linth heard of this model, and came to see it at my own home. This was the first time that I saw that illustrious man. He invited me to accompany him on a geological excursion, and from that time onward I looked up to him as my revered master. Thus the pleasure which I derived from my early visits to the mountains and my desire to represent them in relief led me naturally to the study of geology.

"In receiving this high honour at your hands, I remember with heartfelt gratitude the instruction and encouragement that I have derived from a study of the literature and geology, and especially from personal intercourse with the fellow-workers, of the great nations which lie beyond my own small fatherland. Among these I reckon the British Empire as especially deserving of my gratitude. More than 35 years ago I derived inspiration as a student from a study of the works of Sir Charles Lyell, and since that time have continued to hold intercourse with British geologists—many of them Fellows of your Society—and to study their writings and collections.

"I am conscious that my work is very imperfect, and that in it error is mixed with truth. My life is unfortunately so overburdened with official and private duties that I have but little time for original research; yet I am filled with an earnest desire to do more, for I recognise that in such research is to be found the greatest happiness that human life can afford.

"It seems to me that the work which I have accomplished does not entitle me to this honour. I prefer rather to regard it as the recognition of a sincere effort to extend our knowledge, and I can assure you that, so far as in me lies, the remainder of my life shall be devoted to this object. You have given me a fresh stimulus—a new encouragement. I thank you from the bottom of my heart."

The Chairman then presented the Murchison Medal to Professor George Alexander Lebour, M.A., M.Sc., addressing him in the following words:—Professor Lebour,—

The Council have this year awarded to you the Murchison Medal, in recognition of the importance of your contributions to our knowledge of the Carboniferous and other rocks of the North of England. For thirty years you have been engaged in these researches, which have resulted in more accurate determinations of the stratigraphy of the Carboniferous System of Northumberland, and more satisfactory correlations of the various divisions of that system throughout the northern counties. In conjunction with Mr. Topley you brought forward convincing evidence that the famous Whin Sill is an intrusive sheet, and not, as some observers had supposed, an intercalated lava. Your papers on the salt-measures and on the Marl Slate and Yellow Sands of your district have likewise added to our knowledge of these formations. This original work, however, has for many years been carried on in the intervals of a life primarily devoted to the teaching of geology, and we wish to mark our sense of the value of your educational labours as a Professor in the University of Durham. As one who in former days served under Murchison, you will doubtless value this medal as another link connecting you with that great master of our science. I may perhaps be permitted to add an expression of my own gratification that, looking back on my early association with you as a colleague in the Geological Survey, it has fallen to me to hand you to-day this mark of appreciation from the Council of the Geological Society.

Professor Lebour replied as follows:—Sir Archibald Geikie,—

My feelings on this occasion are divided between regret at the absence of my old friend Professor Lapworth and gratification at receiving the Medal which commemorates my first chief, Sir Roderick Murchison, from the hand of one who was his favourite colleague, his successor, and his biographer. An award such as this is of the greatest value to a teacher: it confirms his pupils in the trust which they place in him, and at the same time gives him confidence in carrying on his own work. In my case, I will not be so presumptuous as to question the propriety of the Council's decision, however it may have surprised me. I am especially pleased that in the too kind words that you have uttered, the name of my dear friend and colleague of long ago, William Topley, has once more been coupled with mine. I am sure that no one would have rejoiced more than he at my good fortune this day. I beg most heartily to thank the Council for the honour which they have done me.

In handing the Lyell Medal, awarded to Professor Alfred Gabriel Nathorst, of Stockholm, to Baron C. de Bildt, Envoy Extraordinary and Minister Plenipotentiary of H.M. the King of Sweden and Norway, for transmission to the recipient, the Chairman addressed him as follows:—Baron de Bildt,—

Your Excellency has been good enough to come here to-day to receive for your countryman, Professor Nathorst, of Stockholm, the Lyell Medal, which has been awarded to him this year by the Geological Society in recognition of his long and distinguished labours to advance our knowledge of the vegetation which at successive periods in the history of the earth has flourished in Northern Europe and the Arctic regions. These labours range from the oldest to the youngest ages of geological time. Among the most ancient rocks various curious markings, which had generally been regarded as traces of marine plants, were shown many years ago by Professor Nathorst, after an ingenious series of experiments, to be probably not of vegetable origin. But while he thus cut off what had been supposed to be an early marine flora, he has greatly extended our acquaintance with the terrestrial floras of Palæozoic time in the Arctic regions. His papers on the extension of the vegetation of the Upper Old Red Sandstone as far north as Bear Island, continuing the earlier work of Heer, are of special interest. He has thrown much light on the flora of the Triassic deposits that extend into the south of Sweden. From the far northern King Charles Land he has made known the existence of a Jurassic and a Cretaceous flora. His researches among Pleistocene and recent deposits, and the history which he has thence deduced of plant-migration and changes of climate in Europe, are singularly interesting and suggestive. Though it is as a student of fossil plants that Professor Nathorst is most widely known, it was his keen eyes that detected for the first time casts of medusæ in the Lower Cambrian rocks of Scandinavia. In transmitting to him our Lyell Medal, your Excellency will, I hope, accompany it with an expression of our best wishes for his health and the long continuance of his scientific energy.

Baron de Bildt, in reply, read the following letter which he had received from Professor Nathorst:—

"Allow me to express my heartiest thanks to the Council for the great and quite unexpected honour which they have conferred upon me by the award of the Lyell Medal. I regard this mark of approval of my geological and palæontological labours as a most gratifying distinction, and it encourages me to hope that, as the end of my life approaches, I may have the satisfaction of feeling that I have not lived altogether in vain.

"My gratification at receiving this honour is increased by the fact that it is associated with the name of Sir Charles Lyell. I vividly remember the enthusiasm with which, as a mere youth, I read the Swedish edition of his admirable and fascinating 'Principles of Geology'; and it is only right to add that it was this work which first excited my love for geology; a branch of science which the Geological Society of London has vigorously promoted for almost a century.

"During my first visit to England in 1872, at the age of 21, I was fortunate enough to be introduced to the great English geologist; and I still cherish a vivid remembrance of his kind and noble personality, and of his keen interest in my then recent discovery of the remains of *Salix polaris* and other Arctic plants in the Glacial deposits of the Norfolk coast. The meeting with Sir Charles forms one of the most highly prized reminiscences of my youth.

"Let me also express my great satisfaction at receiving this Medal through so illustrious a geologist as Sir Archibald Geikie, whose writings have served as a source of information to the majority of geologists throughout the world."

The Chairman then handed the Balance of the Proceeds of the Wollaston Donation Fund, awarded to Miss Ethel Mary Reader Wood, M.Sc., to Dr. J. E. Marr, F.R.S., for transmission to the recipient, and addressed him in the following words:—Dr. Marr,—

The Council have awarded to Miss Wood the Balance of the Proceeds of the Wollaston Donation Fund as an acknowledgment of the value of her contributions to our knowledge of the Graptolites and of the rocks in which these organisms occur. Her papers furnish an excellent example of the application of zonal stratigraphy to groups of rocks which were thought to be already known with tolerable completeness. Much still remains to be done in this department of investigation. We had looked forward with pleasure to seeing her among us here to-day, but she has been unavoidably prevented from coming to London. In sending the award to her, you will be so good as to express to her our hope that she will regard it as a token of the interest which we take in her work, and as an encouragement to her to continue to devote herself to the cause of science with the same skill and enthusiasm which have hitherto so eminently distinguished her career.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Dr. Arthur Hutchinson, M.A., F.C.S., the Chairman addressed him as follows:—Dr. Hutchinson,—

The Balance of the Proceeds of the Murchison Geological Fund has this year been awarded to you, in acknowledgment of the ability which the Council recognise in your published memoirs on mineralogical subjects, and to encourage you in further work. We especially desire to recognise the skill and industry displayed by you in two important memoirs. Your paper on the Diathermancy of Antimonite introduced and successfully applied a new method of crystallographic investigation, wherein an opaque mineral is examined between crossed nicols, by means of transmitted heat-rays, corresponding to the usual optical examination of transparent minerals. Your memoir on Stokesite records the discovery of a new mineral, of which you found only a single crystal upon a specimen of Cornish axinite. Your analysis proved it to be a compound of most unusual type—a silicate containing tin.

The Chairman then presented a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Professor Sidney Hugh Reynolds, M.A., addressing him in the following words:—Professor Reynolds,—

This award is made to you in special recognition of the value of your contributions to our knowledge of the Palæozoic rocks of Ireland and of the geology of the Bristol district, and to encourage you in further work. During the past eight years the Society has received from you a series of important papers which have appeared in its Quarterly Journal. In association with Mr. Lake you presented some interesting facts in regard to the *Lingula*-Flags of the Dolgelly district. In conjunction with Mr. Gardiner you have carried out a series of researches among the Silurian rocks of the South-East and of the West of Ireland, and have thrown fresh light on their associated volcanic rocks. Together with Professor Lloyd Morgan, you have worked out the geology of the Tortworth district, and have cleared up the interesting history of its volcanic eruptions; while you have more recently studied the Carboniferous volcanic rocks of the neighbourhood of Weston-super-Mare. In addition to all these geological undertakings, you are still further widening the range of your studies by continuing the Palæontographical Society's memoir on the Pleistocene Mammalia. We cordially hope that many long years of active scientific work are in store for you, and that you will continue to enrich our Quarterly Journal with the results of your researches.

In handing the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Dr. Charles Alfred Matley, to Professor W. W. Watts, M.A., M.Sc., Sec. G.S., for transmission to the recipient, the Chairman addressed him as follows:—Professor Watts,—

The other moiety of the Lyell fund has by the Council been assigned to Dr. Matley, as an acknowledgment of the value of his work in elucidating the geology of Anglesey, and to encourage him in further work. The complicated structure of that part of North Wales has long been recognised, but the nature and extent of the complication have only been realised in recent years, since more enlarged and accurate views of geological tectonics have been reached. It would be rash to assert that all the difficulties have been cleared away, but Dr. Matley has made a notable forward step in removing them. Besides his work in Anglesey, he has devoted time and thought to the Cambrian formations of Pembrokeshire, and to the Keuper Marls and Sandstones of Warwickshire. We wish him many years of health and continued geological industry.

The Chairman then handed the Proceeds of the Barlow-Jameson Fund, awarded to Mr. Hugh John Llewellyn Beadnell, to Major C. E. Beadnell, late R.A., for transmission to the recipient, addressing him in the following words:—Major Beadnell,—

The Barlow-Jameson fund is awarded to your son, Mr. Hugh John Llewellyn Beadnell, in recognition of the value of his memoirs on the topography of the Oases and other districts of the Libyan Desert, and for his important collections of vertebrate fossils made in Egypt during the last three years. The enthusiasm with which he has prosecuted his researches in the Geological Survey of Egypt led some time ago to an attack of fever which nearly proved fatal. We hope that he will be able henceforth to ward off all such attacks, and to continue the career which he has so successfully begun. In transmitting to him this award of the Council, you will not fail to convey to him an expression of our interest in his researches, and of our hope that he will be encouraged to continue to pursue them.

The Chairman then proceeded to read the Anniversary Address that he had prepared, giving first of all obituary notices of several Fellows deceased since the last annual meeting, including Mr. W. T. Aveline (elected a Fellow in 1848), Mr. R. Etheridge (el. 1854), Sir Charles Nicholson (el. 1841), Mr. W. Vicary (el. 1864), Dr. W. Francis (el. 1859), the Rev. H. Maxwell Close (el. 1874), and Dr. H. Exton (el. 1883); also of Professor J. P. Lesley (el. For. Memb. 1887), Geheimrath K. A. von Zittel (el. For. Memb. 1889), Professor A. F. Renard (el. For. Memb. 1884), and Herr Felix Karrer (el. For. Corresp. 1890).

He then dealt with the bearing of the evidence furnished by the British Isles as to the problem whether in the so-called secular elevation and subsidence of land it is the land or the sea which moves. The first section dealt with the proofs of emergence of land, as displayed in raised beaches or strand-lines. Objection was taken to the explanation given by Professor Suess of the strand-lines of the Norwegian fjords, which, the author maintained, do not mark the levels of ancient ice-dammed lakes, but former margins of the sea. A comparison was made of these strand-lines with the raised beaches of Britain, and it was contended that the Seter or rock-shelves of Norway, which were claimed as the results of weathering caused by diurnal variations of temperature, could be paralleled in the rock-shelves of undoubtedly marine origin round both sides of Scotland. The second section of the address was devoted to the proofs of submergence furnished by fjords and sunk forests. It was shown that in the South of England and Wales a remarkable oscillation had taken place, the raised beaches being first brought much higher than their present level above the sea, and standing at that higher level when the lowest sunk forests existed as land-surfaces; while, by a subsequent submergence, these forests were placed under low-water mark and the raised beaches were brought into their present relations to the sea-level. The third section briefly pointed out the inferences to which the facts seemed most naturally to point. It was argued that the variations in the development and height of the raised beaches could not be satisfactorily explained by any conceivable variation in the level of the sea; while, on the other hand, the proofs of submergence in the south of our island in Neolithic time and of emergence in the north, were only intelligible on the supposition of unequal movement of the land. The conclusion thus reached was in favour of the generally accepted view that changes of level, such as those of Pleistocene and Post-Pleistocene time, in the British area, have been primarily due, not to any oscillation of the surface of the ocean, but directly to movements of the terrestrial crust.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* The Right Hon. Lord Avebury, P.C., D.C.L., LL.D., F.R.S., F.L.S.; F. A. Bather, M.A., D.Sc.; W. T. Blanford, C.I.E., LL.D., F.R.S.; 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.; Professor T. T. Groom, M.A., D.Sc.: Alfred Harker, Esq., M.A., F.R.S.; R. S. Herries, Esq., M.A.; Professor J. W. Judd, C.B., LL.D., F.R.S.; Percy F. Kendall, Esq.; Philip Lake, Esq., M.A.; Professor Charles Lapworth, LL.D., F.R.S.; Bedford McNeill, Esq., Assoc. R.S.M.; J. E. Marr, Sc.D., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; G. T. Prior, Esq., M.A.; Professor W. W. Watts, M.A., M.Sc.; the Rev. H. H. Winwood, M.A.; and H. B. Woodward, Esq., F.R.S.

Officers:—President: J. E. Marr, Sc.D., F.R.S. *Vice-Presidents:* Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec.R.S.; E. T. Newton, Esq., F.R.S.; and H. B. Woodward, Esq., F.R.S. *Secretaries:* R. S. Herries, Esq., M.A.; and Professor W. W. Watts, M.A., M.Sc. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* W. T. Blanford, C.I.E., LL.D., F.R.S.

II.—February 24th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

The President read the following resolution of the Council, which had been forwarded to Mrs. McMahon:—

"That the Council desire to place on record their regret at the death of General C. A. McMahon, F.R.S., who for so many years was one of their colleagues, and took so active an interest in the affairs of the Society; and the Council further wish to express their sincere sympathy with Mrs. McMahon and the family in their bereavement."

The President also announced that Professor T. G. Bonney, Sc.D., F.R.S., and Mr. H. W. Monckton, F.L.S., would represent the Society at General McMahon's funeral on the following day.

The President stated that Professor Lapworth had written, thanking the Fellows for their kind expression of sympathy with him in his illness, and for the telegram despatched to him in the course of the annual general meeting.

The following communications were read :—

1. "Eocene and Later Formations surrounding the Dardanelles." By Lieut.-Col. Thomas English, late R.E., F.G.S.

Our present knowledge of the older rocks, upon which the Tertiary beds surrounding the Dardanelles rest, only suffices to indicate the positions of the outcrops of a succession of schists, crystalline limestones, granites, and serpentines, which can be traced from the Ægean district into the Marmora, where they formed an archipelago in the Eocene sea.

The Eocene deposits surrounding these old rocks commence with sandstones, conglomerates, and clays, which become calcareous and nummulitic upward, and are about 2,000 feet thick in the aggregate. They are succeeded by 3,000 feet of lacustrine sandstones, clays, and schists, interstratified with volcanic rocks, and containing coal-seams. These beds have yielded *Anthracotherium*, plant-remains, and *Corbicula semistriata* at the coal-horizon, which is near the middle of the series. They are widely spread in Southern Thrace, and are cut off to the eastward by the falling-in of the Marmora sea-bed. The author has traced them along the Gallipoli Peninsula to Imbros Island—Lemnos and Samothrake are partly composed of similar beds; and he considers that all these deposits represent the uppermost Eocene and the Oligocene, and that the coal-seams belong to the latter.

The folding of the Lower Tertiary strata is plainly marked, and prolongs the direction of the Greek 'flysch'-deposits into the Marmora, forming basins in which the Miocene beds accumulated.

There are three main folds, all passing east-north-eastward through the Eocene channel between the old rocks of Thrace and those of the Troad.

The central fold developed farther eastward in post-Sarmatic times, rising into a ridge at Dohan Aslan, which dammed the outlet for the Marmora water to the west, and was the proximate cause of the formation of the Bosphorus in the Pontic Period, and of the Dardanelles at the end of the Pliocene. Volcanic eruptions were prolonged from Cretaceous to Miocene times in Thrace, Imbros, Lemnos, and Mitylene. Strati Island is entirely volcanic, and the greater part of Imbros also.

Marine Miocene (Helvetian to Tortonian) deposits appear north of the Gulf of Xeros and in the Marmora, and are probably vestiges of a Lower Miocene sea connection between the Ponto-Caspian and the Mediterranean.

Sarmatic deposits, first fresh-water, then marine, result from the development of a lake, with a narrow opening north-eastward to the Pontic area, which occupied a large portion of the district. The fresh-water beds are still nearly horizontal in the Dardanelles, but are much dislocated along the northern shore of the Sea of Marmora, where they contain naphtha and lignite. The overlying marine (*Mactra*) limestones fringe the fresh-water beds as a shore-belt for 30 miles along this coast, and extend through the Dardanelles to the Southern Troad.

Brackish and fresh-water Pontic strata occur in numerous detached lake-basins which drained north-eastward. The Bosphorus was probably cut by river action through the rim of the lowest of these basins, on the recession of the Sarmatic Sea, and the Ægean drainage then passed into the large, closed, brackish lake described by Andrussov as occupying the Black Sea area from the Pontic to the beginning of the Diluvial Period.

The water-line of this sea lake finally receded to nearly 200 feet below its present shore-line, when the Sea of Marmora stood about 80 feet higher. Then the water began to rise again during the Pliocene, the Sea of Marmora regained its former westerly extension to Gallipoli, and deposited the bed of Caspian shells on which that town is built.

The lacustrine beach at Hora, 130 feet above sea-level, commemorates the last high-water mark of the Ponto-Caspian closed basin. The Ægean land had meanwhile settled down, forming a large depressed area, probably bounded to the south by the chain of the Northern Cyclades, and the Sarmatic beds dipped westward, reversing the drainage of the country south-west from Gallipoli. When the watershed of a river occupying the Dardanelles Valley was worn down to the level of the Marmora, in early Pleistocene times, the channel was rapidly widened and deepened to its present section by the outflow of Pontic water. The Mediterranean also passed the barrier of the Cyclades during the Pleistocene Period, and when equilibrium was restored, the water in the Sea of Marmora stood somewhere near its present level. There have been various oscillations since, of which the positive changes of level are indicated by Pleistocene Mediterranean deposits at Samothrake up to 650 feet, and a raised beach at Hora at 400 feet, also by numerous shell banks and terraces up to 100 feet above the present sea-level. There is, moreover, abundant evidence of a rise to 1000 feet during or after the Glacial Period, by which a red stony clay, formed at the expense of the surface-soil of a land area, has been widely spread.

The paper is accompanied by three appendices, one on the rock-specimens, by Dr. J. S. Flett; one on the collection of Tertiary and Post-Tertiary fossils, by Mr. R. Bullen Newton; and a third, by Mr. R. Holland, on species of Nummulites.

2. "The Derby Earthquakes of March 24th and May 3rd, 1903." By Dr. Charles Davison, F.G.S.

The undoubted earthquakes of this series were four in number. The first and strongest occurred on March 24th, 1903, at 1.30 p.m., and was felt over an area of about 12,000 square miles, its centre coinciding with the village of Kniveton, near Ashbourne. The shock consisted of two distinct parts, separated by an interval of about three seconds, which coalesced, however, within a narrow rectilinear band running centrally across the disturbed area at right angles to the longer axes of the isoseismal lines. The isacoustic lines (or lines of equal sound-audibility) are very elongated curves, distorted along the rectilinear band. The earthquake, it is concluded, was caused by simultaneous slips within two detached foci situated along a fault-service running from north 33° east to south 33° west, hading to the north-west, and passing close to the village of Hognaston. The strongest after-shock occurred on May 3rd, its focus lying along the same fault, for the most part between the two foci of the principal earthquake, but much nearer the surface.

Observations of the principal earthquake were made in many of the mines near the epicentral district. The sound, in such cases, was a much more prominent feature than the shock; it appeared to travel through the overlying strata, and in one pit in which observations were made in four seams at different depths, it was more distinctly audible in the lower than in the shallower seams.

The principal earthquake was registered by an Omori horizontal pendulum at Birmingham, by a Milne seismograph at Bidston (near Birkenhead), and by a Weichert pendulum at Göttingen (502 miles from the epicentre). The larger waves travelled with a velocity of 2·9 kilometres per second.

III.—March 9th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the probable Occurrence of an Eocene Outlier off the Cornish Coast." By Clement Reid, Esq., F.R.S., F.L.S., F.G.S.[1]

An extensive deposit of subangular Chalk flints occurs near Marazion, opposite a deep and wide valley which connects St. Ives Bay and Mount's Bay. This valley, though containing at St. Erth Lower Pliocene beds, is shown to be of much earlier date, and is probably an Eocene river-valley. Eocene rivers seem to have radiated from Dartmoor westward as well as eastward. The flint-and-chert gravel corresponds closely with the Eocene gravel of Haldon, and is apparently derived from a deposit under the sea off St. Michael's Mount. Continuing the direction of the Eocene valley seaward, the isolated mass of phonolite of the Wolf Rock is met with. The evidence suggests that, underlying the western part of the English Channel, an Eocene basin may occur comparable in importance with that of Hampshire.

2. "The Valley of the Teign." By Alfred John Jukes-Browne, Esq., B.A., F.G.S.

The Teign Valley is one of the most remarkable in the British Islands, because it is not a transverse valley preserving a general direction in spite of opposing ridges, nor is it a longitudinal valley

[1] Communicated by permission of the Director of H.M. Geological Survey.

running parallel to a dominant ridge, nor is it a simple combination of one with the other, as often happens; but it apparently consists of parts of two transverse valleys linked by a longitudinal one.

The Teign runs off Dartmoor through a gorge which takes an easterly direction, as if it were going to join the Exe; it is then deflected southward into what, with respect to the Permian escarpment, is a longitudinal valley; this ends in a low-lying plain, and from this plain it escapes eastward to the sea through a transverse valley, which has been cut across the ridge of Permian and Cretaceous rocks.

Several attempts have been made to explain the anomalies of the course taken by the Teign; but none of them is satisfactory, because the writers have not sufficiently considered the probable conditions of the surface on which the river-valleys were originated, or the extent to which the older rocks around Dartmoor may have been covered by Cretaceous and Tertiary deposits.

The author considers these points, and concludes that in Oligocene time a thick mantle of soft Neozoic strata must have stretched across Devon and the adjacent parts of the English Channel; that this mantle consisted mainly of Selbornian Sands and of the later Eocene deposits, the latter overlapping the former and passing on to the surface of the Palæozoic rocks; further, that these Eocene deposits covered all the central parts of Devon, and were banked up against the northern, eastern, and southern sides of Dartmoor. He assumes, moreover, that the post-Eocene elevation of the region gave this surface a general easterly slope; and consequently that, although streams ran off Dartmoor in all directions, those which drained eastward had the longer courses and passed from the moorland area on to a plain, the drainage of which was directed eastward to the shore of the Oligocene sea.

The general direction of the Upper Teign where it flows over the granitic area is east-north-easterly; the direction of its gorge as far as Clifford Bridge is nearly due east, and if the conditions were as above described, the precursor of this river is not likely to have followed the course of the present river beyond Clifford Bridge. There is not likely to have been any ridge or obstacle that would have deflected it so far to the southward, nor anything to prevent it from continuing its easterly course towards, and probably across, the valley of the Exe.

The valley of the Lower Teign below Dunsford is not likely to have existed in Oligocene time, but was part of the eastward sloping plain; the local drainage, however, may have been carried by a little brook flowing southward or south-eastward to join the river which was then initiating the valley of the Teign estuary. The erosion of the present longitudinal valley out of the Palæozoic rocks must have been accomplished in much later times, and was probably due to the development of the Permian escarpment.

The valley through which the Teign now flows from Newton to Teignmouth traverses this escarpment; and its excavation can only be attributed to a stream that flowed eastward from higher ground than the summit of Little Haldon. Such a stream is the Lemon or Leman, which rises on the east side of Dartmoor at a level of about 1200 feet above the sea. The ancester of this stream must have carved its channel out of the ancient plain of Eocene deposits; and it is suggested that the valley of the Teign estuary is a portion of this ancient valley, which has survived all subsequent changes, except that of being cut down to modern base-levels.

The change which led to the diversion of the Upper Teign into this more southern valley is attributed to the later earth-movements, which gave a southerly tilt to the whole region, and a still greater local tilt owing to the formation of the Bovey syncline. This tilt would increase the velocity and erosive power of the stream which was then carving out the valley west of the Haldon Hills, and as it gradually cut down to a lower base-level, the little affluents which formed its head-waters would cut back northward into the watershed which separated them from the eastward course of the Upper Teign. It is supposed that the portion of the Teign Valley which lies between Dunsford and Clifford Bridge was formed by one of these affluents, and that it was deepened till the separating ridge at its head was reduced to a col or pass leading from the one valley into the other. A flood or the damming-up of the river by a landslip might send down the waters of the Upper Teign, and once this was accomplished the capture and diversion of the Upper Teign would be permanent.

The theory of the capture of one river by another has been accepted as an explanation of similar difficulties in the case of other rivers, and its application to the course of the Teign furnishes an intelligible explanation of the facts. The author thinks that some other river-courses and geographical features in Devon can be explained on the same theory of an easterly incline modified by a subsequent southerly tilt.

OBITUARY.

We regret to record the death of Lieut.-General Charles Alexander McMahon, F.R.S., F.G.S., who died at his residence, 20, Nevern Square, South Kensington, S.W., Sunday, 21st February, 1904, in his 74th year. He was a member of Council of the Geological Society of London, and was the author of numerous papers on geology. We hope to publish a notice of General McMahon's geological work in our next number.

We have also to notice with sorrow the death of a valued friend and fellow-worker in America, Professor Charles Emerson Beecher, Ph.D., Professor of Palæontology and Curator of the Geological Collections in Yale University, who died from heart-failure on Sunday, 14th February, in his 52nd year. He was one of the Editors of the *American Geologist* and the author of numerous papers on palæontology. We trust to be able suitably to record his lifework in our next issue.

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MAY, 1904.

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GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. V.—MAY, 1904.

ORIGINAL ARTICLES.

I.—On some Samples of Rock from Borings at Sangregrande, Trinidad.—Part I.

By R. J. Lechmere Guppy.

(FOLDING PLATE VII.)

I HAVE been favoured by P. N. H. Jones, Esq., engineer of the Waterworks, with specimens from a boring at Sangregrande undertaken by the Government of Trinidad with a view to ascertain the extent and position of the Tertiary coal-seams of that district and other facts. The specimens consist of a dark-coloured (blackish) sand-rock, finely (but slightly irregularly) laminated, the lamination being at an angle of about 50° from the horizontal. The samples came from 150, 250, 400, 500, and 600 feet deep below the surface. I examined each one separately, but as the differences between them, whether as regards mineral constitution or organic contents, are only slight, and in fact two portions from the same depth show often as much difference as samples from different depths, I shall describe the whole together. These specimens are from boring No. 3, Plate VII.

The rock is of a blackish or dark-grey colour, and is principally composed of very fine sand with particles of mica. When washed and passed through fine muslin only about $\frac{1}{100}$ part remains. Calcareous matter is under 10 per cent. in quantity, and exists almost entirely as shells of Foraminifera and Mollusca. Crustacea and echinoderm remains also occur, and there are numerous Polyzoa, a few Ostracoda, and scales, teeth, and ear-bones of fishes. I could not detect coccoliths or calcaroma, but the nature of the material is unfavourable for their detection. The material of this rock is not of any economic value, but it is interesting as throwing light upon geological questions and upon the conditions which prevailed at the time of its deposition. The neighbourhood of land is indicated by the quantity of clastic material, but the fineness of the grains and the tenuity of the laminæ of deposition show that it was at some distance off. Data exist for an approximate estimate of the position of such land, and the elementary facts are indicated in my papers in the Proceedings of the Victoria Institute, Trinidad, 1902, and the Journal of the Geological Society of London, 1892.

With one exception the rock appears to be of the same quality and consistence throughout. At 500 feet occurs a harder bed composed of similar material to the other beds, but indurated and not liable, as the other beds are, to disintegration by water. This harder bed contains only traces of calcareous matter, and much fewer organic remains than the others.

I have no particulars of the material found at intermediate depths, but presuming that it is uniform or nearly uniform throughout it would appear that we have here a thickness of more than 500 feet in depth of very fine sedimentary material, probably deposited in a sea somewhere about 20 to 50 fathoms deep. It might even have been more, but to ascertain this other circumstances not at present known would have to be taken into account. The deposition of so extensive a stratum of such material implies a long period of time during which the conditions of the area on which deposition was taking place remained generally the same.

The molluscan and other organic remains exist entire within the matrix, but being for the most part in the state of powder they cannot be extracted. The Foraminifera and a very few Mollusca and Ostracoda alone are of a sufficiently compact consistency to stand extraction by washing, which is the only mode of operation practicable, as any attempt by more forcible means results in the complete disintegration of the fossils.

Doubtless also here, as in the Naparima and Pointapier beds, many Foraminifera appear as fragments only, such as *Rhabdammina, Haliphysema, Dendrophya,* etc. But leaving apart such organisms as these, there will be, if occasion serves in the future, an enormous extension of this list of fossils.

MOLLUSCA.

Balantium.	*Pleurotoma.*
Bulla.	*Nucula.*
Dolium.	,,
Fusus.	*Pecten.*

The only specimens extracted were a *Pecten* and a *Nucula* (single valves). One valve of a *Pecten* is ornamented with radiating elongate-elliptical blotches of purplish-brown colour, showing how persistent the original colouring must have been to have been preserved in such decolorizing material as that of which these beds are composed.

POLYZOA.

The only generically identifiable one is *Cupularia,* but others seem to be *Membranipora,* etc.

OSTRACODA.

Bairdia woodwardiana, Brady; *Cytherella polita,* Brady. There is also a prawn-like crustacean over an inch long.

FORAMINIFERA.[1]

I deal in greater detail with the fossils of this group, as they present determinable specimens belonging to known forms.

Clavulina (Haplostiche) Soldanii, Parker & Jones. (Pl. IX, Fig. 1.)

This species is numerous at all depths, but especially at 150 and 250 feet. It does not occur in the Naparima (oceanic) beds, but I have examples from the *Ditrupa*-bed of Pointapier, which I originally identified as *Clavulina cylindrica*. The length of the longest example from the Sangregrande boring is 3 mm., its breadth being 1 mm.; the stoutest example is 2·5 mm. long by 1·5 mm. in diameter. There are many smaller examples of varying forms.

Reophax scorpiurus, Montf. (Pl. IX, Fig. 2.)

This is not quite as common as *H.* (*Cl.*) *Soldanii*, but is nevertheless fairly abundant in some samples. It has not hitherto been met with by me in any of the other Microzoic rocks of Trinidad. It is usually about 2 mm. in length.

Amodiscus incertus, Orb.

A single specimen somewhat like that figured in Ann. Nat. Hist., vol. iv (1869), pl. xiii, figs. 3*a*, *b*.

Cyclammina cancellata, Brady, var. deformis, nov. (Pl. IX, Fig. 3.)

Most specimens of this form are distorted by a sudden change in the axis of growth of the last whorl, whereby the shell acquires a sort of humpbacked appearance. It is often very thin, seldom indeed as thick as the forms found abundantly in some of the Naparima oceanic beds. It is one of the largest Foraminifera in the Sangregrande boring, being mostly 3 mm. in diameter, and occurs at all depths in the boring.

Miliolina macilenta, Brady. (Pl. IX, Fig. 4.)

Diameter 1·0 mm.

Miliolina seminulum, Linné.

Diameter 2·0 mm.

Spiroloculina tenuiseptata, Brady. (Pl. IX, Fig. 5.)

Longest diameter 1·0 mm. It is questionable if this is distinct from *Sp. limbata*, Orb.

Bolivina punctata, Orb.

Minute *Bolivinæ* are as abundant in this rock as in most of the Microzoic formations of the island.

[1] Plates VIII and IX, illustrating the Foraminifera, will appear in the concluding part of Mr. Guppy's paper.

BULIMINA INFLATA, Seguenza.

TEXTULARIA SAGITTULA, Defrance. (Pl. IX, Fig. 6.)

Length 1·0 mm. Fairly abundant in some samples.

TEXTULARIA GRAMEN, Orb. (Pl. IX, Fig. 18.)

Length 1·0 mm.

TEXTULARIA CARINATA, Hantk. (Pl. IX, Fig. 7.)

Length 1·5 mm.

TEXTULARIA TROCHUS, Orb. (Pl. IX, Fig. 8.)

Diameter 1·0 mm., height 1·5 mm. I take *T. turris* and *T. Bareti* to be merely varietal forms of this species.

TEXTULARIA ASPERA, Brady. (Pl. IX, Fig. 17.)

Only three examples were found, of which one (much the largest) measured 3 mm. in length.

NODOSARIA RAPHANISTRUM, Linn. (Pl. IX, Fig. 9.)

The form found here is identical with *N. bacillum*, Defr., as found in the Vienna Basin and elsewhere. The synonymy of the species includes *raphanus*, *Zippei*, *badenensis*, *acuta*, and many others. It is probably not distinct from *N. obliqua*, the larger and more strongly ribbed forms being found in shallow water, while the smaller, more delicately costate forms come from deeper water. *N. raphanistrum* is not found in the oceanic beds. The longest specimen from the Sangregrande boring is 5·5 mm. in length; it is broken. Some smaller examples are perfect.

NODOSARIA OBLIQUA, Linn. (Pl. IX, Fig. 10.)

The form found in the Sangregrande boring is *N. vertebralis*, Batsch, which is only one of the many names conferred upon more or less distinct varieties of this species. The length of our longest specimen is 3·5 mm.

NODOSARIA SOLUTA, Reuss. (Pl. IX, Fig. 11.)

Our specimens are generally of the curved variety, with little or no constriction between the segments except perhaps one or two of the later ones. It is exactly the same as *N. elegans* of the Vienna Basin. The examples are usually about 2·3 mm. long.

CRISTELLARIA ROTULATA, Lam. (Pl. IX, Fig. 12.)

Under this I include *C. calcar* and *C. cultrata*, as the forms found here are somewhat intermediate. It is mostly small, the largest being 2 mm. in diameter.

CRISTELLARIA ACULEATA, Orb. (Pl. IX, Fig. 13.)

Similar to the Pointapier specimens, except that the last whorl is seldom so much produced. Longest diameter 2 mm.

UVIGERINA (SAGRINA) RAPHANUS, Parker & Jones. (Pl. IX, Fig. 14.)

The specimens are about 1·3 mm. in length. The species is very abundant at all depths in the Sangregrande boring. It is the short form resembling fig. 23 of pl. lxxv of the "Challenger" Report. Brady says it is essentially a coral-reef foraminifer, but the conditions of the Sangregrande deposit would not admit of coral-reefs. Our form may be said to be indicative of shallow water, and a depth of 10 to 50 fathoms would probably suit it best. A very few specimens of the long form have occurred to me in the Naparima oceanic beds, and I think that this long form belongs to deep water.

Brady ("Challenger" Report, p. 580) admits that the term *Sagrina* is not required.

UVIGERINA CANARIENSIS, Orb.

Length about 0·6 mm. Specimens sometimes slightly costate.

POLYMORPHINA LANCEOLATA, Reuss.

A few very minute examples for which the above name may stand until fuller information is obtained.

GLOBIGERINA BULLOIDES, Orb.

The forms found at Sangregrande resemble most the Vienna Basin specimens, and do not attain the great development in number, size, or variety that we find in the Naparima oceanic beds.

SPHÆROIDINA BULLOIDES, Orb.

Not very common.

PLANORBULINA (DISCORBINA) ELEGANS, Orb. (Pl. IX, Fig. 15.)

Diameter about 0·5 mm. This agrees fairly well with the figure of D'Orbigny's Modèle No. 42 given by Parker & Jones, but not quite as well with the figure given by Goës (Carib. Rhiz., pl. viii, figs. 269–71), which is *R. complanata*, Orb. It suggested itself to me as a small and delicate modification of *Planorbulina Wullerstorfi*, a common and well-developed foraminifer in the oceanic beds of Naparima.

It has been proposed to dispense with the genus *Anomalina*, and to include the species classed under that name, together with those comprised under *Truncatulina*, in the genus *Planorbulina*. In my lists no species from the oceanic beds appears under the name of *Planorbulina*, but some five species are recorded under that of *Anomalina*. *Pl. larvata*, a remarkable form, is recorded from the shallow-water beds, and I have since found it in the *Ditrupa*-bed of Pointapier.

PLANORBULINA UNGERIANA, Orb.

One or two small specimens of this species occur.

PULVINULINA ELEGANS, Orb. (Pl. IX, Fig. 16.)

Specimens few and small; the largest was 1 mm. in diameter. This species as a fossil can always be distinguished by its coloration, its white septal bands, marginal rings, and umbilical boss, contrasting with the chocolate-brown interspaces. The Sangregrande specimens are perhaps referable to the var. *partschiana*.

THE SANGREGRANDE BORINGS.—PART II.

Since writing Part I of this paper I have been favoured by the Hon. Walsh Wrightson, C.M.G., Director of Public Works, with reduced diagrams of the three borings made at Cunapo, near Sangregrande, for the purpose of ascertaining particulars relative to the coal-seams in that neighbourhood, and with access to the samples of the cores brought up. These extend our knowledge of the geological conditions very considerably. In Part I of this paper I gave a description of the rocks and fossils of boring No. 3. The diagram of this boring (Plate VII) shows that from 200 feet to the bottom of the boring at 600 feet the composition of the strata is nearly uniform, being the foraminiferal sandstone I have described. This deposit probably recurs in boring No. 2 (82 to 132 feet) and boring No. 1 (90 to 486 feet). At 12 to 18 feet in boring No. 3 there is an ancient river-bed with very hard compact cherty stones, similar to those found in some of the existing river-beds. I do not think that the material of these stones exists anywhere in the form of a continuous layer or stratum, or, if they do, such layer is not of any great extent. It probably exists as lenticular or nodular masses varying in size, and when the containing softer material is carried off these hard stones remain in the river-beds. So with the Naparima rocks near Sanfernando, the harder masses remain heaped upon the beach, while the softer material in which they were imbedded is carried away.

With the exception of two small seams, one of 6 inches at 29 feet, and one of 2 inches at 89 feet, no coal was encountered in any of the borings. Nevertheless, the composition of the strata at the top of each of these borings indicates perhaps littoral conditions or at least shallower water than the material deeper down in the borings. The bed underlying the coal-seam at 89 feet in boring No. 1 is a soft black argillaceous rock with very fine sand, impressions of plant remains, and small bits of coal. This stratum, less than 3 feet thick, is confusedly bedded, and represents, I think, the bottom bed and very beginning of the coal series.

The problem of the relation of the strata pierced by these borings to the coal-bearing series is now before us. These strata are, with a slight exception, of marine formation: are they above or below the coal series?

So far as we can judge from the information now at hand, it would seem that they are below. If they were above it would follow that there had been a depression of land since the deposition of the coal in order to admit of the deposit of a marine formation above it. But taking all the known circumstances into account, I think this unlikely. There was probably a movement of upheaval continued throughout the Miocene period which raised the Cretaceo-Tertiary series of Montserrat (including the Manzanilla Eocene formations) above the level of the sea, leaving an arm of the sea between the Montserrat Range and the Parian Range. Into this channel the river Guarapiche (taking its rise and upper course in Venezuela) emptied itself, and

D.

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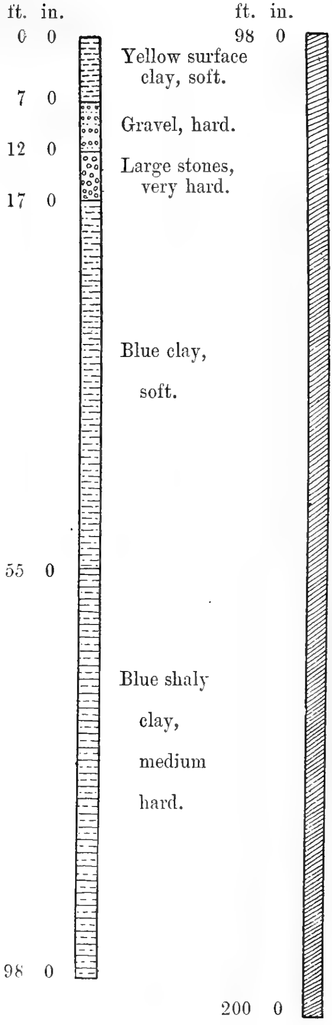
11



GREGRANDE, TRINIDAD :

CUNAPO COALFIELD.

Diagram of Bore No. 1. Diagram of Bore No. 2. Diagram of Bore No. 3.

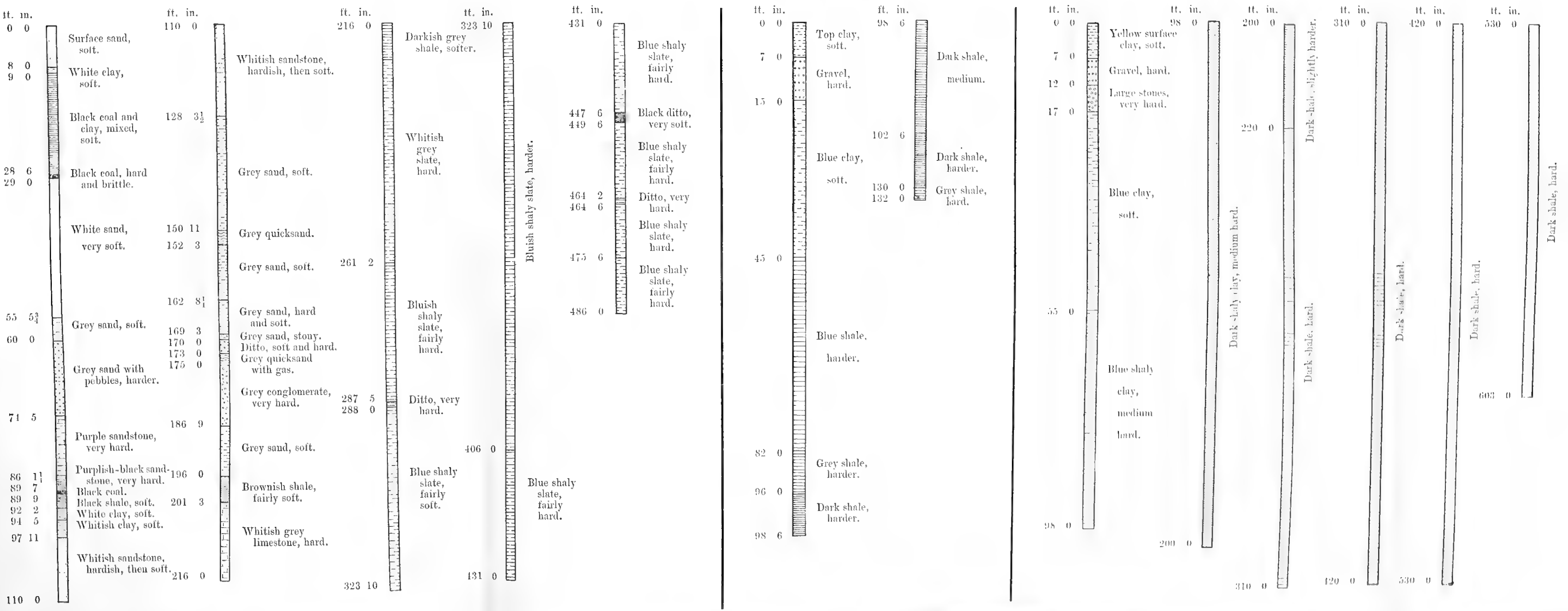


DIAGRAM OF THE BORINGS MADE AT CUNAPO, NEAR SANGREGRANDE, TRINIDAD:

TO ILLUSTRATE MR. R. J. LECHMERE GUPPY'S ARTICLE.

as this channel was filled up by the fossiliferous sands and other deposits the coal-bearing series followed under estuarine and fluviatile conditions. Therefore I think that these borings pierce strata inferior to the coal series.

In some parts of the Caroni and Oropuch country occurs a large estuarine formation which, in my opinion, succeeded the Miocene formation, and was deposited by the Miocene and Pliocene extension just mentioned of the river Guarapiche (see my papers in Geological Society's Journal, 1892; Geological Magazine, 1900; and Proceedings Victoria Institute, Trinidad, 1902). It is a very fine-grained argillaceous formation, frequently capped by fresh-water gravels, and this may very probably overlie the coal series in places.

Note.—I am informed that at the site of the borings near the Cunapo river, about seven miles from Sangregrande, the surface is about 150 feet above sea-level.

Second Note.—In reference to the conclusions arrived at from this imperfect study of the geology of the Sangregrande district, I may quote a remark by S. A. Miller in his "North American Geology," etc., that "a general knowledge of geology is probably of greater importance to the people of the United States than a like amount of information in any other department of natural science," a remark which might be extended to a larger area than the United States.

EXPLANATION OF FOLDING PLATE VII.

Diagrams showing the strata passed through in the Sangregrande Borings Nos. 1, 2, 3.

(*To be continued.*)

II.—Some Graptolite Zones in the Arenig Rocks of Wales.

By Gertrude L. Elles, Newnham College, Cambridge.

The Arenig Series, as originally defined by Sedgwick, has undergone much subsequent modification by its founder and other authors. There have been separated off from it the Tremadoc Series at the base, and the Llandeilo Series above, and a certain amount of ambiguity has arisen as to what constitutes the Arenig thus restricted; possibly, therefore, the recognition of three well-defined graptolite sub-faunas within the series in certain districts may help in some degree towards the solution of the problem.

In both North and South Wales there appears to be a well-defined belt of rocks characterised by graptolites of the 'tuning-fork' type (dependent series). In South Wales this constitutes Hicks' Llanvirn Group; it comprises two zones—

1. Zone of *Didymograptus Murchisoni.*
2. Zone of *Didymograptus bifidus.*

The upper zone of *D. Murchisoni* is the equivalent of the beds forming the lower part of the Llandeilo Series, including the Llandeilo Limestone, in part at any rate; the lower zone of *D. bifidus* is the uppermost limit of the Arenig Series.

While the occurrence of one or other, or both, of these zones has been indicated by Matley[1] and Fearnsides[2] in North Wales, and by Marr & Roberts,[3] Crosfield & Skeat,[4] and the officers of the Geological Survey[5] in South Wales, so far as I am aware, it has not been so generally recognised that this belt of rocks characterised by 'tuning-fork' graptolites gives place downward to a belt of rocks characterised by graptolites of the 'extensiform' type (horizontal series) wherever the graptolitic facies of the rocks is developed. This belt characterised by 'extensiform' graptolites may also be divided into two zones—

1. An upper zone of *Didymograptus hirundo.*
2. A lower zone of *Didymograptus extensus.*

The succession of these zones has been determined in widely separated areas, and other localities will no doubt be found in the future, so the object of the following notes is to indicate where they are at present known to occur, and the characteristic association of the graptolites which constitute the sub-faunas.

There are then, three well-defined graptolite zones in the Arenig rocks of Wales—

1. The zone of *Didymograptus bifidus.*
2. The zone of *Didymograptus hirundo.*
3. The zone of *Didymograptus extensus.*

These probably represent the upper part of the series only.

The following are the principal localities where they may be studied:—

RIVER SEIONT. (Fig. 1.)

The occurrence of fossils in the rocks in the neighbourhood of Pont Seiont was indicated long ago by Ramsay[6] and later by Marr.[7] The rocks present a certain amount of variation in lithological character, but have a practically identical fauna; they are for the most part sandy or slightly micaceous blue-black shales with a few calcareous bands. They are well exposed on the left of the road before reaching the white gates into the Public Park, and again just beyond the gates, though at this point they have been somewhat altered by the intrusion of a dyke of diabase. The fossils collected from these beds include—

Didymograptus bifidus, Hall (very common).
Diplograptus dentatus, Brong.
Climacograptus confertus, Lapw.
Cl. Scharenbergi, Lapw.
Caryocaris, sp.

The beds clearly, therefore, must be regarded as belonging to the zone of *D. bifidus.*

[1] GEOL. MAG., 1902, p. 118.
[2] Brit. Assoc., 1903.
[3] Quart. Journ. Geol. Soc., 1885, p. 476.
[4] Quart. Journ. Geol. Soc., 1896, p. 523.
[5] Summary of Progress, 1902.
[6] Mem. Geol. Survey, vol. iii, p. 161.
[7] Quart. Journ. Geol. Soc., 1876, p. 134.

Marr also recorded fossils from the old tramway near Pont Seiont on the left bank of the river, but so far as I am aware the beds exposed from Pont Seiont to the mouth of the river have never been described in detail, and since they contain three clearly defined graptolitic faunas the succession is not devoid of interest.

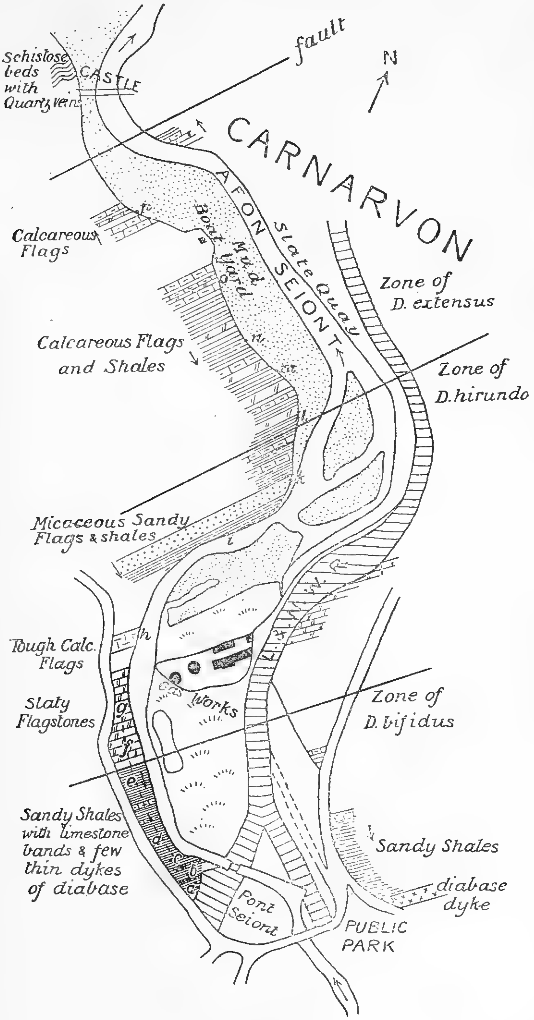


FIG. 1.—Sketch-map of Afon Seiont below Pont Seiont. Scale, 6 inches = 1 mile.

(a) *Left Bank.*

The beds are first seen below the bridge to the west of the railway, along the cutting made for the Nantlle Tramway, long disused, and now much overgrown. For 200 yards north-west of this point *a*, the beds consist of sandy or slightly micaceous bluish-black shales with narrow limestone bands, dipping S.E. at angles of 40°-50°; they are invaded by a few thin dykes of diabase not exceeding one foot in thickness; between points *a–e* indicated on the map they have yielded numerous specimens of *Didymograptus bifidus*, Hall, *Æglina* (*Cyclopyge*) *binodosa*, Salt., *Placoparia*, sp., *Caryocaris Wrightii*, *C. Marri*, Hicks, *Entomidella Marri*, Hicks, sp., *Acrotreta* ? and *Lingula*, sp.; they therefore belong to the zone of *D. bifidus*. Beds somewhat more slaty in character underlie these to the north-west, and at a point *f* due east of the bend in the road above, have yielded a characteristic assemblage of graptolites. Here, however, the fauna has changed its character; the 'tuning-fork' graptolites are found no more, while the predominant forms are those of the 'extensiform' or horizontal type, *Didymograptus hirundo*, Salt., and *D. nitidus*, Hall, being the characteristic fossils of the beds exposed between the points *f* and *g* of the map. At this point *g*, due south of the Gasworks, the tramway cutting ends, and opposite the Gasworks the section is much obscured by drift; descending to the shore it is, however, soon continued in a north-west direction by a series of tough calcareous flags with concretions *h*, in which, however, no identifiable fossils were found. These highly calcareous beds are underlain by a series of micaceous sandy flags and shales *i*, which extend round the bend of the river; they have yielded numerous specimens of *D. hirundo* and *D. nitidus*, a solitary specimen of *D. extensus*, *Placoparia*, sp., and numerous Phyllopods. A little further to the north-west bluish calcareous flags weathering brown are seen to pass under the micaceous beds; these beds have also yielded *D. hirundo* and *D. nitidus*, but fossils are not abundant, except at *k*, where in a more shaly band *D. hirundo* is especially common. From this point to the Boatyard a series of calcareous flags with shaly partings is exposed in continuous downward succession; they dip slightly more E. than the higher beds, but the inclination is the same in amount. The fauna also changes its character somewhat, for while the beds from *k* to the old tramway contain *D. hirundo* as the characteristic fossil, and therefore constitute the zone of *D. hirundo*, in the beds from *k* to the Boatyard *D. hirundo* is rare, and the common graptolite still of the 'extensiform' or horizontal type is *D. extensus* itself; this fossil is found in abundance at *m*, and less commonly at *l* and *n*; with it at *m* are also found *D. hirundo* (rare), *Azygograptus suecicus*, Mbg. (one specimen), *Æglina* (*Cyclopyge*) *binodosa*, Salt., and numerous Phyllopods. These flaggy beds must therefore be regarded as belonging to the zone of *D. extensus*.

Beyond the Boatyard some calcareous flags occur, which have, however, yielded no organic remains other than Phyllopods; they are seen to be dipping W.N.W. in an opposite direction to those above the Boatyard, and are probably the same beds slightly disturbed by the proximity of the Bangor–Carnarvon fault. There is then a break in the succession, and the next beds, seen at the corner beyond the ferry house and bridge, are much contorted and disturbed, and of a nature totally different from any of those just described. The Arenig Series seems to be terminated by the Bangor–Carnarvon fault, which crosses the river close to the Castle and brings on the contorted beds.

(b) *Right Bank.*

A similar but less complete succession may be found on the right bank of the river below the beds previously described by Marr (loc. cit.). Flags which seem to belong to the zone of *D. hirundo* are exposed in the railway cutting at two points, and below the Castle the calcareous flags, which form the lowest visible members of the Arenig Series in this district, are seen again.

The zone of *D. bifidus* is also seen in a quarry by the mill near the Brickworks, where the river makes a big bend, doubling back on itself for a short distance and then continuing in a direction almost at right angles to its previous course. The beds are here bent into a slight fold, the centre of which is occupied by greatly slickensided calcareous flags; graptolites are found in the associated thinly bedded shales, which are much iron-stained; in general the fauna resembles that of the beds at Pont Seiont, but the *Didymograpti* are rarer and the Diplograptidæ relatively more abundant. The beds have yielded—

Didymograptus bifidus (Hall), rare.
Diplograptus dentatus, Brong.
Climacograptus confertus, Lapw.

Beds on approximately the same horizon are also exposed at Peblig Mill, where greasy blue-grey calcareous mudstones are seen in the quarry below about 20 feet of drift. They are underlain at the north end by a series of lighter-coloured ochreous flags with darker bands, which give place downward to blue-grey mudstones.

The only fossils obtained from this locality were *Didymograptus bifidus* and *Diplograptus dentatus*, both found only after much searching.

Menai Straits.

Closely connected with the lowest beds seen in the Seiont River, though shifted slightly to the north-west by the Bangor–Carnarvon fault, are the beds which come out on the Menai Straits beneath the Carboniferous rocks, and to which attention was first directed by Greenly (Geol. Mag., 1898, p. 560). The beds are well exposed at low tide between the Suspension and Tubular Bridges. Working westwards from the Suspension Bridge, the nearly horizontal Carboniferous beds are at first all that is visible, but shortly some fissile red-coloured slaty beds appear beneath them with a general E.S.E. dip. They are at first only observable on the foreshore, but soon rise into a low cliff, then disappear beneath the Carboniferous, to reappear before reaching the rocky point opposite the rocks in the Strait known as the Swillies. They form the rocky point itself, and an examination of them shows that the red colouring characteristic of the higher beds is merely due to staining; the lower beds are uncleaved fissile blue-black shales with some calcareous flaggy bands. Numerous graptolites can be obtained at this point, and are particularly abundant in the more shaly bands, especially in a band close below the limit of staining.

I have collected the following fossils from this locality:—

Didymograptus extensus, Hall.
D. Nicholsoni, Lapw.
D. nitidus, Hall.
D. gibberulus, Nich.
D. cf. *uniformis*, Elles & Wood.
Tetragraptus serra, Brong.
T. Amii, Lapw.
Caryocaris, sp.
Lingulella, sp.
Trilobite (indet.).

Didymograptus extensus is an abundant form, and the beds seem therefore to belong to the zone of *D. extensus*, though I consider the presence of *Tetragrapti* indicates that the beds are somewhat lower down in the zone than those of the Seiont River.

Lleyn Peninsula.

In the neighbourhood of Aberdaron Matley has described several localities where Arenig rocks may be found (loc. cit., p. 118). He groups these into two districts, the eastern and the western.

(a) *Eastern District.*

The succession and mutual relation of the beds is best indicated in the eastern district near Llanfaelrhys.

As Matley (and previously Tawney) have indicated, the Penarfynydd shales contain numerous and excellent specimens of *Didymograptus bifidus*, as well as some trilobites and other fossils; these, therefore, represent the zone of *D. bifidus*. They are well exposed on the north side of Mynydd Penarfynydd, south and south-east of Penarfynydd Farm, and Matley has shown that the same shales are again seen on the coast between Porth Llawenan and Porth Alwm. They occur here between two dolerite sills, and seem to be faulted slightly out of their normal position. Further west excellent exposures of a series of slaty shales, mudstones, and ironstones are seen in the little gorge of Nant y Gadwen, and are termed by Matley the Nant y Gadwen shales. These shales belong to the zone of *D. hirundo* and the zone of *D. extensus*. The upper, more slaty beds, which are now best seen on the east side of the gorge and contain *Didymograptus hirundo*, *D. nitidus*, and *Azygograptus suecicus*, constitute the zone of *D. hirundo*; while the lower, more sandy beds of the extreme west side of the gorge seem to belong to the zone of *D. extensus*, since they have yielded the following graptolites:—

Didymograptus extensus, Hall.
D. nitidus, Hall.
D. gibberulus, Nich.
D. uniformis, Elles & Wood.
Tetragraptus Amii, Lapw.
T. cf. *Headi*, Hall.
Trinucleus Gibbsi, Salt.?
Calymene, sp.

These lower beds have a fauna almost identical with that of the Arenig beds of Menai Straits.

The fauna of the beds of the manganese-works of Benallt, near Rhiw, seems to be that of the zone of *D. hirundo*.

(b) *Western District.*

In the western or Aberdaron tract the masses of shale are for the most part faulted patches, and the only idea of their place in the succession is obtained from the fauna they contain.

The shales seen at Parwyd, since they contain *Didymograptus hirundo* and *Azygograptus suecicus*, seem to represent the zone of *D. hirundo*, while the lower zone of *D. extensus* appears to be represented by the beds at Porth Mendwy, though the graptolites here are rather fragmentary, and it is certainly exposed in the quarry opposite Dwyrhos Farm, where numerous, though badly reserved, specimens of the zone fossil may be obtained.

Arenig. (Figs. 2 and 3.)

In the Arenig district there are two graptolite-bearing shale bands associated with the volcanic group. One occurs in the middle of

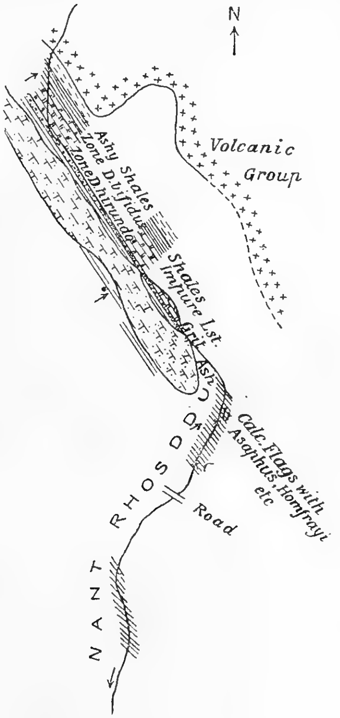


Fig. 2.—Sketch-map of Nant Rhos Ddu. Scale, 6 inches = ½ mile.

the volcanic series, the other underlies it, and both have hitherto been regarded as being of Arenig age. The upper shale band, known to some as the Daear Fawr shale, contains Diplograptidæ and a few Dicranograptidæ: the *Diplograpti*, which are chiefly

Diplograptus foliaceus, var., and *Diplograptus angustifolius*, Hall, are not of the type commonly met with in the Arenig beds of other localities, but, on the contrary, are of the type characteristic of the beds of other areas now generally regarded as being of Llandeilo age; the occurrence of *Dicellograptus Moffatensis*, Carr, and a *Dicranograptus* points the same way. With this shale band, therefore, I am not at present concerned, though its fauna is clearly of interest as bearing on the age of the volcanic group as a whole; it is possibly the equivalent of the middle and upper slates of the Moelwyn district.[1] The lower shale band underlies the main volcanic group and contains two zones, the zone of *D. bifidus* above and the zone of *D. hirundo* below. The succession may be studied on the slopes of Arenig Fach and Arenig Fawr.

On the side of Arenig Fach there rises a little stream, Nant rhos ddu, which flows at first in a S. 15° W. direction, then bends abruptly, running approximately south-south-east for a short distance, but soon resuming its former direction, crosses the Bala–Ffestiniog road about 160 yards below Taihirion Farm, and ultimately runs south to join the river Tryweryn. A series of shales, impure limestones, and gritty beds are exposed in the little gorge made by the stream when it runs south-south-east, and also where it resumes its south-west direction above and below the road.

The general succession is as follows (Figs. 2 and 3):—

		feet.
	8. Felspathic ash of main volcanic group.	
Arenig.	7. Banded slates with light-coloured ashy bands (fossiliferous)	6
	6. Blue-black slates with graptolites in bands	3
	5. Impure limestones with few shale partings containing a few graptolites	4½
	4. Grit with shale wisps	4
Tremadoc.	3. Calcareous flags.	
	2. Ash.	
	1. Calcareous slates and flags (fossiliferous).	

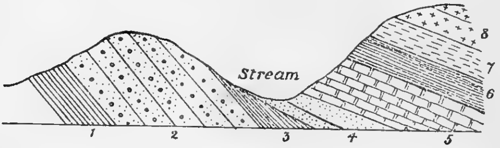


Fig. 3.—Diagrammatic Section across Nant Rhos Ddu. Vertical scale exaggerated.

The Arenig beds dip E. 25° N. at 20°, they are strongly cleaved, the cleavage making with the bedding an angle of about 20°. Some of the ashy bands of the uppermost series have yielded *Ogygia Selwyni* (Salt.) and other fossils, and the blue-black slates which underlie them have yielded graptolites characteristic of the zone of *D. bifidus*, namely, *D. bifidus*, Hall, *Diplograptus dentatus*, Brong., and *Climacograptus confertus*, Lapw. The only fossiliferous band among the impure limestones is at the very base where it rests

[1] Quart. Journ. Geol. Soc., 1891, p. 368.

upon the grit, and this has yielded a few specimens of *D. hirundo* and seems to indicate the highest bed of that zone. The grit which underlies the limestones appears to rest unconformably upon calcareous flags, and in these and the beds beneath it is worthy of note that the dip practically coincides with the cleavage, and hence the difference in dip between the two series, while similar in direction, differs to the amount of about 20°. There may also be some faulting along this line. The ash of the lower series seems to be a lenticular patch; it never crosses Nant rhos ddu, and its presence seems to be the factor determining the south-south-east course of the stream, for with its appearance the stream turns south-south-east, and with its disappearance resumes its original direction. The age of the lower series seems to be sufficiently determined by the presence of *Asaphus Homfrayi*, Salt., *Agnostus*, sp., and *Olenus triarthrus*, Walc., which have been found in several localities in beds dipping 40° E.N.E. They seem to be the beds designated Lower Arenig by the officers of the Geological Survey.[1] The Arenig beds are probably present below the ash band on the slopes of Ffridd Bwlch-llestre; they are, however, only exposed at one other locality, namely, in the stream north-east of Brynmaenllifo, where they are found beneath the basal agglomerate of the main volcanic group.

On the other side of the valley the most continuous exposure of the Arenig beds is found on the north-west slopes of Arenig Fawr, in the stream running down to Hafodty Milltir Cerig (Hafody Filltir Gerig). Here the succession is as follows:—

Felspathic ash (?) of main volcanic group.
Thickly bedded ashes, ashy flags, and shales, with *Ogygia Selwyni* (Salt.), *Monobolina* (*Obolella*) *plumbea*, *Maclurea*, sp., *Calymene*, sp.
Thinly bedded slates and flags with *D. bifidus*.
Grits.
Finely bedded banded shales.
Diabase intrusion.

The thickly bedded ashes, ashy flags, and shales are very like those of the Taihirion side, but somewhat thicker, and the underlying slates contain *D. bifidus* and seem to represent the zone of *D. bifidus*.

The lower zone of *D. hirundo* is probably also present, since in a collection made by Professor Hughes from this locality there are several specimens of *Azygograptus suecicus* in an impure limestone, and *Az. suecicus* is commonly found associated with *D. hirundo* elsewhere; I have not myself, however, detected the zone *in situ*. The rocks below the diabase intrusion seem to be of Tremadoc age.

South Wales.

The graptolite-bearing beds of South Wales, for the sake of convenience, may be considered as belonging to two districts—

(1) Western or St. Davids District.
(2) Eastern or Haverfordwest–Carmarthen District.

[1] "Geology of North Wales," vol. iii.

(1) *Western District.*

Hicks[1] and Hopkinson[2] long ago drew attention to the graptolite-bearing beds of the St. Davids district, and recorded fossils from the mainland and also from Ramsey Island, but while recent work tends to confirm Hicks' view that the beds of Llanvirn and Porth-Hayog were of Upper Arenig age, it tends to modify his conclusions respecting the age of the other graptolite-bearing beds.

(a) *Abereiddy Bay.*

The relation of the lowest Llandeilo beds, forming the zone of *D. Murchisoni*, to the uppermost Arenig slates, constituting the zone of *D. bifidus*, is particularly clear in this western district and worth notice. At the extreme south end of Abereiddy Bay a series of much cleaved black slates, dipping a few degrees W. of N., is seen crowded with *Didymograptus Murchisoni*; ascending the cliff, a well-marked band of felspathic ash separates these black slates from an underlying series of lighter-coloured slates, which can be observed for a considerable distance along the track leading from the spring to Nant; they also dip a few degrees W. of N. at a high angle, and have been extensively quarried in the past. The most fossiliferous beds, as indicated by Hicks, are those in the middle quarry, and from this place and the 'tips' lying north-west of it most of my fossils were obtained.

The beds contain

Didymograptus bifidus, Hall.
D. nanus, Lapw.
D. Nicholsoni, Lapw.
D. patulus, Hall.
D. euodus, Lapw.[1]
Cryptograptus tricornis, Carr.
Glossograptus ciliatus, Emmons.
Diplograptus dentatus, Brong.
Placoparia cambrensis, Hicks.

This light-coloured slate series therefore clearly represents the zone of *D. bifidus*; it is underlain by a succession of grits and flags well exposed in the old quarry near Nant.

(b) *Ramsey Island.*

Beds with a fauna very similar to that just described, but differing somewhat in their lithological characters, were found by Hicks and Hopkinson (loc. cit.) on Ramsey Island at the head of a little creek on the south-west known as Porth-Hayog or Porth Llanog. The beds here are soft black shaly mudstones, sometimes highly micaceous; they dip N.W., and have yielded an abundant fauna, including the following graptolites:—

Didymograptus bifidus, Hall.
D. stabilis, Elles & Wood.
D. artus, Elles & Wood.
D. Nicholsoni, Lapw.
D. affinis, Nich.
Didymograptus acutidens, Lapw.
D. patulus, Hall.
Diplograptus dentatus, Brong.
Climacograptus Scharenbergi, Lapw.
Cl. confertus, Lapw.[3]

[1] Hicks, Brit. Assoc. Rep., 1872, 1873; Quart. Journ. Geol. Soc., 1875, p. 167.
[2] Hopkinson, Brit. Assoc. Rep., 1872, 1873.
[3] Cf. lists of Hicks and Hopkinson, loc. cit., and Hopkinson and Lapworth, Quart. Journ. Geol. Soc., 1875, p. 631.

Possibly the shales, which seem to be responsible for the formation of the little bay south of Trwyn Gaelic, and thence run south-east, belong also to this zone of *D. bifidus,* but I have been unable to determine this with certainty.

The greater part of the black slaty beds forming the cliffs at Road Uchaf and Road Isaf have the fauna characteristic of the higher part of the zone of *D. extensus*; the beds dip landwards at a very high angle, and run approximately north and south. The following fossils occur:—

Didymograptus extensus, Hall.
D. sparsus, Hopk.
D. pennatulus, Hall.
D. gibberulus, Nich.
Trigonograptus ensiformis, Hall.
T. truncatus, Lapw.
Callograptus radiatus (Salt.).
Dendrograptus arbuscula, Salt.
D. flexuosus, Hall.
D. divergens, Hall.
D. diffusus, Hall.
D. Homfrayi, Hopk.
Ptilograptus Hicksi, Hopk.
P. cristata, Hopk.

The higher beds seen possibly represent the lower beds of the zone of *D. hirundo,* since they are crowded with a species of graptolite, *D. sparsus,* closely allied to *D. hirundo,* if not merely a variant of it, and the typical fossil, so far as I am aware, has not yet been recorded from the island; the higher beds of the zone of *D. hirundo* may be present west of Aber Mawr, but they are not well exposed owing to the nature of the country. The rocks may be faulted as Hicks' map would indicate, yet it is remarkable that the graptolite zones occur precisely where they might be expected were the succession normal.

(c) *Whitesand Bay.*

Slaty beds containing an abundant *Dendrograptus* fauna[1] are found on the mainland in Whitesand Bay, north of Trwyn Hwrddyn; they were considered by Hicks to be of the same age as the beds of Road Uchaf and Road Isaf, but the evidence tends, I think, to show that these Whitesand Bay beds are considerably lower in the Arenig Series than any seen on Ramsey Island.

These slaty beds are highly inclined, and dip a few degrees west of north at a high angle, they pass upward into a series of well-bedded slates with gritty bands seen in the old quarry in Porth Llenog, and from these beds there have been obtained—

Azygograptus Hicksi, Hopk.
Tetragraptus Amii, Lapw.
T. quadribrachiatus, Hall.
Didymograptus (*extensus* type).
Clematograptus implicatus, Hopk.
Dendrograptus arbuscula, Hall.
D. flexuosus, Hall.
Callograptus elegans, Hall.
C. Salteri, Hall.[1]

This fauna suggests the lower part of the zone of *D. extensus,* and hence these beds are rather lower than any seen on Ramsey Island; thus the beds which underlie them to the south must be still lower in the series.

These slates pass up into others containing a rich fauna, Trilobites and Brachiopods, but no identifiable graptolites. These are also seen at Porth Melgan, east of St. Davids Head.

[1] Cf. lists of Hicks and Hopkinson, loc. cit.

(2) *Eastern District.*

Further east in South Wales, in the eastern part of the Haverfordwest district, Marr & Roberts[1] have indicated in their '*Didymograptus* shales' the extension eastwards of the zones of *D. Murchisoni* above and *D. bifidus* below. And a collection of fossils made long ago by the late T. Roberts, and now in the Sedgwick Museum, Cambridge, seems clearly to point to the existence of the zone of *D. extensus* at Talfan, near Whitland, since the beds there have yielded *D. extensus*, Hall, *D. nitidus*, Hall, *Tetragraptus serra*, Brong., *T. Amii*, Lapw., *T. Headi*, Hall, *Dendrograptus fruticosus*, Hall,[1] *Callograptus persculptus*, Hopk., and *C. Salteri*, Hall.

In the Carmarthen district Crosfield & Skeat[2] have mapped the zones of *D. Murchisoni* and *D. bifidus* over a considerable tract of country, and the fauna of the shales of Hafod Wen, which they have courteously permitted me to examine, containing as it does both *D. hirundo* and *D. nitidus*, leads me to believe that the Hafod Wen shales represent the zone of *D. hirundo*; the beds of Glan Pibwr possibly indicate the still lower horizon.

Correlation and Conclusions.

	Wales.		Shropshire.		Lake District.	Scania.
	Zone of *D. Murchisoni.*		Upper Hope Shales.		Millburn Beds ?	Zone of *D. geminus.*
Arenig Series.	Zone of *D. bifidus.*	Shelve Series.	Lower Hope Shales.	Skiddaw Slates.	Ellergill Beds.	Zone of *Glossograptus.* Zone of *Phyllograptus* cf. *typus.*
	Zone of *D. hirundo.*		Upper Mytton Flags.		Upper *Tetragraptus* Beds.	Zone of *Isograptus gibberulus.*
	Zone of *D. extensus.*		Shelve Church Beds.			
	?		Lower Mytton Flags.		*Dichograptus* Beds.	Zone of *Phyllograptus densus.* Zone of *Didymograptus balticus.*
	Garth Grit ?		Stiper Stones Quartzite.		Lower *Tetragraptus* Beds.	Zone of *Tetragraptus phyllograptoides.*
	Tremadoc Beds.		Shineton Shales.		*Bryograptus* Beds.	*Bryograptus* Beds.

The correlation of the Welsh Arenig Series with beds of other areas is indicated in the above table.

The facts noticed about the beds would lead us to suspect that the series is incomplete in Wales, and a comparison with other areas tends to confirm this suspicion.

[1] Loc. cit. [2] Loc. cit.

With the possible exception of the lowest beds of the series seen in Whitesand Bay, there is, so far as our present knowledge goes, nothing comparable with the *Dichograptus* beds of the Lake District or the Lower Mytton Flags of Shropshire. In the Lake District the many branched graptolites are characteristic of this horizon. It is always possible that the beds may not be represented in Wales by the graptolitic facies, but up to the present time no graptolite-bearing beds of true Arenig age have been recorded resting conformably upon the Garth grit of Garth (Portmadoc) and its true equivalents. The beds of Ty Obry and Ty Fry have a fauna more closely allied to that of Llandeilo rocks than to that of any Arenig beds with which I am acquainted. Hence there is the possibility of a break in the succession between the grit of Garth and higher beds; there may be other grits in the series indicating recommencement of deposition, but these are not strictly the equivalents of the grit of Garth.

TABLE SHOWING EXTENT OF ZONES IN WALES.

	Menai Straits.	River Seiont.	Aberdaron.	Arenig.	St. Davids.	Carmarthen.
Zone of *D. bifidus* ...		———	———	———	———	———
Zone of *D. hirundo* ...		———	———	———	. . ? . .	———
Zone of *D. extensus* ...	———	———	———		———	———

In conclusion, I offer my grateful thanks to Dr. Matley for the loan of his maps of the Lleyn Peninsula, and for advice concerning the working of it; to Dr. J. E. Marr for allowing me to examine his collection of fossils; to Miss H. Drew, of Newnham College, and Mr. W. G. Fearnsides, of Sidney Sussex College, for help in collecting fossils in various places.

III.—FURTHER NOTES ON THE MAMMALS OF THE EOCENE OF EGYPT. PART III.

By C. W. ANDREWS, D.Sc., F.G.S., British Museum (Natural History).

AMONG the collections now in Cairo I find several new mammals, the remains of which have been collected by Mr. Beadnell, for the most part during the last few months. Brief descriptions of these new forms are now given in order that the names may be included in the lists in Mr. Beadnell's forthcoming report on the geology of the Fayûm area.

Pterodon macrognathus, sp. nov.

This creodont is known from the nearly complete left ramus of the mandible. The last molar, the first premolar, and the incisors are represented by the alveoli only, but the other teeth, with the exception of the canine, the crown of which is broken off, are in fairly good condition. The mandible is long and narrow from above downwards, the distance between the last tooth and the condyle being remarkably great. The transversely elongated cylindrical condyle is about on a level with the alveolar border, and is separated from the prominent angle by a deep notch; the coronoid region is imperfect. The teeth are not very unlike those of *Pterodon*, but it may subsequently be found necessary to establish a new genus for the present species. The last molar is represented by the alveolus only. M. 2 consists of a high blunt main cusp, a small antero-internal cusp, and a large talon with a blunt cutting edge near its outer side. M. 1 is much smaller than m. 2, but the talon is relatively larger and consists of a distinct tubercle, on the inner side of which there is a prominent cingular ridge. The last premolar (pm. 4) is much larger than m. 1; it consists of a high cusp and a small talon; the cingulum is distinctly developed on the inner side of the tooth. Pm. 3 and pm. 2 are simple conical two-rooted teeth, the crowns being small in comparison with the roots, at least in pm. 3. Pm. 1 was a small one-rooted tooth, squeezed outwards by the large canine, which was oval in section. The three incisors were so crowded together that the median one was situated behind and above the other two.

On the outer side of the jaw beneath the premolars there were four foramina separated by equal intervals. The dental foramen lies far back and is very small. This species may for the present be referred to *Pterodon* under the name *P. macrognathus*.

The dimensions of the type-specimen (No. 8982, Cairo) are:—

	mm.
Total length of the jaw	212
Depth of ramus at hinder end of the symphysis...	32
Depth of ramus beneath m. 3	32
Length of symphysis	58
Width of condyle	23
Distance between hinder border of the alveolus of m. 3 and the posterior angle of the condyle	102
Length of the alveolus of m. 3	16
,, m. 2	16
,, m. 1	13
,, pm. 4	17
,, pm. 3	14
,, pm. 2	12
Antero-posterior diameter of canine	20

Geniohyus major, sp. nov. (No. 8980, Cairo).

Three beautifully preserved premolars (pm. 1, 2, 3) indicate the existence of an animal closely similar to *Geniohyus fajumensis*, but much larger, the antero-posterior length of the teeth in the two species being—

	Geniohyus major.	*G. fajumensis.*
pm. 1	18 mm.	13 mm.
pm. 2	19 ,, ...	14 ,,
pm. 3	20 ,, ...	15 ,,

In fact, the length of the three anterior premolars in the present species is the same as that of the whole premolar series in *G. fajumensis*. In structure these teeth differ from those of *G. fajumensis* in much the same way as the latter differ from the premolars of *G. mirus*, that is to say, their selenodont character, particularly of the posterior cusp, is more distinct.

Megalohyrax minor, sp. nov.

A left maxilla (No. 8188, Cairo) with the very well preserved molars and premolars may be taken as the type of this species. Except for their smaller size the teeth are very similar to those of *Megalohyrax eocænus*. The chief differences are that the premolars are somewhat simpler. Thus, pm. 1 has an elongated crown without a postero-internal cusp, and is very similar to the canine of the larger form, and in the same way the succeeding premolars each resembles the tooth in front of it in *M. eocænus*. Another peculiarity is that the parastyle is better developed. The molars are much alike in the two species.

The dimensions of the upper teeth in the type-specimens of *Megalohyrax minor* and *M. eocænus* are given below :—

Length.	*M. minor.*	*M. eocænus.*
m. 3	29 mm.	37 mm.
m. 2	26 ,,	37 ,, (approx.).
m. 1	21 ,,	30 ,,
pm. 4	17 ,,	— ,,
pm. 3	15 ,,	25 ,,
pm. 2	14 ,,	23 ,,
pm. 1	15 ,,	18 ,,

The total length of the molar-premolar series is 13 cm.

Portions of a mandible perhaps referable to this species also occur in the collection. The specimen consists of two pieces, one the greater part of the right ramus with pm. 2–4 and m. 1–3, the other the anterior portion of the left ramus with part of the symphysis, containing pm. 3–4, m. 1–2, and in front two incisors, probably i. 1 and i. 2. The incisors have very broad short spatulate crowns, greatly compressed from within outwards, and bearing a continuous wear-surface along their edges. It is difficult to see how such teeth could have bitten against the large upper incisor, which it has been suggested was present in *Megalohyrax*, but it is not impossible that they may have worked against a ledge on the hinder surface of a tusk-like incisor. Further material is necessary, particularly the anterior portion of a skull of one of the species of this genus.

The molars and premolars each consist of two crescents, and from the inner end of the hinder limb of the anterior crescent a short ridge runs back on the inner side of the tooth, partly closing the opening of the hinder V of the tooth. The posterior premolars and anterior molars are alike. The dimensions of the teeth are :—

	Length.	Greatest width.
m. 3	33 mm.	20 mm.
m. 2	23 ,,	18 ,,
m. 1	19 ,,	16 ,,
pm. 4	18 ,,	16 ,,
pm. 3	16 ,,	14 ,,
pm. 2	17 ,,	11 ,,

Length of series from pm. 2 to m. 3 inclusive, 12·7 cm.
The width of the crowns of the incisors are: i. 1, 14 mm.; i. 2, 16 mm.

Saghatherium magnum, sp. nov.

Further examination of the type of *Saghatherium antiquum* in the museum at Cairo shows that a specimen of the upper dentition preserved in the British Museum, which I had regarded as belonging to that species, is actually much larger and differs slightly in some other points. I propose, therefore, to make this specimen the type of a new species, *Saghatherium magnum.* The approximate dimensions, compared with those of the type of *S. antiquum*, are :—

Length.	*S. magnum.*	*S. antiquum.*
Cheek teeth (molars, premolars, and canine)	78 mm.	62 mm.
Premolar series	32 ,,	25 ,,
Molar series	39 ,,	34 ,,
m. 3	17 ,,	15 ,,
m. 2	15 ,,	14 ,,
m. 1	10 ,,	11 ,,
pm. 4	10 ,,	8 ,,
pm. 3	9 ,,	7 ,,
pm. 2	8 ,,	6 ,,
pm. 1	8 ,,	6 ,,

The separate teeth are measured along their outer wall.

One of the most striking differences between the two species, other than size, is that in the last molar of *S. magnum* the metastyle is much less developed than in *S. antiquum.*

The anterior portion of the upper jaw showing the large incisor, figured in the Geological Magazine, 1903, p. 340, under the name *S. antiquum*, is actually part of the type-specimen of the present species.

All the species described above are from the Upper Eocene beds of the Fayûm.

Zeuglodon isis, Beadnell MS.

The existence of a large species of *Zeuglodon* other than *Z. osiris*, Dames, in the beds beneath the Qasr-es-Sagha series has already been referred to by Stromer [1] and also in this Magazine (1901, p. 437). Mr. Beadnell refers to this species in his memoir on the geology of the district, which will be published shortly, as *Zeuglodon isis*, and this name is here adopted. The most important specimen, which may be taken as the type, is a right ramus of the mandible complete as far as the back of the tooth series; this was collected from the Birket-el-Qerun beds of the Middle Eocene. The teeth in the anterior portion are lost, but the hinder ones are present, though somewhat broken and obscured by matrix which cannot be removed.

The total length of the specimen is 83 cm. In front it terminates in a blunt point, and is convex from above downwards on its outer face, while the inner face forms a flat symphysial surface for union with the opposite ramus. The depth of the ramus at the second alveolus is about 64 mm., but posteriorly it deepens, till behind the last molar it is about 220 mm. The extreme anterior end is occupied by an empty alveolus, and behind this there are three

[1] "Zeuglodon-reste aus dem Oberen Mitteleocaen des Fajum": Beitr. Pal. u. Geol. Oster.-Ung. u. d. Orients, Bd. xv, Heft 2 and 3 (1903), p. 83.

other alveoli for single-rooted teeth; these occupy the anterior 26 centimetres of the jaw. The next tooth is *in sitû*; its anterior border is 32 cm. from the tip of the jaw. The crown is high and conical, somewhat compressed from side to side, with sharp anterior and posterior edges and slightly curved backwards. On the anterior edge near the base of the tooth there are five or six blunt, upwardly directed denticulations, while on the posterior edge there are four or five larger ones. The height of the tooth crown was 6·5 cm., the length of its base 5 cm. The next tooth, separated from the last by an interval of about 5 cm., was broad and double-rooted; its crown is somewhat broken, but it can be seen that on its anterior and posterior edges there were several large and sharp denticulations. The length of the tooth at its base was about 6·6 cm. The next tooth, which is separated from the last by an interval of 4·5 cm., is similar, as also is the next, which is in contact with that in front. The last three teeth (the molars) differ considerably from those just described. They are closely crowded, and have a nearly straight anterior border, denticulations occurring on their posterior edge only. On the whole the dentition closely resembles that of *Zeuglodon osiris* as figured by Stromer.[1]

A number of very large vertebræ have also been found; the dimensions of one of these are:—Length of centrum, 23·5 cm.; transverse diameter, 17·7 cm.; vertical diameter, 15 cm.

P.S.—In reference to my account of the teeth of *Arsinoitherium* given in the last part of these notes, my attention has been drawn to the fact that in a footnote to one of his geological papers Blanckenhorn has mentioned the similarity between this dentition and that of *Coryphodon*.

CAIRO, *April*, 1904.

NOTICES OF MEMOIRS, ETC.

I.—PALÆONTOLOGY IN THE NATIONAL MUSEUM, MELBOURNE.

THE following Report of the Palæontologist of the National Museum, Melbourne, Mr. Frederick Chapman, has recently been issued, and gives a good general idea of the material available for study in that Institution:—

After the preliminary work of unpacking and generally inspecting the collections of fossils placed in my charge, the work of selecting a series of specimens to illustrate Australian, and particularly Victorian, palæontology was commenced. This has been progressing, in conjunction with other necessary work, with the result that there are now on view 15 table-cases of typical Australian fossils, including the Cambrian, Ordovician (Lower and Upper), and the Silurian. I have introduced certain noteworthy features, such as explanatory diagrams and illustrations, into the arrangement of these cases, in order to make them more interesting, both to students

[1] Op. cit., pl. viii, fig. 2.

and the public. Our collections of Palæozoic fossils have been considerably enriched by the purchase of the valuable series formed by the Rev. A. W. Cresswell, M.A., and Mr. F. Spry respectively, and the donation by Mr. G. Sweet, F.G.S., of the entire series of Cambrian fossils now on exhibition. The large fossils and casts have been repaired and repainted, and the whole labelled in accordance with the latest nomenclature. These exhibits are arranged in the Upper Gallery of the Museum on the north-east side, which was thrown open to visitors last November.

I have prepared and hung in the Gallery two long, coloured geological sections, one illustrating the geology of Victoria, running through the State in a west to east direction, and the other taken through Melbourne from Brunswick to Ormond Point, near St. Kilda. Every care has been taken to render these correct according to the latest information, and in working out these details I have been greatly assisted by the friendly help of Professor Gregory, F.R.S., and Mr. T. S. Hall, M.A. One thousand and thirty-seven fossils have been determined, most of which are now exhibited.

Since a large number of the Palæozoic fossils of Victoria are still awaiting description, this work has been taken in hand, and I have figured and described (Proc. Roy. Soc. Vict., vol. xv, pt. 2) fourteen fossils in the National Museum, ten of which are new to science; two new genera have also been established to receive two of these fossils.

The very comprehensive and valuable collection of fossils in the Museum, brought together under the direction of the late Sir Frederick McCoy, was a distinct and agreeable surprise to one who, although familiar with the English national collection, did not anticipate meeting with anything at all comparable in the southern hemisphere; and these, chiefly the foreign specimens, will be most valuable for purposes of comparison with those of Victoria.

II.—Various Short Notices.

1. The subject of "Clastic Dikes" is dealt with by Mr. J. F. Newsom (Bull. Geol. Soc. America, xiv, 227, 1903). He describes a number of sandstone dikes in San Luis Obispo and Santa Cruz counties, California. The rocks of San Luis Obispo are Cretaceous sandstones, overlain by Miocene shales, which are cut by sandstone dikes. These dikes occur near the axis of a low synclinal fold, where former conditions were probably favourable to great hydrostatic pressure. The author is of opinion that soft sands were forced up from below along joint planes, and that the sands were afterwards firmly cemented by calcium carbonate. Near Santa Cruz there are dikes of sandstone, varying from mere films along joint planes to intruded masses several feet thick. These cut the Miocene shales at various angles on the western side of a faulted monoclinal fold. The smaller films are usually bituminous. In the author's opinion there is evidence that the underlying sandstones were formerly oil-bearing, and that the oil-bearing sands were forced into joints in the shales. The larger dikes formed the avenues of escape for the

petroleum, and subsequently for water which carried the oil and oil residues from the intrusions. The author concludes with a very full summary of the literature of Clastic Dikes.

2. Dr. F. H. Hatch has written a brief description of "The Boulder Beds of Ventersdorp, Transvaal" (Trans. Geol. Soc. S. Africa, vi, 95, 1904). The boulder ('banket') beds consist of pebbles and large masses of slate, conglomerate, and quartzite, identical with rocks occurring on the Rand and belonging to the Witwatersrand Beds; and they include also various igneous rocks. Some of the banket boulders have been found to contain gold in payable quantity, but these occurred amid many non-auriferous masses, the fact being that the boulder beds have been derived chiefly from the Witwatersrand Beds upon which they rest unconformably. Dr. Hatch remarks that the boulder beds include not only conglomerates but igneous breccias, and the formation appears to have been initiated by the outpouring of vesicular lavas known as the Klipriversberg Amygdaloid. For the group he applies the term "Ventersdorp Beds."

3. "The Geological History of the Gouritz River System" is the title of an essay by Mr. A. W. Rogers (Trans. S. African Phil. Soc., xiv, 375, 1903). This river system drains the country southwards from the Nieuweveld Ranges, and the principal rivers, after crossing a broad tract of less elevated ground, traverse in succession the mountainous tracts of the Zwartebergen and Langebergen. The author describes the physical changes to which the area has been subjected, and which have led to the present drainage system.

4. An Index to Geological Papers.—Many valuable papers on the geology of Devonshire are scattered through the first thirty-four volumes of the *Transactions* of the Devonshire Association for the Advancement of Science, etc. Vol. xxxv (1903) contains a continuous alphabetical index to these, by Mr. J. G. Hamling, who has placed each paper under three headings, viz., subject, locality, and author. Geologists will be grateful to the compiler, and it is only because he asks for intimation of any mistakes or omissions that we venture to suggest the desirability for an extension of the subject entries; for example, there are only eight entries under 'Caverns' and only eight under 'Fossil,' although the number of papers dealing with those subjects is vastly greater.

5. "Devonshire in the time of the Lower Chalk" is the title of a paper by Mr. Jukes-Browne (Trans. Devon Assoc., xxxv, 787, 1903). An accompanying map shows the probable geography of the south-west of England and north-west of France in the Cenomanian (Lower Chalk) age. Exmoor is represented as an island, while the country south-west of Tintagel and Dartmoor is regarded as part of "the Western Land" connected with Brittany and Normandy.

6. In another paper on "The Geology of the Country around Chard" (Proc. Somerset Arch. and Nat. Hist. Soc., xlix, 1903)

Mr. Jukes-Browne gives a particular account of the Selbornian Sands (Upper Greensand) and Chalk, with an excellent photographic view of the quarry at Snowdon Hill, Chard, famed for its rich fossil-bed at the base of the Chalk.

7. In an article on "The Cotteswold Hills" (Proc. Cottesw. Club, xiv, 205, 1903) Mr. S. S. Buckman discusses the area of the Cotteswolds, the spelling of the name, and other matters of topographical interest—entering fully into the literature of the subject. A map on the scale of an inch to 4 miles accompanies the article, and on it he has marked the limits he is led to assign to the Cotteswold Hills and the names of the bordering vales. To aid in his decision he has sought the best advice from residents and others. The greatest difficulty in fixing a boundary was in the region east of Burford, a tract sometimes spoken of as the Oxford or Oxfordshire Downs. With regard to this term Lord Moreton writes that it is not a geographical expression, but "simply means the sheep of Oxfordshire of a down character." The Cotteswold Hills as now marked out extend from Ebrington Hill on the north to Lansdown by Bath on the south. The western limit is naturally bounded by the escarpment of the Oolites. The eastern limit is taken to include Badminton (but not Malmesbury), Tetbury, Cirencester, Fairford (but not Witney), Leafield, and the western side of the Vale of Moreton. Names of places where the Cotteswold Club has held field-meetings are marked on the map, showing plainly that the Club has trespassed far and wide into bordering tracts. A full list of the field-meetings, drawn up by Mr. L. Richardson, is appended. —H. B. W.

8. Labelling of Objects in the Geological Department, British Museum of Natural History.—Much attention has been paid of late years to the question of explanatory labels for the exhibition cases, and among those who have given special thought to this important subject is Dr. F. A. Bather, M.A., F.G.S., the Assistant Keeper of Geology. The subjoined is a specimen of a recently printed label prepared by him for the Echinoderm case, which serves to show how much information may be imparted to the student of geology and to the public at large by this means.

"*How Sea-Urchins are turned into Flint.*

Silica, the substance of which flints are made, is scattered through the Chalk formation in very minute particles, which are dissolved to some extent by water, especially if it be slightly alkaline. Consequently, as rain-water sinks into the Chalk it dissolves the silica and carries it with it through the Chalk. When the sea-urchins died and were buried in the chalky ooze, the inside of their shell or test was sometimes filled with the ooze, but sometimes it remained empty. In the latter case, when the Chalk became hardened and raised out of the sea, a cavity was left, into which flowed the dissolved silica. It may have been deposited on the walls of this cavity (i.e. the inside of the urchin's test) as minute crystals of quartz (rock-crystal); or, as was more usually the case, it filled the cavity with a formless mass of the impure chalcedony that we call flint. So was fashioned in silica a cast of the inside of the sea-urchin test; and later on, as the Chalk was worn away by rain and rivers, and as its fossils thus came out on the surface, then the relatively soft and soluble test was worn or dissolved off. Therefore it is that many of these flint casts turn up on the surface of the downs or in gravel-pits. In some cases, however, the test itself became impregnated with silica; for the limy substance, of which the test is made, is very porous. The pores usually are filled in fossil specimens with crystalline carbonate of lime; but sometimes the silica got in first. When the flint was once deposited in this way, so long as it remained in the Chalk there was a tendency for further flint to be deposited round it, and so the sea-urchins are occasionally found embedded in masses of flint. Sometimes one finds only this surrounding flint with the impression of the outer surface of the urchin."

REVIEWS.

I.—The Atoll of Funafuti. Borings into a Coral Reef and the Results. Being the Report of the Coral Reef Committee of the Royal Society. 4to; pp. xiv and 428, with 6 plates at end of text and folding chart of soundings, 69 cuts in text, also with 19 plates in a separate portfolio. (Published by the Royal Society, 1904.)

The much-discussed question as to the origin of Atolls has, of late years, been left a moot point, because the adherents to this theory or to that have recognised that no satisfactory conclusion can be come to without much further evidence, particularly that which would probably be supplied by a deep boring into an atoll. Such an undertaking, advocated by Charles Darwin, who first made the question of the origin of atolls notorious, has at last been accomplished by expeditions during three consecutive years, sent out under the control and at the expense of the Royal Society and the Government of New South Wales, and aided by private donations.

The Report of the Coral Reef Committee of the Royal Society on these expeditions occupies the pages of the volume under consideration. It has been edited by Professor T. G. Bonney, D.Sc., F.R.S., who became responsible for passing the volume through the press, and was also Chairman of the Coral Reef Committee. In the preface he gives a brief history of the various stages of the enterprise from its inception in 1893 to its completion. Its primary object, as defined in the instructions to its first leader, Prof. Sollas, was to investigate, by means of a boring, the depth and structure of a coral-reef, and all other work undertaken in furtherance of natural knowledge was to be considered as secondary to this object, whilst with regard to the publication of the results, the Council of the Royal Society authorised the preparation of a monograph of which the main feature should be a description of the whole core from the points of view of the naturalist and the chemist. The cores and loose material were brought to London for detailed examination, and subsequently the half-cylinders of core and duplicate portions of the loose material have been returned to Sydney, and the part retained in England has been placed in the British Museum (Natural History) at Cromwell Road, South Kensington.

Professor Bonney further states, "that into the controversies about the development of coral-reefs, those who have been concerned in the preparation of this volume have not attempted to enter. They have endeavoured to state facts, and leave it to readers to interpret these for themselves. . . . . At any rate the composition, zoological and chemical, of an atoll down to a depth of 1,114 feet has now, for the first time, been made known." The final success of the undertaking is attributed by Professor Bonney to the zeal, energy, and liberality of friends in New South Wales, more especially of Professors Edgeworth David and Anderson Stuart, and of the Government of that Colony.

The Report is divided into fourteen sections, in which each author gives an account of the observations in his own branch of the work and of the results obtained, and in many cases inferences from these results are drawn. It is, however, desirable to bear in mind that these inferences represent the views of the individual authors of the respective sections, as in some instances they appear to be rather speculative.

The narrative, by Professor W. J. Sollas, D.Sc., F.R.S., of the first expedition, sent out under him in 1896, occupies the first section. The expedition was of little importance, except as paving the way for those that followed, and enabling them to succeed through the knowledge gained by its failures. For a failure it was as far as its main object was concerned; although two borings were attempted the first reached a depth of only 105 feet, and the second 72. They failed mainly through the inability of the machinery to deal with alternations of hard cavernous rock and loose sand.

To quote Prof. Sollas:—"Although the boring proved a failure, several other objects of the expedition were attained with complete success. Messrs. Hedley and Gardiner made a thorough investigation of the flora and fauna, both land and marine. Dr. Collingwood obtained a good deal of information of ethnological interest, and we all made a fairly complete collection of native implements and manufactures. A daily record was kept of maximum and minimum temperatures, and of the readings of dry and wet bulb thermometers. . . . . The most important contribution, however, is afforded by the investigations of Captain Field, who made a complete topographical survey of the Atoll, and a vast number of soundings both in the lagoon and the outer sea; he also carried out magnetic and tidal observations."

A general description of the atoll is given, of its submarine slopes and of its surface features. The latter present six zones from the ocean to the lagoon, namely: (1) the Nullipore Rim; (2) the reef-flat; (3) the glacis of coral rock; (4) the Hurricane Beach; (5) the central flat of the islet; (6) the lagoon mound.

The features of the glacis of coral rock, especially its isolated outliers, are discussed, and also the mode of growth and the horizon of *Heliopora* and *Porites* now growing in the lagoon, as bearing on the former condition of the island; and the conclusion is arrived at that the island has undergone oscillations of level, which may possibly be correlated with a preglacial, glacial, genial, and present-day period in geological time.

Section ii, by H. C. Russell, C.M.G., F.R.S., gives an account of the meteorological observations made during the stay of Professor Sollas on the island; and section iii, by Captain E. W. Creak, R.N., F.R.S., is the report on the results of the Magnetic Survey of the atoll made by the officers of H.M.S. "Penguin," the ship which conveyed the expedition under Professor Sollas to Funafuti.

Section iv is the narrative, by Professor T. W. Edgeworth David, B.A., F.R.S., of the second and third expeditions made during the years 1897 and 1898.

After the failure of the expedition in 1896, Professor David, of Sydney, incited those interested in New South Wales to make a further effort to bore Funafuti, with improved boring-plant. By means of generous gifts of £650 from Miss Eadith Walker, of Sydney, and £100 from Mr. Ralph Abercromby, together with the loan of a diamond drill from the New South Wales Government, it was possible to send out a second expedition in 1897. A main bore was started, and, while this work was proceeding, an attempt was made to bore the floor of the lagoon. This lagoon boring proved a failure, and the raft on which the plant was erected was wrecked during a gale. Meanwhile the main bore proceeded slowly, and when it became necessary to return a depth of 698 feet had been reached.

In addition to the boring a geological survey was made of the various islets of the atoll, and a collection formed of various organisms living on the seaward slope of the atoll from depths of between 20 and 200 fathoms.

In the next year, 1898, "it was considered very desirable that an attempt should be made to deepen the main bore, and accordingly the Government of New South Wales and the Royal Society of London were approached on this subject. They both generously responded," and a third expedition was sent out under the leadership of Mr. A. E. Finckh. The Admiralty detailed H.M.S. "Porpoise," Captain F. C. D. Sturdee, for the work of again attempting a boring through the lagoon floor. This was accomplished successfully by Mr. G. H. Halligan, who sank two bores, one reaching 144 feet and the other 113 feet below the floor of the lagoon. The main bore, started during the previous year, was reopened, and a depth of 1,114 feet was attained. In addition to these results, permanent marks were left on the island by Mr. Halligan.

Section v, written by Professor David and Mr. G. Sweet, F.G.S., deals with the geology of the Funafuti atoll. Describing first its shape as a whole, they suggest that its elongation in a meridional direction is due rather to its being situated in a volcanic zone or fold-ridge, than to any influence of prevalent winds and ocean currents. The prevalent winds are the north-west monsoons and the south-east trades, the former being the stronger, and the storms caused by both result in the formation of the hurricane beaches of the islets.

The islets, as shown on the maps and sections accompanying the volume, may be divided into zones as already stated. A glance at the maps, however, shows a much more detailed division of the surface of the land than was given by Professor Sollas. It is to be regretted that Professor Sollas' divisions and those of Professor David are not compared, for in casually reading the account of one and then of the other the correlation is not obvious. However, the order from the ocean to the lagoon, and the correlation with the divisions of Professor Sollas, seem to be as follows. The symbols on the maps are given in brackets.

1. The outermost rim of living *Lithothamnion* (O.L. 10) = the Nullipore Rim of Sollas.
2. Zone of dead *Lithothamnion* (O. 3) = the reef-flat of Sollas.
3. Old reef of *Heliopora* and *Porites* (O.L. 1) } = glacis of coral rock of Sollas.
4. Breccia which overlies 3 (O. 2 B., O. 2 C., O. 2 D.) } = glacis of coral rock of Sollas.
5. Hurricane beach (O. 4) = hurricane beach of Sollas.
6. Old reef of *Heliopora* and *Porites* and breccia, together with various newer and older superficial deposits (L. 6, L. 7, etc.) = central flat of islet of Sollas.
7. Inner hurricane beach (O. 4), not always present.
8. Various superficial deposits of lagoon beach (L. 8, L. 9). } Not mentioned by Sollas.
9. Old reef of *Heliopora* and *Porites* and breccia, cropping out on lagoon side. } Not mentioned by Sollas.
10. Zone of living *Lithothamnion*, present in channels leading into the lagoon, and in some places on the lagoon side of the islets. } Not mentioned by Sollas.

The reef of *Heliopora* and *Porites* is the oldest rock which crops out on the island, and is in most places covered by the breccia. All the other deposits are superficial, and lie irregularly on these, which thus form the primitive reef-platform.

The sequence of events, which is not very clearly stated, seems to have been as follows:—First the *Heliopora* and *Porites* reef was formed, and then there was an uplift of from six to ten feet, during which time the breccia was formed by the marine denudation of the reef. The land then sank about 8 feet, and the breccia became cemented by *Lithothamnion*. Then another elevation occurred, allowing the breccia to come under the action of the waves which made breaches in the breccia barrier; and so the several islets were formed, and subsequently the Hurricane banks were piled up from the material of the breccia. Minor oscillations of level occurred, the present subaerial deposits were laid down, and the present fauna was introduced; a deposit of silt killed the *Heliopora* near the lagoon shore. Finally, there was an upward movement of 6 or

7 inches which killed the *Lithothamnion*, then living in the zone now marked as 'dead' *Lithothamnion* (O. 3). At the same time the Hurricane beaches were pushed further back.

In the future, probably, the lagoon will be filled up by the growth of *Halimeda*, and the islets will be gradually levelled by marine denudation. Against this destruction may be set a present upward movement of the land, as well as a very slowly widening rim of *Lithothamnion*. But another levelling factor is the subaerial denudation caused by the torrential tropical rains.

The biology of the reef-forming organisms, by Alfred E. Finckh, forms the subject of the next section.

Three main marine biological zones are noted, namely: (*a*) that of living *Lithothamnion*; (*b*) a zone of less active growth between the former zone and that line which marks the limit of the waves at low-water spring-tides; (*c*) the lagoon in which occur all forms found outside and in addition *Heliopora cærulea*. The bottom of the lagoon is formed mainly of *Halimeda* sand.

The organisms of the reef now forming, in the order of their importance, are as follows: (*a*) *Lithothamnion*, (*b*) *Halimeda*, (*c*) Foraminifera, (*d*) Corals and Hydrocorallines. *Lithothamnion* occurs in three forms, two encrusting and one frondose. *Halimeda* is the most important organism in the lagoon. The chief use of the corals and hydrocorallines in reef-building is to form a basework on which *Lithothamnion* can grow. There are five main groups of corals and hydrocorallines occurring as follows in order of importance in reef-building: (*a*) *Heliopora cærulea*, (*b*) the Millepores, (*c*) the *Porites* family, (*d*) *Madrepora*, (*e*) *Pocillopora*.

Mention is made in this section of the enemies of the reef-formers. Excluding *Lithothamnion*, which, by its cementing action, constructs the reef more than it destroys it by its swamping effects on the other reef-forming organisms, the chief enemies are two Gephyrean worms, one of which is a Sipunculoid (*Aspidosiphon*). Holothuroids, supposed by Darwin to be destructive to the reef-formers, are acquitted of this charge, for it was found that their food was entirely composed of microscopic organisms.

A series of experiments are next described, carried out to ascertain, if possible, the rate of growth of the reef-forming organisms. The lack of experience in such experiments, their novel character, and the consequent absence of suitable apparatus caused the results to be somewhat vague. The situation of the camp precluded experiments upon the branching form of *Lithothamnion* and upon *Heliopora*. Four methods were employed, namely, weighing at intervals, measuring at intervals areas marked out on the coral by glass pins, measuring the distance of approaching portions of a coral and noting how long they took to meet, and causing the organism to grow through a hole in a board. Many of these specimens are now exhibited in the Geological Department of the British Museum, South Kensington. Experiments were also made on the amount of exposure to the sun needed to kill the various reef-formers. Less than two hours sufficed in the case of all except *Porites*.

Section vii is a short report of the dredging at Funafuti, by Professor David, G. H. Halligan, and E. A. Finckh.

In the lagoon seventeen out of eighteen dredgings were composed of detrital *Halimeda* and fragments of shells intermixed with a little seaweed. In the ocean living *Halimeda* only occurred down to 45 fathoms, the limit of penetration of red and yellow light. No pieces of an ancient coral-reef were dredged.

The branching form of *Lithothamnion* was found only to occur in shallow water. Thus it was thought that its presence in the cores might be of use in determining the depth at which any particular piece was formed. However, Dr. Hinde is of opinion that the exact form of *Lithothamnion* in the cores cannot be satisfactorily determined, that is, whether the branching, nodose, and incrusting forms correspond with the similar growth-forms from the reef-slopes.

Section viii is a report on the lagoon borings by G. H. Halligan.

Two borings were made at spots in the floor of the lagoon where the depth at low water spring tides was 101 feet. The first passed through 81½ feet mostly of *Halimeda* débris, next through 18 inches of hard coral, 33 feet of coral fragments, 18 inches of coral, and, finally, again through 26½ feet of coral material, thus in all 144 feet beneath the floor of the lagoon, or 245 feet below the sea-level. The second boring, a short distance from the first, went through 91½ feet of *Halimeda* débris, next through 3 feet of hard coral with intermediate bands of softer material, and then entered coral gravel and sand, to a depth altogether beneath the lagoon floor of 94½ feet, or 196 feet below the sea-level. Mr. Halligan finishes his report with the following words:—"It is perhaps only fair to mention that the lagoon borings here described were undertaken without the least idea of the formation to be expected, and were carried out under the most unfavourable circumstances possible. . . . . Had it not been for the co-operation and energy of the captain, officers, and men of H.M.S. 'Porpoise,' the work could not have been carried out at all."

Section ix, by the same author as the last, describes the permanent marks left by him on the island of Funafuti, to register for future reference the present levels of different spots. These marks were made of iron pipes let into the coral rock.

Section x is the general report by Professor J. W. Judd, C.B., LL.D., F.R.S., on the materials sent from Funafuti and the methods of dealing with them. The cylindrical cores and fragments of solid rock from the different borings were, on their arrival in London, slit longitudinally, and from those in the main boring to a depth of about 800 feet from the surface a thin slab of the whole size of each core was cut out of its middle. This slicing proved a very arduous task, particularly in the nearly continuous solid cores of the lower 400 feet of the boring, but it was very effectively done by means of a lapidary's wheel driven by an electro-motor. The slit surfaces of the hard cores when thus treated were sufficiently well polished to allow of the determination of the larger organisms by means of a lens, whilst for the examination of the minute forms and of the mineral characters of the rock, more than 500 microscopic sections were prepared.

In addition to the materials from the borings, large collections of the existing fauna and flora of the atoll were made by Mr. Stanley Gardiner and Mr. Hedley, and Professor David and Mr. G. Sweet made strenuous efforts, at no small personal risk, to dredge up the organisms existing on the steep ocean slopes of the present reef to a depth of 200 fathoms. As a description of the existing organisms of the atoll was not included in the scope of the undertaking, the collections made have been, in part, studied by different specialists in this country and in Australia, and the results published in various scientific journals. A list of these memoirs is given by Professor Judd.

Section xi, by Dr. G. J. Hinde, F.R.S., contains the report on the materials from the borings at the Funafuti Atoll.

The main achievement of the later expeditions to Funafuti, under the direction of Professor David and Messrs. Finckh and Sweet, was the penetration of the reef at the main boring to a depth of 1,114 feet and obtaining materials which showed distinctly the nature of the rock to this depth. These materials were subjected to very careful scrutiny, and a detailed record of the various organisms recognized in each separate portion of the cores and their general mineral condition is given in this section of the Report. The nature of the material varied greatly in different parts of the boring. To the depth of 748 feet from the surface the greater part of the rock seems to have been of a friable and incoherent character, which in the process of boring was reduced to fine granular particles usually called sand, whilst the aggregate length of the solid portions of the core only reached 73 feet, or about one-tenth of the distance passed through. On the other hand, the lower third of the boring from 748 feet to the bottom at 1,114 feet was to a very large extent solid rock, forming a nearly continuous cylindrical core 311 feet in length. The friable upper portion down to 637 feet was mainly of calcium carbonate, whilst the lower solid third of the core was of dolomitic limestone.

No true oolitic grains were met with in any part of the cores, nor was any pumice or other volcanic material recognized. The presence of silica was not detected, though siliceous boring sponges were originally very numerous. Lines of stratification were not distinguished in the cores.

The rock throughout was entirely organic, derived from the calcareous skeletons of marine invertebrate animals and calcareous algæ; the principal rock-formers belong to Foraminifera, Corals, and Algæ, and with these are associated detached spines and test-plates of echinoderms, annelid tubes, crustacean tests, spicules of calcisponges and tunicates, and the shells or casts of lamellibranchs and gasteropods. The only vertebrate remains found in the cores was a single fragment of fish-bone or spine less than an inch in length.

Of the Foraminifera 35 genera are represented in the main boring;

they are equally as abundant in the cores and loose materials throughout the boring as in the beds at the surface of the reef now forming. The most important rock-forming genera in the order of their relative abundance are *Amphistegina*, *Polytrema*, *Orbitolites*, *Heterostegina*, *Carpenteria*, *Gypsina*, and *Calcarina*. All the forms belong to genera still existing, and no examples of characteristic Tertiary species were recognized. For the determination of critical forms the author acknowledges the invaluable assistance of Mr. F. Chapman.

Corals, including Alcyonaria and Hydrocorallinæ as well as the Madreporaria in this term, are present throughout the main boring, but, especially in the lower 350 feet, they are more numerous and varied than in the upper part. They have suffered greater changes in fossilization than any other group of organisms, and below a depth of 180 feet in the boring their walls and other structures have been for the most part dissolved and removed, and only casts in sedimentary or crystalline materials remain. In many instances they appear to be in the position of growth. Twenty-eight genera have been recorded from the borings; 22 of these are living at the present time on the reefs or in the lagoon at Funafuti. The commoner genera such as *Millepora*, *Lobophytum*, *Stylophora*, *Pocillopora*, *Astræa*, *Orbicella*, *Fungia*, *Madrepora*, *Astræopora*, *Montipora*, and *Porites* range from the top to the bottom of the main boring, but not continuously, for a particular form which has flourished through a series of consecutive cores will often disappear for a variable interval and then come in again. All the forms met with are reef corals; no examples of deep-water forms have been recognized in any of the cores.

Of the calcareous Algæ the most important genus, *Lithothamnion*, is represented by branching nodular, and, more especially, by encrusting forms which grow over corals and other organisms so as to bind them fast together and form layers of very compact dense rock. Another genus, *Halimeda*, is widely distributed throughout the cores; in some parts of the main boring and in the boring beneath the floor of the lagoon the rock is mainly composed of their detached segments.

Though the main boring reached to a depth of 1,114 feet it did not penetrate through the reef-rock, and the cores from the bottom were as distinctly reef-like as those from any other part of the boring.

The last three sections, dealing with the chemical and mineralogical composition of the cores, are of great interest.

First, Professor Judd describes the chemical aspect of the cores as shown in numerous analyses made by his assistants, Dr. C. G. Cullis and Dr. E. W. Skeats, and by Mr. Hart Smith, and this may be generally stated as follows. As far as 637 feet from the surface the core consists of calcium carbonate with a small proportion of magnesium carbonate. Below 637 feet the proportion of magnesium carbonate rises fairly suddenly to nearly 40 per cent. of the whole. Calcium phosphate is present throughout in minute quantities.

Volcanic rock is entirely absent. The proportion of magnesium carbonate between the depths of 10 and 20 feet rises considerably, and then falls away again. Professor Judd shows that under certain conditions calcium carbonate is more soluble than magnesium carbonate, and he thinks that "down to 637 feet the degree of enrichment of the rock by magnesium carbonate may be probably ascribed to the *leaching out* of calcium carbonate," and this accounts for the friability of the upper part of the core.

The presence of the large percentage of magnesium carbonate in the lower part of the boring is considered by Professor Judd to be due to some such segregation as has produced flints in the Chalk, and the iron disulphide nodules of other formations. The material of a reef "is everywhere permeated and acted upon by sea-water, containing a very notable proportion of magnesium, principally in the condition of chlorides and sulphates. May not these materials, enriched by the magnesium carbonate, exercise an attractive action on the magnesium salts of the ocean waters, giving rise to double decomposition and the gradual replacement of a part of the calcium in the carbonates by magnesium?"

Section xiii consists of some remarks by H. C. Sorby, LL.D., F.R.S., concerning the production of aragonite and dolomite in the coral rock. Dr. Sorby thinks that there "may be special conditions not fully understood under which carbonate of lime may crystallise as aragonite at such a temperature as would be met with in coral rock." Obviously this must be so, for Dr. Cullis has found secondary aragonite in the cores. Dr. Sorby was not able by artificial means to replace calcium carbonate by dolomite; he only succeeded in replacing it by magnesium carbonate.

The last section is the account, by C. Gilbert Cullis, D.Sc., F.G.S., of the mineralogical changes observed in the Funafuti borings. Near the surface the cores consist of calcite and aragonite according to the composition of the skeletons of the organisms of which it is made. The magnesium carbonate and other chemicals present in the cores are not perceptible in a microscope-section as crystals.

The first change that occurs as a greater depth is reached is that the cavities in the organisms composing the cores become filled with secondary calcite and aragonite. Next the secondary aragonite becomes converted into calcite, and finally the primary aragonite also becomes similarly converted. Thus at 220 feet the cores consist entirely of calcite. From 637 feet dolomite begins to replace the calcite, and from 650 to 820 feet pure dolomite is present. From 820 to 875 feet, and again from 1,050 to 1,070 feet, calcite is again present with the dolomite. Apart from this the core from 650 to 1,114 feet, the lowest point reached, is of pure dolomite.

This section is excellently illustrated with figures of microscope-slides of sections from different depths, and also by diagrams illustrating the mineralogical changes.

The volume is illustrated by six plates, a number of woodcuts, and charts of the atoll. Accompanying it is a portfolio with geological maps and sections of the islands. Printed in large, clear type, and finishing with a good index, it has all the requirements of a book of reference.

The evidence of the borings shows that, in the case of Funafuti, with small temporary oscillations of level, there must have been a steady downward movement for a very long time to account for 1,100 feet of coral rock of comparatively recent accumulation. Another noticeable conclusion is that, at any rate in the case of this 'coral island,' corals are not the most important reef-formers.

It is a matter for regret that the Royal Society should be unable to afford a larger sum for carrying out an undertaking of the importance of that described. The expeditions in consequence had to depend largely on private donations and individual help, and without these the second expedition would never have been started. On the other hand, all scientific men will read with pleasure how willingly assistance of all kinds was rendered by those private persons with whom the expedition came in contact.

W. D. L.

II.—Dr. A. W. Rowe on the Zones of the White Chalk of Yorkshire. (Proc. Geol. Assoc., vol. xviii, pt. 4; 104 pp., 24 plates and 2 text-figures.) (London: E. Stanford, 1904. Price 3*s*.)

In this breezy record of his work in Yorkshire Dr. Rowe has compounded a bracing tonic for all geologists, and especially for those whose appreciative faculties may have become so impaired by the undigested load of accumulated facts that they have lost that keen relish for discovery which should be the never-failing reward of the investigator. We are made to feel as we read this paper that to its author every fresh discovery still comes, as it should come, with the force of a revelation, and is honoured as such. Surely, whoever reads that exciting dramatic episode—so well told and withal so refreshing in technical literature—of the finding of the prognosticated *Micraster* after a venturesome voyage to a well-nigh inaccessible part of the coast must realize that there are moments when it is indeed good to be a geologist! The importance of our discoveries in science, where not directly 'practical,' depends mainly upon the force with which they appeal to our imagination, and herein lies the strength of Dr. Rowe's method. His naive surprise when the new knowledge happens to burst the bounds of his previous experience, and his satisfaction when it happens to conform to that experience, are admirably expressed and equally delightful. The whole process by which dead facts become vital thoughts is exemplified as Dr. Rowe picks up shred after shred of evidence and pieces it into his fabric. We are forcibly reminded of Browning's fine description of the scientific method—

> "Up and down, inch by inch, with the taper his reason
> No torch, it suffices—held deftly and straight.
> Eyes purblind at first, feel their way in due season."

The author knows that he is doing work worth doing and is doing it well, and he is happy in doing it. No wonder, then, that geologists and palæontologists alike have watched his progress with admiration and with critical interest! The results which he has already achieved are of far-reaching importance, and the paper before us shows that he has not yet reached the zenith of his powers.

The zonal correlation of the Yorkshire Chalk with the Chalk of the South of England presents many difficulties, and in spite of the brave attempt made by Dr. C. Barrois over a quarter of a century ago, it has been long recognized by local workers that the problem was still unsolved. This problem Dr. Rowe has taken as his latest holiday task, and with the aid of his trusty coadjutor, Mr. C. D. Sherborn, has shown that by proper methods even the sturdily resistant mass of Flamborough Head may be sliced up into zones more or less closely equivalent to those of the south, with well-nigh the same ease as the less obdurate cliffs that overlook the Channel.

On taking his giant-stride northward, however, Dr. Rowe has found himself confronted by many conditions that were new to him and by many problems that for the present he is content to waive. He has wisely concentrated his forces upon the establishment of the broad correlation, and has regarded other matters as side-issues to be dealt with when the opportunity occurs.

The keynote of his attitude is struck in the introduction to his paper and is well sustained throughout. "We have long cherished a furtive ambition," he writes, "to explore this mysterious and legendary coast." And again, "There is a glamour and fascination attached to the unknown, which, coupled with the acknowledged difficulties of a coast like this, greatly adds to the zest of the work. For this coast is unknown. It is a veritable *terra incognita*."

Now, this last sentence will seem a hard saying to the assiduous local investigators to whom Dr. Rowe warmly expresses his indebtedness; and even to anyone knowing only the previously published literature it may appear high-pitched. But the author justifies his statement in the context, by explaining that the only kind of information which he himself desired was not available until he had explored the land. After all, he has only taken the customary privilege of the explorer of new regions, with whom the uncoordinated local knowledge of the aborigines does not count. And in similar manner it may happen in the future that Kent itself will prove a *terra incognita* to a worker carrying some special line of investigation southward from the Northern Chalk, for it is certain that there is still an open field for research in every part of the formation.

Dr. Rowe's Yorkshire work is of peculiar interest inasmuch as it reveals not only the strength but also the weakness of the zonal method of correlation when applied to districts lying apart. We find that again and again is the author startled by the strangeness of his northern experiences, until at last he is constrained to declare—"The record of the fauna in this area constitutes a veritable zoological romance. Verily it is a land of strange zonal occurrences and of still more strange zonal omissions. It is, indeed, the remarkable absence of some of the commonest zonal fossils, together with the unreliability of others which do exist, which has rendered the task of zoning this Chalk so difficult, but, withal, so fascinating." That is how the scanty ill-preserved fauna of the Yorkshire Chalk appeals to one who has the art to read its lesson!

Now, the meaning underlying this and other similar sentences evidently is that Dr. Rowe, having been able to define the range of most of the Chalk fossils in the cliff-sections of the South of England within fixed limits, and having found them persistent within these limits in that region, had begun to have faith in these zonal boundaries as representing the full life-history of the species. But his journey northward has impressed upon him that the range of many of his zonal species is not everywhere the same. It is true that he has still managed skilfully to extract sufficient evidence to re-establish Barrois' system of correlation on a firmer basis, and to prove, what was indeed already acknowledged, that the general zonal succession in Yorkshire corresponds to that in the South of England. In studying the range of the individual species, however, and their grouping, he finds that some cherished guides have wandered far from the path of zonal rectitude. Thus we read—"The vertical range of certain fossils, usually restricted in their distribution, is so vast that their very persistence is bewildering. As instances of this contention we may quote a range of 800 feet for *Actinocamax granulatus*, and 650 feet for *Actinocamax verus*; while *Cardiaster ananchytis* has been traced for 640 feet, and *Infulaster rostratus* for nearly 700 feet."

"That *Actinocamax verus* should be found in the *quadratus*-chalk; that *Actinocamax granulatus* should be found some 350 feet up in the same zone; that *Infulaster rostratus* should range from the zone of *Micraster cor-testudinarium* to that of *Actinocamax quadratus*; and that *Cardiaster ananchytis* should extend from the *Micraster cor-anguinum*-zone to the same horizon, are facts sufficiently unusual to warrant special comment."

Therefore, although Dr. Rowe and Mr. Sherborn have been able to prove the presence in the Flamborough cliffs of all the zones from that of *Rhynchonella Cuvieri* to that of *Actinocamax quadratus*, inclusive, it is acknowledged that for some of these zones the guide-fossils on which they had been accustomed to rely are inadequate in this district for the identification of the divisions.

To meet this difficulty Dr. Rowe suggests, though with evident reluctance (p. 219), that in certain cases the name of some other fossil, locally abundant, should be associated with the established name-fossil as its "local equivalent." We commend the wisdom of this course, for however much it may be desirable to adhere to established zonal nomenclature for purposes of wide-reaching correlation, it is unnecessarily perplexing to the student and irritating to the stratigrapher to find that a particular zone is marked by the *absence* of its name-fossil!

Hence the choice of the characteristic *Inoceramus lingua* as the local guide for the zone of *Actinocamax quadratus*, since the last-named form appears not yet to have been found at all in Yorkshire, will meet with the approval of every local worker.

The choice of *Infulaster rostratus* to serve a similar purpose for the zone of *Micraster cor-anguinum* is, however, open to question, although when first suggested it seemed to the present writer to be well adapted. But its range has been so greatly extended by Dr. Rowe's researches, both above and below the belt in which it is most abundant, and with which its name is now associated, that its unsupported presence seems inadequate to determine the zone, and we should feel less confident than the author in assigning a small inland pit "without hesitation" to the zone of *Micraster cor-anguinum* on the strength of the discovery of this fossil alone (p. 233).

And here we may note that in respect to Dr. Rowe's demarcation of the zone of *Micraster cor-anguinum* there appears to be a certain arbitrariness, perhaps unavoidable but still unsatisfactory, especially since the zone as now defined is made to bestride the only lithological line traceable in the Yorkshire Chalk, namely, that separating the flinty from the flintless Chalk. Indeed, with regard to several of the zonal boundaries Dr. Rowe will no doubt himself be ready to allow that in these Yorkshire sections, when the evidence is often so imperfect, the chosen line reflects in its particular location an opinion or deduction rather than an absolute fact, even though it represent the best conventional line that is likely to be attained. The position is precisely that in which the mere stratigrapher often finds himself in tracing boundaries that he knows to lie within certain limits but to be indeterminable within these limits. And just as the stratigrapher's line when drawn on the map sometimes gives an unwarranted impression of finality, so may these zonal boundaries if too rigidly interpreted.

One important deduction to be drawn, then, from Dr. Rowe's experiences in the Yorkshire Chalk — a deduction that has also impressed itself upon the present writer in extending the area of his investigations in the Lower Cretaceous rocks—is that, although the general succession of life-forms that go to the making of 'zones' remains constant over wide areas, the range and association of individual species, however sharply defined at one spot, can rarely be traced far without showing disintegration and change. Thus the difficulties that beset the stratigrapher owing to gradual change in the lithological character of sediments have their counterpart in the difficulties that beset the zonal palæontologist in the gradual change of zoological assemblages.

The diversity between the fauna of the southern and northern Chalk has long been recognized, but it has never before been so definitely formulated as by Dr. Rowe, and we regard this detailed comparison as the most valuable part of his paper. For the present he is content to state the differences without attempting further to discuss the cause than to state (p. 280) that they afford "convincing evidence of the working of variation in geographical distribution." It is indeed astonishing that in such a continuous and homogeneous mass as the Chalk, which seems to postulate that the physical conditions of the sea-floor must have been well-nigh identical over the whole region covered by the deposit, there should be this great difference between the fauna of corresponding horizons in Yorkshire and in Kent. It is true that in the Lower Cretaceous the difference between the two areas is even more conspicuous, but in this case we are dealing with beds of diverse lithological composition, and with complex geographical conditions that are sufficient to explain the anomalies.

What is the meaning of this extraordinary diversity within the same geographical province? We can scarcely believe that climatic variation due to the trifling difference in latitude could make itself directly felt at the bottom of the comparatively deep Upper Cretaceous sea. Can it have been due to the influence of cold-water currents creeping down from the north? Or may we surmise that some of the life-forms themselves in spreading from separate centres of dispersal have exerted a mutually antagonistic effect upon each other, so that they could not pass freely beyond their respective frontiers? Or is it, after all, only that ever-present mischief-maker, 'the imperfection of the geological record,' that is to blame for our difficulties?

We hope that at some future time Dr. Rowe will deal more fully with this fascinating problem, for assuredly he is peculiarly well qualified for the task. And in doing so we shall expect that he will give us that comparison of the Yorkshire fauna with the fauna of the equivalent beds in Germany which is referred to (p. 284), but at present withheld. This comparison is likely to be of singular interest, for apparently some portions of the Yorkshire Chalk have, like portions of the Speeton Clay, closer faunistic affinities with the equivalent rocks of Germany than with those of the South of England.

In laying stress upon this aspect of Dr. Rowe's results we must not omit to call attention also to the discoveries of the author which go to strengthen the correlation between the northern and southern Chalk. Thus, his recognition of the plentiful occurrence of *Uintacrinus* in Yorkshire in its customary position at the base of the *Marsupites*-zone is a notable bond in the correlation and an advance on our previous knowledge. Several other southern fossils not hitherto recorded from Yorkshire have now been identified and are included in the new list.

The value of the author's method from the stratigraphical point of view is strikingly exemplified by his discovery that the zone of *Rhynchonella Cuvieri* is absolutely crushed out for a space by the overthrust fault in the Buckton Cliffs. The character of the disturbance at this place had been previously recognized, but its effect upon the sequence was unknown until established by the palæontological evidence.

Another result given in this paper which the local geologists will be eager to apply in the field is the demonstration of a progressive deepening in the alveolar cavity of *Actinocamax granulatus* when this fossil is traced upward through the *quadratus*-zone. We congratulate Dr. Rowe on his acumen in seizing upon practically the only organism of the Yorkshire Chalk which is sufficiently abundant and well-preserved to allow its zonal variation to be worked out.

As the author expressly disclaims that his paper should be taken as more than "a preliminary attempt to bring the fauna of the Yorkshire coast into line with that of our southern sections," and as he has so successfully achieved this object, it would be both unjust and ungrateful to consider his work in any other light. Now that the way is made clear we shall expect that the group of persistent investigators dwelling in the East Riding will push forward the work with renewed energy, not only testing what has been done but also adding to it where necessary. Especially should we like to hear of the establishment of local zones of less extensive dimensions than those which Dr. Rowe has given us. The value of a narrow zone to the stratigrapher was strikingly manifest in the above-cited instance at the Buckton overthrust fault. Here the author had the advantage of having to deal with the only narrow zone in his category—that of *Rhynchonella Cuvieri*. The thickness of this zone in the Buckton cliffs is no more than 11 feet, whereas the next in dimensions, those of *Micraster cor-testudinarium* and *M. cor-anguinum*, are given as 120 feet and 125 feet; and all the others range between 200 and 300 or more feet. Moreover, even with such extensive bounds allotted to them some of the zonal forms are still not content, but manage to invade their neighbour's territory. Thus we learn that "*Holaster planus* is as common in Yorkshire in the zone of *Ter. gracilis* as at its own horizon." Faults of considerable magnitude may remain undetected in the interior unless we can find means to identify belts of strata of much narrower limits. Indeed, we are reminded by the coloured map which accompanies Dr. Rowe's paper of a long-standing suspicion that there is likely to be some disturbance of the normal succession at Speeton between the railway line and the coast, to which the pinching in of the zones in this quarter may be due; and the reviewer would recommend this area, with the country to the south and west, to further consideration.

The Cenomanian or 'Lower Chalk' in this as in his former papers does not come within the range of Dr. Rowe's investigation. We think, however, that it would have been well at least to include it in giving estimates of the total thickness of the White Chalk of Yorkshire, since in this region the division is essentially part of the lithological mass which we mean when we refer to the 'Yorkshire Chalk.' Moreover, this part of the series had previously been worked out with great care by Mr. W. Hill, so that accurate measurements were already available. It is true that passing reference is made to Mr. Hill's paper, but there would have been a distinct advantage if we had had a few sentences giving a summary of this work in the present publication, so that some account of the whole section might have been contained under one cover.

The lavish wealth of illustration to which Dr. Rowe has accustomed us in his previous works is again granted to us and deserves our gratitude. The magnificent series of photographic reproductions (in most cases from originals for which the author tenders his acknowledgments to Professor H. E. Armstrong) brings up vivid reminiscences of this noble coastline.

The sections, prepared by Mr. C. D. Sherborn, are effective, though somewhat crudely diagrammatic. We notice, however, that the displacement by the fault at Selwicks is not indicated. The coloured map already referred to, also prepared by Mr. Sherborn, is a useful guide to the probable range of the zones in the interior of the headland, though in drawing the boundaries it is probable that insufficient allowance has been made for the relief of the ground in view of the prevalent low dip. The Appendices to the paper include the description by Mr. G. C. Crick of a curious Belemnite, probably deformed by some injury to the living animal; and there is also a short note by the present writer on the state of preservation of some of the Chalk fossils.

In conclusion, let it be acknowledged that no adequate criticism of work of this kind could be made except by one whose knowledge of the subject transcended that of the author. And our only hope, therefore, of ever obtaining such a criticism is that Dr. Rowe may himself undertake it some time in the future, when he has completed his examination of the separate districts and reviews his previous work as a whole.

G. W. Lamplugh.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

March 23rd, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communication was read:—

"On the Moine Gneisses of the East Central Highlands and their Position in the Highland Sequence."[1] By George Barrow, Esq., F.G.S.

The paper is divided into two parts. The first deals with the parallel banded grey gneisses or gneissose flagstones of the Perthshire and Aberdeenshire districts, which, in their field-characters as well as in their composition and structure, are identical with the Moine gneisses of the North-West Highlands. A description is given of these gneisses, as seen in and about the Garry in Perthshire, and this is followed by a brief account of the same rocks in the ground to the east and north-east, extending to the Forest of Invercauld, north of Braemar in Aberdeenshire. Special attention is drawn to the fact that towards the eastern end of the area large masses of highly quartzose gneiss occur, which are really part of the Central Highland quartzites in what the author conveniently describes as a 'Moine phase,' and should not strictly be included in the typical banded grey gneisses at all.

In the second part, dealing with the mode of ending off of these gneisses to the south-east, it is shown that they cease to be recognizable as Moine gneisses, owing to the fact that they thin away and also become more finely banded, while at the same time they become less crystalline or cease to be gneisses. To prove this, an account

[1] Communicated by permission of the Director of H.M. Geological Survey.

is given of a series of sections lying along a belt of 40 miles in length, extending nearly from Blair Atholl to the east of Balmoral, in Aberdeenshire. The first and most important of these occurs about Gilbert's Bridge (in Glen Tilt), where the parallel banded Moine gneisses can be traced passing slowly into the honestones, in which parallel banding is equally well shown. This is a well-known horizon in the Central Highland sequence, lying next the white edge of the Highland Quartzite, forming, in fact, its orginal flaggy margin. These parallel banded rocks are in many cases succeeded directly by a very impure phase of the Main or Blair Atholl Limestone; but in places patches of other material intervene, of which the most important is a dark schist: this suggests a small hiatus at the margin of the Limestone, and a photograph was exhibited to show this hiatus. The conclusions drawn from this section are supported by the section seen below Gilbert's Bridge, and a somewhat similar one in the Banvie Burn, north of Blair Castle. As before, there is clearly a small hiatus at the base of the Limestone.

In order to ascertain the meaning and extent of this break in the sequence, an account is next given of the complete succession near Braemar, and it is then seen that at Gilbert's Bridge the Little Limestone and part, or at times the whole, of the Dark Schist is missing. The hiatus always tends to occur as an area is approached where the material forming the Moine gneiss thickens, and was originally of a rather coarser or more sandy nature.

Where, however, the section is complete, it is seen that the material of the Moine gneisses is the flaggy margin or top of the Central Highland Quartzite; it is succeeded by the Little Limestone, above which is the Dark Schist, and then the Main or Blair Atholl Limestone.

Other sections along the line of change are described, showing the varying phases of the honestones, and in two instances their passage into Moine gneiss. There is a constantly varying hiatus at the base of the Main Limestone, but in the whole 40 miles this never exceeds the omission of the entirety of the Black Schist and the Little Limestone (of no great original thickness). This break in the sequence is of small importance, and, as already stated, often disappears as the material from which the Moine gneisses were formed became thinner and finer, or more of the nature of a mud.

Evidence is then given to show that the honestones tended to become more sandy and to thicken south-eastward again, or in the opposite direction to that in which the Moine gneisses come on. From this the author concludes that the parallel banded material was deposited in a series of fans; in the larger fans we have the material of the Moine gneisses; in the smaller that of the honestones. Both are simply the flaggy top of the sandstone now forming the Central Highland Quartzite, and are in fact a passage rock on its margin. Anything like an unconformity between the two is obviously impossible.

II.—Mineralogical Society, March 22.—Professor H. A. Miers, F.R.S., Vice-President, in the Chair. The following papers were read:—Irregularly developed crystals of zircon (specific gravity 4·0) from Ceylon: L. J. Spencer. The crystals were sent recently by Mr. A. K. Coomáraswámy to the British Museum for determination, and at first were thought to be rutile. They are of a dark-brown colour and almost opaque; the specific gravity is 4·09, and is unaltered by heating. A section cut perpendicular to the principal axis shows interesting variations in the optical characters, successive portions being isotropic, uniaxial, and biaxial; the mean refractive index is about 2·0. After being heated to redness and cooled, the material is bright-green in colour, and a crystal section is now entirely biaxial, although the interference figures and birefringence vary in different parts.—Notes on 'Feather Ore,' identity of 'domingite' (= 'warrenite') with jamesonite: L. J. Spencer. 'Feather-ore' is usually considered to be a variety of jamesonite; but, since the latter has a good cleavage perpendicular to the length of the fibres, only brittle 'feather-ore' can be included in this species; on the other hand, 'feather-ore' the fibres of which are flexible may be either stibnite, zinckenite, plumosite ($2\,PbS, Sb_2S_3$), boulangerite, or meneghinite. 'Warrenite' is a brittle 'feather-ore,' and further has the same chemical formula ($3\,PbS, 2\,Sb_2S_3$) as that originally given for the cleavable Cornish jamesonite.—Note on the indices of refraction of antimonite: A. Hutchinson. A prism of refracting angle 8° 51′ was found sufficiently transparent to red light for the refractive indices to be determined in the usual way. The results obtained are 4·129 and 3·873 for rays vibrating parallel to the axes of z and x respectively. Measurements of the deviation of the ultra-red rays indicate high dispersion in this region of the spectrum. The investigation is being continued. The connection between the atom arrangements of the crystals of certain allied carbon compounds: W. Barlow. Using balls of the same relative size as employed in his previous work, for instance in models of calcite, the author forms a carboxyl slab. By uniting such slabs with balls representing barium, a structure is obtained which has the symmetry of barium formate. Again, by uniting the slabs with balls representing hydrogen, a structure with the symmetry of oxalic acid is formed. The author showed that in certain cases, in order to effect close packing, a relative shift was necessary between successive layers. He also briefly discussed the tartaric acids.—On the construction and use of the moriogram: G. F. Herbert Smith. The moriogram is a diagram devised by the author for the graphical determination of the angles between tautozonal poles, obeying the law of rational indices.—Note relative to the history of the Caperr meteorite: L. Fletcher, F.R.S.—On the meteoric irons of Bethany, Lion River, Springbok River, and Great Fish River, South Africa: L. Fletcher, F.R.S.—Professor J. W. Judd, F.R.S., exhibited two Gardette twins of quartz.

CORRESPONDENCE.

BRIDLINGTON CRAG.

Sir,—The shelly patches in the Basement Boulder-clay at Bridlington, known as the "Bridlington Crag," have been so long inaccessible that it may interest glacial geologists to know that these beds are being temporarily exposed in the foundations for a new sea-wall. It is now twenty-one years ago since these shelly patches were last seen, in a brief exposure on the foreshore, and when the new wall is built they will be more hopelessly hidden than ever.

The excavations are carried on between tide-marks, in short lengths which are filled in at once. The section which I saw three weeks ago during a hasty visit to Bridlington showed about 5 feet of Boulder-clay with narrow streaks and dabs of richly glauconitic sand full of broken shells. I learn that, in other places, larger patches of the sand, with some unbroken shells, have been found, like the masses which I saw and described in 1882–3.

It is satisfactory to be able to add that the East Yorkshire geologists are alive to the opportunity, and are taking steps to secure material for the further study of this exceptionally interesting Arctic fauna. G. W. Lamplugh.

Dublin.

OBITUARY.

LIEUT.-GENERAL CHARLES ALEXANDER McMAHON, F.R.S., F.G.S.

Born March 23, 1830. Died February 21, 1904.

We regret to record the loss of an excellent geologist and petrologist, and a prominent Fellow of the Geological Society of London.

The name of General McMahon suggests the thought of the number of Army officers who have taken up our science as a pursuit and achieved distinction, either in geology, palæontology, or in mineralogical geology, often without any early scientific training, as was the case with General McMahon. We recall the names of General Portlock, Sir Roderick Murchison, General Strachey, General Sir Proby T. Cautley, General Hardwicke, General F. T. Hobson, Colonel Godwin-Austen, Captain Hutton, Major Brickenden, Major Broom, Captain H. G. Lyons, Dr. Leith Adams, and many others. How great would be the list if our cadets at Woolwich, Sandhurst, and elsewhere were encouraged to work at such subjects by means of lectures, laboratories, museums, and field-work, proficiency to be rewarded by suitable marks in examinations!

Charles Alexander McMahon was born at Highgate 23rd March, 1830, and was the son of Captain Alexander McMahon, of the H.E.I.C. Service. He served for eight years in the 39th M.N.I., and for thirty years on the Punjab Commission. He was late Commissioner of Lahore and a Fellow of Lahore University.

Although, outside his official life, Lieut.-General C. A. McMahon was well known as an ardent and able geologist, his name is remembered in India for the thirty years of excellent work as a Commissioner and Civil Judge. The most exciting period of his career was at the time of the Indian Mutiny, when, as a young man under thirty, he was suddenly called upon to assume charge of the Sialkot district, just at the moment (May, 1857) when the native troops rose in revolt. Lieutenant McMahon managed to send off a few lines to General John Nicholson, who was taking a movable column to Delhi. This prompt action led to the mutineers being met and destroyed by Nicholson at the action of Trimmos Ghat.

When Commissioner of Hissar, in 1871, General McMahon took up the study of geology and petrology; and when on furlough to England in 1879–80 he joined the Royal School of Mines, studying geology under Professor Judd, mineralogy under Sir Warington Smyth, and biology under Professor Huxley. Professor Judd writes:—"On his return to India he took up a series of geological studies of the granites and other rocks of the Himalayas, the result of his labours being given to the world in a number of papers published in the Records of the Geological Survey of India. After his retirement he continued these researches with the same enthusiasm as before, devoting special attention to petrological and mineralogical investigations. Even after the failure of his health, and when afflicted with almost complete blindness, he not only maintained an interest in his favourite pursuit, but dictated a paper which appeared quite recently in the GEOLOGICAL MAGAZINE."[1] He became a Fellow of the Geological Society in 1878, and received the Lyell Medal in 1899 "in recognition of the value of his services to petrology, and more particularly of the work done by him in India." He served on the Council, was a Vice-President of the Geological Society; and President of the Geological Section of the British Association at Belfast in 1902. He was elected President of the Geologists' Association in 1894–95. Dr. W. T. Blanford, a valued friend of General McMahon's, and for 30 years connected with the Geological Survey of India, says:—"In the exploration of the principal rock groups in the Western Himalayas he was a pioneer, and his discoveries were of great scientific importance. From 1877 to 1887 General McMahon contributed 24 papers to the Records of the Geological Survey of India, for the most part descriptive of the geology and petrology of districts in the Simla area, thence northward to Spiti, and around Dalhousie and Chamba, and in a few other localities. The so-called Himalayan Central Gneiss he showed to be an intrusive granitic formation." The death of General McMahon closes a strenuous life of recognized service to Government in his administrative career in India, and of fruitful scientific research in geology, a combination testifying to intellectual equipment unusually varied and to uncommon mental energy maintained until the very last.

General McMahon married, first, Elizabeth, daughter of Colonel C. F. Head, late Queen's Royal Regiment, and secondly, Charlotte

[1] November, 1903, p. 492.

Emily, daughter of Mr. Henry Dorling, of Stroud Green House, Croydon, who survives him. The distinguished Indian frontier political officer, Lieutenant-Colonel A. H. McMahon, C.S.I., C.I.E., F.R.G.S., F.G.S., Judicial Commissioner at Quetta, Beluchistan, is his eldest surviving son. (In part from *The Times*.)

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"The Rape of the Chlorites": Geol. Mag., Dec. IV, Vol. I (1894), pp. 111–114.
(With Hutchings, W. M.) "Note on Pseudo-Spherulites": Geol. Mag., Dec. IV, Vol. II (1895), pp. 257–259.
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CHARLES RICKETTS, M.D., F.G.S.

BORN 1818. DIED FEBRUARY 29, 1904.

BORN about 1818 at Tichfield, Hants, Charles Ricketts was educated at Bath, having previously attended a preparatory school at Stubbington, where he appears to have shown an interest in geology, as he treasured in his collection the first fossil he obtained from the Hampshire cliffs.

After graduating in Medicine he went to the North of England in 1845 or 1846, and although he was some time in Lancaster and the neighbourhood, the principal part of his life since then was spent in Birkenhead, where he practised as a physician.

He was elected a member of the Geological Society of London in 1867; he frequently attended the meetings, and in 1885 contributed a paper "On Erratics in the Boulder-clay of Cheshire, etc., and the Conditions of Climate they denote" (Q.J.G.S., vol. xli, pp. 591–8).

The bulk of his papers were read to the Liverpool Geological Society, of which he became a member in 1863. He was elected to the Council in 1865, and served as President in 1870–2 and again in 1889–90. He read his first paper to the Liverpool Geological Society in 1865 "On a Wooden Implement found in Bidston Moss," and in it he incidentally refers to the action of deposition and depression, a subject on which he held original views, which were fully elaborated in his Presidential addresses of 1871 and 1872. In these addresses he strove to prove that the relation of denudation and deposition to elevation and depression were those of cause and effect. The convolution of strata caused by the differential weight of overlying deposits was illustrated by numerous models, some of which were exhibited at one of the conversaziones of the Royal Society. These were constructed by him and are still in existence. He further developed his ideas in a communication to the GEOLOGICAL MAGAZINE "On some Physical Changes in the Earth's Crust" in 1889 (pp. 49, 115, and 165), in which he discusses the views of some leading geologists on the same subject. It was in his Presidential address of 1872 that he attributed earthquakes to movements of faults, and anticipated the theory now generally held. He also wrote on the Carboniferous Limestone and on glacial phenomena, to which he gave much attention. Twenty-five of his papers are printed in the Proceedings of the Liverpool Geological Society. He was an active member of the Naturalists' Field Club and other Societies. On leaving the neighbourhood he presented his valuable and extensive collection to University College (now the University of Liverpool).

He was a careful observer, an original thinker, and an indefatigable worker in the field, till absolutely prevented by the weight of increasing years. His kindly and unselfish disposition endeared him to all who knew him, and had he been less unobtrusive his work would probably have attracted more general notice.

On leaving Birkenhead about four years ago for his native county he was elected an honorary member of the Liverpool Geological Society. He died at Curdbridge, Hants, on 29th February last, at the advanced age of 86. T. M. R.

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JUNE, 1904.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. VI.—JUNE, 1904.

ORIGINAL ARTICLES.

I.—Observations on some of the Foraminifera of the Oceanic Rocks of Trinidad.

By R. J. Lechmere Guppy.

(*Concluded from the May Number, p.* 199.)

(PLATES VIII AND IX.)

THE oceanic beds of Naparima, in Trinidad, contain numerous forms of Foraminifera of great interest, and I propose to make some observations on a few of them. These rocks and their contents were described by me in the Journal of the Geological Society of London, 1892 (vol. xlviii, p. 519). Messrs. Jukes-Browne and Harrison treated of the same subject in the same journal in 1899 (vol. lv, p. 177), and I have given further particulars in the Proceedings of the Zoological Society, 1894 (p. 647), in the Proceedings of the Trinidad Field-Naturalists Club, 1893, and in the Geological Magazine, 1900, p. 322. A few further observations are published in the Proceedings of the Victoria Institute.

On *Gonatosphæra*. (Pl. VIII, Figs. 1–7.)

In the Proceedings of the Zoological Society, 1894, I described a new genus and species from the *Ditrupa*-bed of Pointapier, in Trinidad, under the name of *Gonatosphæra prolata*. The specimens then discovered and described did not enable me to ascertain with any certainty the relationships of the form. Since then I have discovered other specimens which may throw additional light upon these relationships, and I think that there is sufficient interest attached to the subject for me again to bring it forward. The specimens originally discovered were either almost spherical (this being the young form) or a more or less prolate spheroid with a ridge encircling it, as shown in the figs. 14, 16, 19 of the plate appended to the paper quoted. This ridge is the remnant of the wall of the last chamber, which has been broken away in these specimens; while in figs. 15, 17, 18 the last chamber has not been added. The shell begins its existence as a small spherical chamber which in the adult generally shows as a protuberance more or less marked at the initial or aboral end of the shell. The next segment invests this almost entirely, leaving only a small part of the initial chamber uncovered, and each succeeding segment invests the portion of the shell already formed in the same manner until the last segment is added. This last segment is of a size equal to or larger than the whole of the previous segments together, and does not (as the previously formed ones did) completely invest the preceding segments, but only to the extent of about one-half of the longer diameter or length of the shell. This chamber further differs from the preceding ones in being oval in cross section instead of circular. The mature shell thus described (Pl. VIII, Figs. 1–4) recalls to mind *Lingulina,* which appears to be its nearest relation. From the first the aperture of *Gonatosphæra* is an elongate slit, while the section of the shell at right angles to the axis of its growth is circular. It is therefore evident that an elongate aperture is not necessarily induced by a flattened or compressed contour of the shell, as in *Vaginulina.*

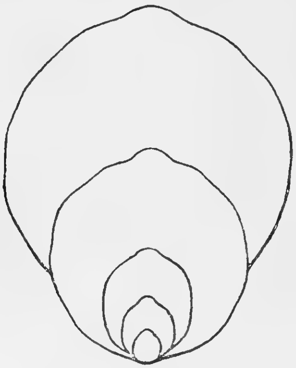


Diagram-Section of *Gonatosphæra.*

As to *Lingulina,* Carpenter says (Introd., p. 164) that it is nothing but a compressed *Nodosaria* whose transverse section is oval, and whose aperture has undergone a corresponding elongation. But the case of *Gonatosphæra* shows that a shell of a circular section may have an elongate slit-like aperture, and that moreover a shell having such a character in its younger stages may develop a subsequent segment of compressed or oval contour, as if indeed the shape of the aperture had ultimately a greater controlling influence than the shape of the shell. I think these facts tend to establish the validity of *Lingulina* as a generic group near which *Gonatosphæra* might be placed in the family Nodosaridæ.

As regards the minuter structure of *Gonatosphæra,* the test is minutely and closely tubulated like that of the unornamented *Nodosariæ,* but it seems to be composed of two or more layers of shell-substance.

Brady (Chall. Rep., p. 517) regards *Lingulina* as representing transition stages between *Nodosaria* and *Frondicularia.* This may be so; but if so, *Lingulina* comes earlier on the line of development still, retaining more of a frondicularian character than *Nodosaria*. But I could not assert that any of these forms are on the exact line of development: they each represent side branches of such a line of which *Nodosaria* is the last and highest development in its own direction. *Cristellaria, Frondicularia, Uvigerina* (including *Sagrina*) are forms which have branched out of the main line of development between *Polymorphina* and *Nodosaria*.

I should doubt if the fig. 16 of pl. lxv of the "Challenger" Report is *Lingulina carinata*; it looks more like a *Nodosaria*. Goës gives a good figure ("Caribean Rhizopoda," pl. i, fig. 67). Brady's figs. 14, 15 of pl. lxv have the fissurine aperture of the typical *Lingulina*, while 16, 17 have the polymorphine aperture.

This will be an appropriate place to refer to the resemblance between *Fissurina* and *Lingulina*. On consulting Reuss's monograph of *Lagena* (1862, Taf. vi and vii) I noticed at once the resemblance of the aperture and other features of *Fissurina* to *Gonatosphæra*, and I find since that Goës (Carib. Rhiz., p. 58) considers *Fissurina* to be the young of *Lingulina*. I am not by any means sure that this is not so; but the young of *Gonatosphæra*, while possessing the slit-like aperture, differs from *Fissurina* in being spherical instead of compressed.

Remarks on Nodosaridæ.

Dentalina is not a genus at all, as has been shown by Parker, Brady, Rupert Jones, and Carpenter. Indeed, it is not even a variety. Yet, while maintaining *Dentalina* as a group distinct from *Nodosaria*, rhizopodists formerly included under the latter name several entirely distinct forms which are now known under different generic names, e.g., *Lituola* (*Haplostiche*), *Reophax, Clavulina, Pleurostomella, Ellipsoidina*, etc. Possibly a form like that I have named *Stilostomella* may have been the original of Linné's *N. radicula*. Even so lately as 1882 Goës (whose splendid memoirs on Caribean, Arctic, and Scandinavian Rhizopoda are so highly to be valued) has included *Nubecularia* under the name of *Nodosaria* (see Carib. Rhiz., pl. i, figs. 4, 6, 7).

Ludwig Rhumbler (in *Verhandlung der deutschen zoologischen Gesellschaft*, 1897) has pointed out the distinguishing characters of *Nubecularia* and the relationships of that form, which is admittedly distinct from *Nodosaria*. He there explains clearly the transition of *Ophthalmidium* on the one hand into *Spiroloculina*, and on the other into *Nubecularia*. His explanation is well supported by the facts. And here we may ask if *Articulina* is not the same generically as *Nubecularia*?

Amphicoryne is no more a genus than *Dentalina*. It is simply a *Nodosaria* in which the embryonic character of *Polymorphina* passing into *Cristellaria* has been retained until a late stage in the growth of the organism. And it is this occasional persistence of an embryonic character which shows us the true phylogeny of an organism, in this case *Nodosaria*, as indicated in my paper of 1894 (P.Z.S.).

The term *Sagrina* is superfluous, as pointed out by Brady (Chall. Rep., p. 580). The name *Uvigerina* sufficiently covers the forms so named. *Uvigerina* as well as *Spiroplecta* shows a cristellarian commencement. *Uvigerina* is the form connecting *Polymorphina* through *Cristellaria* with *Nodosaria*, while *Spiroplecta* is the analogous arenaceous form. The biserial and triserial forms of the arenaceous Foraminifera passing into uniserial forms are due to their descent from *Polymorphina*. Very minute Textularians as well as *Bolivina* often show a similar kind of commencement.

Goës ("Arctic and Scandinavian Rhizopoda," p. 6) gives figures of three forms of *Frondicularia*, two of which closely resemble those I have given in P.Z.S., 1894, pl. xli, figs. 3, 4. His observations are entirely in accordance with mine. He says: "Thus in this instance we have before us the plainest proceeding of evolution from one type to another, in which an earlier type becomes larva for another type. At last the larval condition is reduced to a single segment, and a new form has originated seemingly standing without much morphological connection with its origin." He further remarks that the smallest embryo segments do not always give rise to a dimorphous form, but at once assume the mature arrangement of the segments. This is exactly what I pointed out in my paper above referred to. Thus *Flabellina* is not a genus, but merely represents those Frondicularias that retain an embryonic cristellarian commencement. That these were more abundant in the past than they are at present is natural, for the tendency would ever be for the embryonic form to pass at once to the mature form. And this condition is not confined to Foraminifera, but is exhibited in species belonging to Crustacea, Insecta, and Mollusca. These, as they increase by interstitial and not by incremental growth, do not permanently show the embryonic form, though Mollusca do so to some extent. They pass through the embryonic stages, and the embryonic condition can only be observed while they are passing through it. But Foraminifera, growing by stages and each stage being retained as part of the mature organism, show more or less all the stages they have passed through from the first segment.

We have not yet arrived at a true appreciation of the full significance of the various characters of Foraminifera. Doubtless we shall do so after careful study and comparison. Without being able myself to point out all the significance of the facts, I may still advert to some of them.

The close affinity between *Nodosaria*, *Uvigerina*, and *Polymorphina* has long been acknowledged by rhizopodists. It is stated by Carpenter (Introd., p. 168). It is only the order of their development and affinity that has been matter of doubt. The aperture of *Nodosaria* is normally circular with radiating fissures or grooves. This aperture is characteristic of *Polymorphina*, *Cristellaria*, and *Frondicularia*. In some Nodosarians the radiating fissures are obsolete or disappear, and the aperture becomes simply circular, often at the end of a neck which is usually everted and encircled by ridges spiral or circular. In other forms, the test being oval in transverse section, the aperture becomes a slit, the animal taking on a compressed form, e.g. *Vaginulina*.

The old ideas about the phylogeny of *Nodosaria* arose from the fact that it was so easy to imagine the unicellular *Lagena* budding another segment on to itself, which process, if continued, would result in an organism resembling a *Nodosaria*. Carpenter says (Introd., p. 165) that the relationship of the *Nodosaria* to the unilocular *Lagena* "is extremely obvious, many forms of *Nodosaria* being in all essential particulars *Lagenæ,* of which the segments that are successively formed by gemmation have remained in continuity with each other." But I have seldom found a *Lagena* that I could mistake for the chamber of a *Nodosaria,* or the broken-off chamber of a *Nodosaria* which I could mistake for a *Lagena*. And, indeed, if such were the descent of *Nodosaria* the existence of the amphicoryne form would be inexplicable. In order to supply an explanation rhizopodists have been compelled to assume an extreme instability of character in Foraminifera which is beyond the fact. It may be added that the aperture of a typical *Lagena* seldom resembles that of a *Polymorphina* or *Nodosaria*. The fine series of figures given by Goës ("Arctic and Scandinavian Foraminifera," pls. ix–xiii) shows the persistency of the polymorphine aperture in forms descended from the polymorphine type. The "Challenger" figures are not excelled by any in fidelity to nature, and they show the same feature. So likewise with the figures given by Flint ("Recent Foraminifera," Smithsonian Institution, 1899). And Rupert Jones, in the Monthly Microscopical Journal (1876), gives some good figures showing the typical form of the nodosarian aperture to compare with that of *Lingulina costata* which he figures at pl. cxxix, fig. 11.

Nodosaria hispida and others.

I have retained the name of *Nodosaria hispida* for one of the most abundant Nodosarians of the oceanic beds of Naparima in Trinidad, and though I was at first doubtful of this determination, it seems confirmed by Flint's fig. 1 of his pl. lvii and fig. 4 of pl. lvi. In our *N. hispida* (Pl. VIII, Figs. 10, 11) the segments, though spherical internally, and therefore of the same shape as those of the typical *N. hispida,* are closely connected externally by shell-substance filling up the sutures, one or two only of the latter segments being distinctly separated by a sunken suture or constriction. The shell is thus somewhat fusiform in outline; it is often straight, but occasionally curved or dentaline. The surface is covered with tubercles or spines, and this character is pretty evenly maintained. The aperture is circular, and is situated in a short doubly-lipped neck as in *N. abyssorum* and other species. In beds which seem to have been deposited in shallower water the tubercles become bolder and more elongate, and this form is called *N. conspurcata* (Reuss, Tert. Foram., pl. ii, figs. 10–12). Many of the specimens recall *N. verruculosa,* Neug., and are not distinguishable by any trustworthy character. *N. rugosa,* Orb. (For. Cuba), appears to be a poor example of the same species. *N. hirsuta,* Orb., Parker, Jones & Brady (Ann. & Mag.

Nat. Hist., Sept. 1871, pl. ix, fig. 45), is another form of the same species; indeed, it is by those authors (p. 154) assigned to *hispida*. The minute structure of the test is probably similar to that of other Nodosarians, that is to say, minutely and closely tubulated. But the appearance under the microscope is similar to that of *Orbulina*, as figured by Carpenter (Introduction, pl. xii, fig. 8). What appear to be large pores are probably the transparent shell-substance of the tubercles.

Other Nodosarians of the Naparima oceanic beds are worthy of a notice. These are specially *N. abyssorum*, *N. longiscata*, and *N. arundinea*. Neither *N. longiscata* nor *N. arundinea* are noticed in the "Challenger" Report, but both are recorded from the London Clay and Vienna Basin; also from the oceanic beds of Barbados. *N. arundinea* (Pl. VIII, Figs. 14, 15) consists of a long tube-like body with occasional slight constrictions and inflations. In its general form it resembles *Rhabdammina*, while *N. longiscata* resembles *Hyperammina*. The shell-structure of both species is minutely and closely tubulated as in other Nodosarians, and shows no sign of any arenaceous condition. I have not access to any satisfactory figures of either species. *N. longiscata* (Pl. VIII, Figs. 12, 13) generally consists of a sub-globular initial segment succeeded by one or two, rarely three, extremely elongate segments, scarcely separated by a more or less evident constriction. Some of the simpler forms recall certain forms of *Lagena vulgaris*, although they cannot be mistaken for *Lagenæ*. It is possible that *N. arundinea* is really the same as *N. longiscata*, but I have not been able to prove this. The specimens of the former showing the nearest approach to the latter are somewhat like a thermometer-tube in shape.

Nodosaria abyssorum (Pl. VIII, Figs. 8, 9) was described by Brady, who in Chall. Rep., p. 504, says of it, "It is not by any means certain that it really belongs to the genus *Nodosaria*, that it is not rather a deep-sea variety of *Sagrina*." I am of opinion that it is a *Nodosaria*, the polymucronate apex, by which character it is distinguished from all other Nodosarias, being in no way like the apical portion of a *Sagrina* (*Uvigerina*).

Nodosaria abyssorum was found at Challenger Station 296, southwest of Juan Fernandez, at a depth of 1,825 fathoms, and, so far as I can ascertain, it is not recorded from any other locality. It is not mentioned either by Brady or Chapman in their lists of Barbados Fossil Foraminifera. It occurs in the Naparima oceanic beds, and specimens in all respects similar to those figured by Brady (Chall. Rep., pl. lxiii, figs. 8, 9) are common. Indeed, that and *N. hispida* are the two most abundant and easily recognized Nodosarias found in these rocks, and it was owing to the frequency of their occurrence that I called some of the beds *Nodosaria* beds. The non-occurrence of *N. abyssorum* in the Barbados oceanic beds is remarkable, as their fauna is almost identical with that of the Naparima beds of Trinidad.

In the identification of Reuss's species *retrorsa*, it appears to me that Brady has not made use of his usual acumen. Brady's figure (Chall. Rep., pl. lxiii, fig. 7) represents what I take to be a slender form of *abyssorum.* Reuss's figure (Sitzungsb. d. k. Akad. Wiss. Wien, vol. xlviii, 1863, p. 46, pl. iii, fig. 27) shows a very different form. The species seems to have been based on a single fragment with imperfect first and last chambers; there is therefore nothing from which to infer a polymucronate apex. But this is the essential character of *N. abyssorum,* and such an apex is clearly shown in Brady's figure above quoted, and I know of no other *Nodosaria* which exhibits this feature; I take it, therefore, that Brady's *retrorsa* (not Reuss's) must be considered a variety of *abyssorum,* and thus the range of distribution of *N. abyssorum* (in a varietal form) is extended to the Ki Islands at a depth of 580 fathoms. *Nodosaria abyssorum* is so distinct a species that one seldom has any doubt about any specimen of it. The character of its apex or initial end is so marked, and its other characters are usually constant.

It is remarkable that the nearest relation of an echinoderm (*Cystechinus*) found in the oceanic rocks of Barbados is also from the neighbourhood of Juan Fernandez, at a depth of over 2,000 fathoms.

Concluding Remarks.

I have at the present only a few further remarks to make about the Foraminifera of the oceanic beds. *Pulvinulina Menardi* and *Virgulina* are remarkable for their absence from these deposits. The record of the occurrence of an example of *P. Menardi* by me was an error. *Pulvinulina canariensis* (a near relation of *P. Menardi*) occurs in the Pointapier *Ditrupa*-bed and in the Radiolarian marls of Naparima, and it is recorded from one locality in Barbados, but I have not found it in the foraminiferal beds of Naparima. (See the observations of Parker & Rupert Jones, "North Atlantic and Arctic Foraminifera," 1864, p. 395.) *Virgulina* has not occurred either in Barbados or Trinidad. Is it possible that this may be an indication of the age of these beds, while the absence of *Pulvinulina Menardi* may be due to the extension of the continent to the north-eastward, as indicated in my papers of 1892 and 1902?

The list of Foraminifera from Bissex Hill, Barbados, given by F. Chapman (Journ. Geol. Soc. London, 1898, p. 550), is almost identical with ours from the Naparima oceanic beds. The few differences are mainly due to the determination of forms under different names by each of us. The only significant difference is the absence of *Orbulina* from the Barbados oceanic beds. It is abundant in the oceanic beds of Trinidad and in the Pointapier *Ditrupa*-bed.

It may be useful to repeat here the conclusions as to depth of water and other physical conditions arrived at by Messrs. Harrison and Jukes-Browne as the result of their examination of the geology of Barbados (published by authority of the Barbadian Legislature, 1890).

"In the calcareous earths the shells of Foraminifera are common, most of them belonging to species which are now found at considerable depths . . . . the assemblage of species being such as might now be found in Atlantic ooze at a depth of 1,000 fathoms.

There can be no doubt, therefore, that these chalky earths and limestones were formed in the same manner and at the same depths as the chalky muds which are now being formed in many parts of the Atlantic and Pacific Oceans. The siliceous radiolarian earths indicate even a greater depth than the calcareous deposits. Radiolarian ooze does not exist in the Atlantic, but is found in the Pacific and Indian Oceans at depths of from 2,000 to 4,000 fathoms. Its existence in Barbados therefore suggests the idea that it was formed in a deep basin which was open to the Pacific as well as to the Atlantic, and consequently at a time when the Isthmus of Panama did not exist."

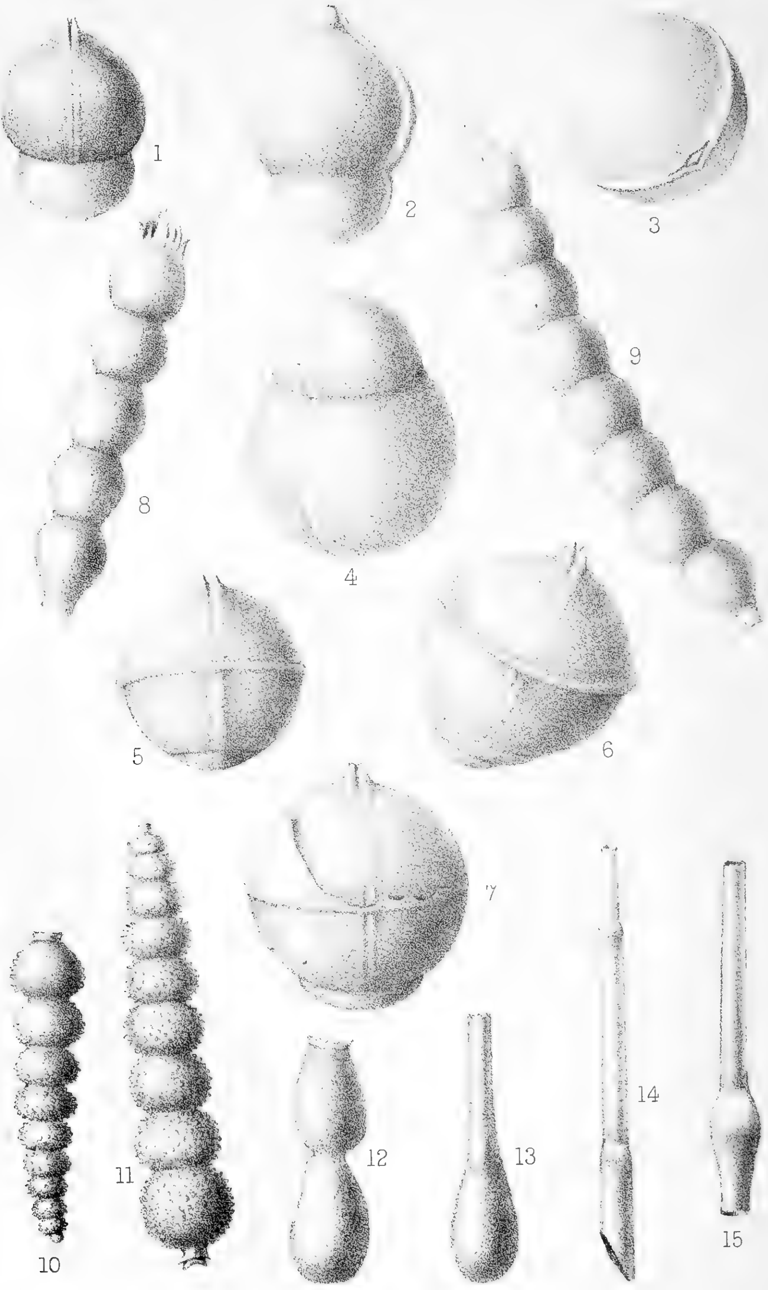
These conclusions are exactly applicable to the Naparima oceanic beds. But it must be admitted that the enormous amount of change in the physical geography of this portion of the earth's surface which would be required to satisfy these conclusions makes one feel inclined to be contented to accept a less depth of water than that above indicated, if other circumstances can be shown to admit of this. And I think that this can be done; for the amount of clastic material found in certain of the beds (Nariva Series) betokens (as I may hereafter have an opportunity of showing) nearness of land and a shallower sea than might apparently be indicated by the Microzoic fauna.

Note on the foregoing Paper.

Ludwig Rhumbler has (in *Nachrichten Gesellschaft der Wissenschaften zu Göttingen*, 1895, p. 51, and the paper before cited) two very noteworthy papers on the phylogeny of Foraminifera. In the first of these papers he has propounded a very ingenious systematic arrangement of the families. My researches have not enabled me to say how much of his system is founded in fact, but the observations in the foregoing paper show that so far as regards the phylogeny of *Nodosaria* the system is not exactly applicable. Indeed, it is most likely that all triserial and biserial Foraminifera have been evolved from *Polymorphina*, their triserial and biserial nature being in fact due to that parentage, the primordial form being a unicellular *Polymorphina*.

The theory that *Nodosaria* is derived directly from *Lagena*, and that *Cristellaria* and related forms are derived from *Nodosaria*, is the result of an idea that complex forms must be evolved from simpler ones, and that a simple form cannot be evolved from a composite one. The fact cannot be denied, however, that in *Clavulina, Bigenerina, Uvigerina*, etc., the simpler form follows on the more complex one.

Rhumbler's observations tend, I think, to confirm mine respecting the so-called gemmation or colony-building of Foraminifera. This theory appears to me to be founded on a misconception of the real mode of growth of the foraminifer. The body of the foraminifer, like that of the mollusc, grows by interstitial increase, while the shell is extended by incremental increase. To accommodate the integument to the increase of size, the insect and the crustacean exuviate their old shells and form new ones. But the mollusc and the foraminifer,



L. Guppy jr. del.
G. M. Woodward lith.

West, Newman imp.

Trinidad Foraminifera.

instead of doing this, develop an additional portion, segment, or cell to accommodate the increased size of the body. This is incremental growth as contrasted with the interstitial growth of the soft parts. The idea, therefore, that a polythalamous foraminifer is a colony and not a single organism is not well founded. No doubt the idea is derived from the cœlenterata, where separate polyps are developed one from another, the whole mass of polyps nevertheless remaining in union and forming what is designated as a colony. In one sense perhaps every animal may be regarded as a colony. But the foraminifer is not more so than a Nautilus.

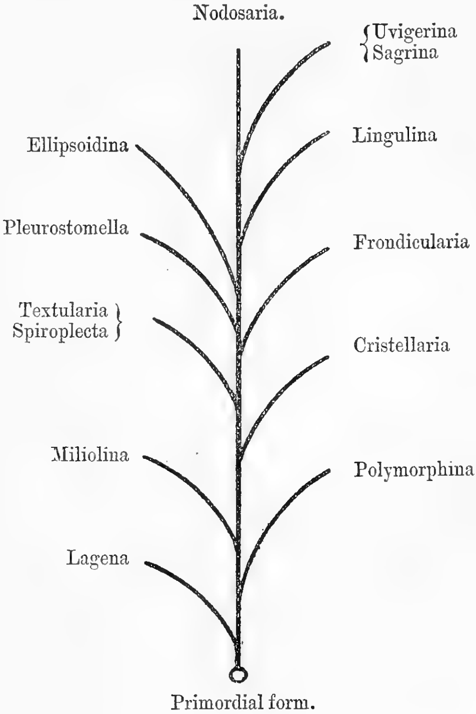


DIAGRAM TO ILLUSTRATE THE PHYLOGENY OF *Nodosaria* AND ALLIED FORMS.

EXPLANATION OF PLATES VIII AND IX.

PLATE VIII.

FIGS. 1–4.—*Gonatosphæra prolata.* Views of different specimens of the perfect adult form.

,, 5–7.—Specimens in which the last chamber has been broken away, leaving the ridge where the wall of the last chamber was adherent to the previous segment. In Fig. 7 a portion of the wall of the last chamber still remains.

,, 8, 9.—*Nodosaria abyssorum.*

,, 10, 11.—*Nodosaria hispida.*

FIGS. 12, 13.—*Nodosaria longiscata.*

,, 14, 15.—*Nodosaria arundinea.*

PLATE IX.

FIG. 1.—*Clavulina Soldanii.*
,, 2.—*Reophax scorpiurus.*
,, 3.—*Cyclamina deformis.*
,, 4.—*Miliolina macilenta.*
,, 5.—*Spiroloculina tenuiseptata.*
,, 6.—*Textularia sagittula.*
,, 7.—*Textularia carinata.*
,, 8.—*Textularia trochus.*
,, 9.—*Nodosaria raphanistrum.*
FIG. 10.—*Nodosaria obliqua.*
,, 11.—*Nodosaria soluta.*
,, 12.—*Cristellaria rotulata.*
,, 13.—*Cristellaria aculeata.*
,, 14.—*Uvigerina raphanus.*
,, 15.—*Planorbulina elegans.*
,, 16.—*Pulvinulina elegans.*
,, 17.—*Textularia aspera.*
,, 18.—*Textularia gramen.*

II.—OCCURRENCE OF MIOCENE ROCKS IN EASTERN SINAI.[1]

By W. F. HUME, D.Sc. (Lond.), A.R.S.M., F.G.S.

THE study of Egyptian geology during the last few years has thrown a flood of light on the former extension of the Mediterranean southward in Miocene times. Th. Fuchs,[2] in examining the rich collections from the Cairo–Suez desert and the oasis of Siwah, recognized that the Miocene strata had a close resemblance to those of the Vienna Basin, and corresponded to the Grunder Beds at the base of the second Mediterranean stage, or the lower portion of the Middle Miocene. Later L. H. Mitchell,[3] when studying the neighbourhood of Ras Jemsa and Jebel Zeit in 1887, obtained a number of large oysters, which Meyer-Eymar recognized as *Ostrea crassissima* and *Ostrea gigantea*, and which were regarded as proving the existence of strata of Upper Miocene age along the western border of the Suez Gulf. From these results Blanckenhorn[4] concluded that the Gulf of Suez must have been a Mediterranean bay in Miocene times, and further noted (Zeitsch. Deutsch. Geol. Gesell., Band liii, 1901, p. 79) that characteristic Miocene Pectens, viz. *Pecten Sub-Malvinæ*, occurred in the collection made by Barron at Abu Sha'ar. He further formed the opinion that all the marine Miocene strata in Egypt were of the age assigned to them by Fuchs (see also Barron & Hume, "Miocene Rocks in Eastern Desert," Memoir of Egypt. Geol. Surv., 1902, pp. 159–165).

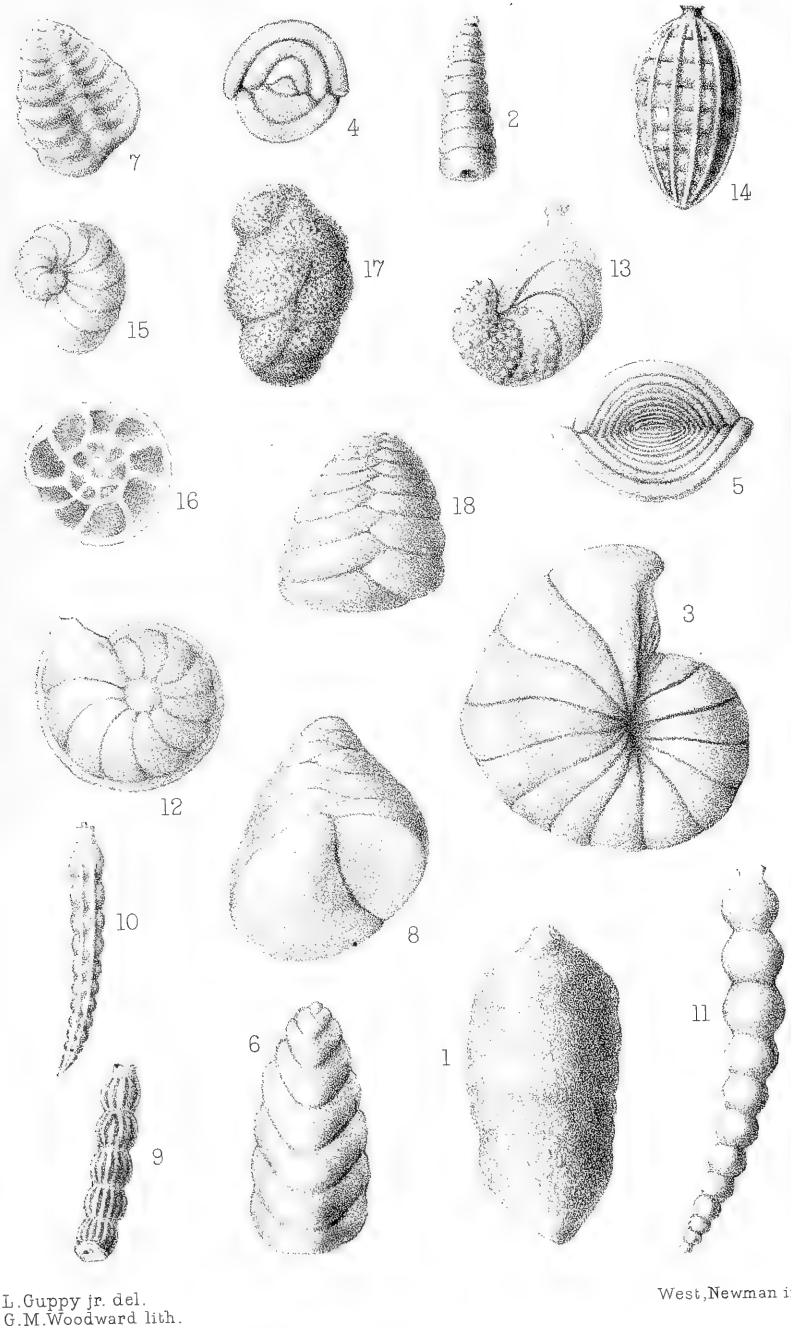
Strata of similar age were first found in the Sinai Peninsula by Bauerman in 1868 ("Note on a Geological Reconnaissance in Arabia Petræa," Quart. Journ. Geol. Soc., xxv, pp. 24 and 37), and were subsequently examined by Rothpletz ("Stratigraphisches von der Sinai-Halbinsel," N. Jahrb. für Min., 1893, i, p. 103) and Blanckenhorn (Zeitsch. Deutsch. Geol. Gesell., Bd. liii, 1, 1901, p. 75), the latter tracing them from Wadi Gharandel to the mouth of Wadi Tayiba. When examining the southern end of Eastern Sinai, the present

[1] Published by permission of Sir W. Garstin, Under-Secretary of State for Public Works, Egypt, and Captain H. G. Lyons, R.E., Director-General Survey Department, Cairo.

[2] Th. Fuchs, "Beiträge zur Kenntnis der Miocaenfauna, etc.," in Zittel, "Erforschung der Libyschen Wüste," p. 36.

[3] L. H. Mitchell: "Ras Gemsah and Jebel Zeit: Report on their Geology and Petroleum"; Cairo, 1887.

[4] M. Blanckenhorn, "Die Struckturlinien Syriens und des Rothen Meeres": Richthofen Festschrift, Berlin, 1893.



L. Guppy jr. del.
G. M. Woodward lith.

West, Newman imp.

Trinidad Foraminifera.

writer was surprised to find beds of large oysters in the terraces a few kilometres south of Sherm, at the foot of a marked transverse range, the Jebel Zafara, these being especially marked in Wadi Khoraiyah. On comparing these with the oysters from the Miocene west of the Suez Gulf, there seemed little doubt that the species were identical, but to fully establish the point the specimens were submitted to Dr. Blanckenhorn, who has recognized the oysters of Wadi Khoraiyah as *Ostrea Virleti*, Desh., and typical *Ostrea gingensis*, var. *setensis*, Blanck., while *Ostrea Virleti* was further recorded from a limestone above brown sands between Nebk and Sherm. The latter was evidently derived from the older Miocene series, but is now associated with Pleistocene fossils.

In a paper on the geology of Eastern Sinai (International Geol. Congress, Paris, 1901) the writer called special attention to the existence of certain highly tilted beds occurring at the southern end of the peninsula, in most cases standing well back from the sea and having undergone extreme alteration. South of Jebel Zafara these are well developed, forming a series of yellow hills close to the junction of the igneous rocks, and rising nearly 200 metres above the sea. Here the beds have been tilted to an extraordinary extent, in some cases dipping from 30° to 60° E., and being apparently connected with a longitudinal fault of importance. In the paper above-mentioned it was further pointed out that their appearance recalled the altered coral-reefs of this region, and that they still contained oysters and casts of *Pecten*, but their age was not then definitely stated. The identification of the oysters of Khoraiyah leaves little doubt, however, that these beds also are of Miocene age, and we therefore arrive at the conclusion that the *Older Tilted Reefs at the southern end of the Gulf of Akaba are Miocene in age* and agree with those on the western side of the Gulf of Suez. Dr. Blanckenhorn has made some observations in sending the specimens which it may be of interest to quote here. "It is to be assumed that *Lithodomus (Botula) cinnamomea*, *Gastrochæna Retzi*, oysters of the *crassissima–gingensis* group, *Lucina* sp. aff. *tigrina*, and corals like *Cyphastræa chalcidicum*, etc., persisted from Miocene to Pleistocene times in the Erythræan region in a salt 'Binnensee' situated somewhere in the deepest part of the Gulf of Suez. In the Upper Pliocene there was the second invasion of Mediterranean forms into the Erythræan region. At this point there came in *Pecten varius*, *Pecten benedictus*, *Cerithium conicum*, *Ostrea cucullata* and *plicatula*, *Arca lactea*, etc. Possibly in the neighbourhood of Sinai there may be a place which still contains remains of this more continental transition period between the Middle Miocene (Helvetian) and the Upper Pliocene. Might the No. 4798 [this is the above-mentioned *Ostrea gingengis*, var. *setensis*, of Wadi Khoraiyah] be included here?"

Having seen the deposits from both the Eastern Desert of Egypt and Eastern Sinai, it seems to me impossible to separate the two, and if the former are Helvetian the latter must also be of the same age, so that the conclusion is forced on us that the Gulf of Akaba (at least in part) was already occupied by the sea at this early period. The question thus opened is a wide one, and whatever its solution demands far-reaching hypotheses. Did the Miocene sea extend over the whole peninsula, and are these but faulted relics of this Mediterranean advance, or was the present configuration of this district so far outlined that two arms of the sea already bounded the Sinai peninsula, though connected with the Mediterranean instead of the Red Sea, as at the present day? In the Central Sinai ranges no traces of such strata have been met with in the fault-valleys, and the final answer will probably only be obtained when the plateau of El Tih has been more closely examined. The other alternative appears to be that fault or rift action had begun at a far earlier date than is usually assumed.

In any case it can now be definitely stated that *Miocene* strata of well-marked character are also present in the Gulf of Akaba area, and Barron permits me to add that he has found *Pecten*, *Ostrea*, and *Heterostegina* beds of the same age to be present in the whole sedimentary area of the west of Sinai. We both agree in regarding the raised reef at Ras Mohammed as belonging to the same stage, a view which is supported to a certain extent by Blanckenhorn's identification of the fossils sent from this locality, though the latter are always poorly preserved.

III.—Hot Springs.

By Ernest H. L. Schwarz, A.R.C.S., F.G.S.,
Of the Geological Survey, Cape of Good Hope.

THROUGH the great kindness of Professor Suess I have received the full text of his paper on Hot Springs, read before the Congress of Naturforscher und Aerzte[1] held last year in Karlsbad, in which he adduces very strong arguments in favour of their being due to vapours given off from the molten interior of the earth as it gradually cools. I have for a long time been observing the hot springs that occur in the Cape Colony, and had come to the conclusion that they were surface-waters that had sunk deep into the earth's crust, and were returned heated in consequence of their having been in the neighbourhood of potential fusion of the rocks. This latter view I alluded to in a recent paper,[2] and I do not like to have to give up a long-cherished idea before submitting to the public a statement of the reasons that led me to my view of the subject.

The first point is the position in which we find the hot springs of the Colony. Those at Aliwal North occur apparently in the Beaufort Beds, and those at Malmesbury in the old clay-slates and granite, but all the others come out at or near the junction of the Table Mountain Sandstone with the Bokkeveld Beds. The following is a list of those that I have visited:—Caledon; Montagu; Brand Vlei, on the Worcester–Villiersdorp road; Warm Water, on the road

[1] "Prometheus," vol. xiv, Nos. 690, 691, 692, beginning p. 209, Berlin, 1903; abstract in Geographical Journal, vol. xx, p. 517.

[2] "An unrecognised Agent in the Deformation of Rocks": Trans. S. African Phil. Soc., p. 391, Cape Town, 1903.

from Montagu to Ladismith; Warm Water, a spring in the bed of the Ondtshoorn Oliphant's River, just before it enters the gorge through the Samka Hills; Tover Water in Uniondale Division, south of the Zwartebergen; and Warm Water in the upper part of the Clanwilliam Oliphant's River. Brand Vlei is the hottest spring, the water being sufficient to scald pigs with—an unscientific way of expressing things, perhaps, but preferable, I think, to giving the readings from the thermometer of commerce; the water from the spring in the valley of the Clanwilliam Oliphant's River has to be cooled down before one can get into it; but the rest are just so hot that one can cautiously enter the water as it issues. Most of them contain iron in solution, but Brand Vlei does not deposit anything. In the same position there are very many ordinary springs, and, in fact, the hot springs are each accompanied by a cold spring that issues alongside. In the next two series of beds, the

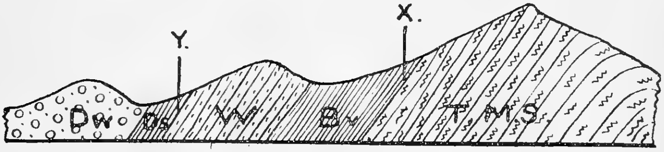


FIG. 1.—The succession of the beds in the folded region of the Cape Colony. T.M.S., Table Mountain Series; Bv., Bokkeveld Series (Devonian); W., Witteberg Series; Ds., shales below the Dwyka Conglomerate, Dw. X indicates the position where most of the hot springs of the colony come out; it is a well-recognized water-zone. Y is a corresponding water-zone, but no hot springs come out here, though some are highly ferruginous.

Witteberg and the Dwyka series, the former corresponding in character to the Table Mountain Sandstone, and the latter, as far as the lower shales are concerned, to the Bokkeveld Beds, there is a water-zone at the junction, but owing to the less porous nature of the sandstones the springs are very weak and scarce, though some of them are charged with iron, as at Hartnek's Kloof in the Ceres Karroo; the Witteberg–Dwyka springs are never warm. Besides the hot and the cold and the ferruginous springs, we have in the Colony what are known as sand-fountains, which are, as it were, quicksands inverted, for if a stone is pressed into the moist sand it is promptly returned to the surface; should, however, the spring dry up, owing to the drought, the sand-fountains become true quicksands, and cattle going down to drink are quickly entombed. The sand-fountains occur on the junction of the sandstone formations with the overlying shale beds, but the kruid- or stink-fountains, that is to say, those giving off sulphuretted hydrogen, usually occur away from the mountains. Hot springs occur also in the Table Mountain Sandstone in the bed of the Umzimvubu River, near Pont St. John's, and in the Molteno Beds in the bed of the Kenigha River, near the trading station called Kenigha, but these occur irregularly, without any apparent general cause for their appearance. What I wish to call attention to is that there is a great water-zone at the junction of the Table Mountain Sandstone and the Bokkeveld Beds, and that ordinary springs, which are certainly the water returned to the surface after a short course underground, occur plentifully along it; the hot springs, instead of taking advantage of veins or fissures, come up in exactly the same way. In other words, the hot springs at the surface occur in the same manner as the cold ones, though it is probable that the hot water reaches the water-zone through underground fissures. When there is a good exposure of the Malmesbury clay-slates, from which the Table Mountain Sandstone has been removed by denudation, the veins of quartz are seen everywhere traversing the rock; north of Van Rhynsdorp, indeed, the surface of the ground is so covered with the white quartz which has weathered out of these veins that it looks as if there had been a heavy fall of snow. My first point, therefore, will depend on whether these fissures are being filled by materials from solution in water which is essentially different in origin to that of the surface springs.

As far as I am aware, no heavy metals, such as gold or mercury, have been found in connection with lavas.[1] Dykes are known to contain them in workable quantities, as in some of the acid veins in Australia; I have even found gold in the dolerite traversing the banket-reefs on the Rand; also the precious metal occurs in some of the volcanic tuffs of Australia, for instance on the Lyndhurst goldfield, but in all these cases there is a very strong suspicion, or some would say conclusive proof, that the gold has got into the rock by absorption and infiltration, and is not original. At Ongeluk's Nek, in the Drakensberg, there was a very great gold-rush at one time, and the lavas were prospected to the topmost peaks of the range, but without result.[2] Should volcanoes be the orifices of pipes that go down to the inmost recesses of the earth, then one would expect oceanic islands and volcanic areas to be the best places to prospect in, instead of the older sedimentary rocks, and the difference to my mind proves that the mineralized beds have been carried beneath the earth's surface to greater depths than those at which volcanoes have their origin. All this seems to point to an essential difference between volcanoes and hot springs. The latter do deposit gold and other heavy metals from solution, as one can actually see now in progress at the Steamboat Springs in Nevada,[3] though the process is one that usually goes on at a very great depth. The hot springs may be due to expulsion by superheated vapour, and it seems an obvious explanation when we see the enormous pressure which steam will exert. In the interior of

[[1] Reference may be made to the occurrence of native iron, which has been discovered in considerable quantities at Ovifak, Disko Island, Greenland, and which was at one time supposed to be of meteoric origin, but has since been shown to be disseminated through an eruptive basaltic rock on the spot, and must therefore have come to the surface from a deep-seated source in the interior of the earth. (See K. I. V. Steenstrup in Mineralogical Magazine, July, 1884, vol. vi, p. 1.)—Edit. Geol. Mag.]

[2] Ann. Report Geol. Commission for 1902, Cape Town, 1903, p. 46.

[3] Becker: U.S. Geol. Surv., Mon. 13, 1888.

the earth, however, things are in equilibrium; enormous pressures do exist, but they are produced by the superincumbent masses of rock, and the heat that there is at great depths only exists as a mode of energy which helps in balancing the stress. In other words, looked at from an isostatic point of view, there is no surplus energy in the earth's interior to expel the large quantities of water that come up in hot springs; these must rise in accordance with hydrostatic laws. The argument from the permanency of such springs, which would seem to imply that they are independent of supplies from the surface, can be met with the counter argument that, as they are hot, and must therefore come up from great depths, the area with which they are in hydrostatic connection is sufficiently large to ensure a constant average.

The third point is that raised in my paper on the deformation of rocks, referred to above. It is that though lavas do undoubtedly contain a large quantity of water-vapour, nevertheless this water-vapour is held up in occlusion, and is unavailable unless the lava has cooled down to a certain point. My inference was drawn from a study of the Drakensberg lavas, in which there are very large vesicles in the shape of branching pipes; these occur only on the bottom of the lava-flows, the topmost portions having got rid of most of their water-vapour and show only the normal rounded vesicles. This seemed to me a sufficient proof that the water-vapour was held in actual occlusion, just as gases are held in occlusion in furnace slag.[1] For when the lava was flowing, the pressure on the surface being reduced from that of many atmospheres in the chimney of the volcano to that of one atmosphere, one would naturally expect that all the water-vapour would explosively escape; this, however, was not the case, or else the vesicles would not have been formed. What happened was this: the topmost layers of the lava-flow cooled down to the expulsion point, and then only gave off their occluded water-vapour; later, the lower layers cooled down and endeavoured to get rid of their water-vapour, but the upper layers had already cooled below the expulsion point, and were therefore unable to absorb and pass on that which the lower layers tried to get rid of; the consequence was that the water-vapour was obliged to come out from the body of the molten rock, and had to force this apart in the shape of the very large vesicles in order to accommodate itself. From a study of the microscopic characters of the lavas I was led to infer that the temperature of the extrusion of the water-vapour was a little above the melting-point of labradorite, that is to say, somewhere in the neighbourhood of 1200° C. The whole of this question is one that can be settled by laboratory experiment, and I am earnestly hoping that there will be early opportunities of doing such work.

My fourth point is in connection with the moon. That body was separated from the earth at a time when the water now existing on the surface of the earth formed part of the atmosphere. It has

[1] Sir Lowthian Bell: Journal of the Iron and Steel Institute, No. 11, 1881.

been calculated that the pressure on the earth's surface was 327 times that at present exerted,[1] and, therefore, much water-vapour must have been forced into the liquid rock-mass. If the principle of occlusion is confirmed, then the molten magma must have been able to take in far greater quantities than that which would be due simply to pressure.

However this may be, away went the moon into space, and immediately both the enormous pressure of the earth's atmosphere was removed and the mass was cooled below the expulsion point. The surface of the moon then became subjected to enormous volcanic activity, sufficiently violent, as some have imagined,[2] to throw out materials beyond the attraction of itself, and which are only now occasionally falling on our earth in the form of meteorites. What became of the water-vapour? If large quantities of water are contained in molten rock, as much, for instance, as comes out in the eruptions of Vesuvius, would there not be some trace of water on the moon, seeing that practically the whole of the surface is one vast field of volcanoes? One can account for much by the evaporation into space and attraction by the earth, but an entire hydrosphere to disappear and leave no traces behind seems impossible. On the other hand, if we imagine that the moon only took away a small amount of water occluded in the molten rock, then we have a quantity which can be more reasonably treated in this way. The form of the lunar volcanoes approaches that of the quiet caldera-form of which Kilauea is the type on earth, but we cannot attach much weight to an argument based on mountains that one can only see and which we cannot ascend hammer in hand.

I am painfully aware of the weakness of much of my reasoning, but most of this is due to the want of knowledge of the fundamental facts of earth-structure. The stresses and strains in a ship of war are known in the smallest detail, but those existing on the earth are little known, although the comparative times during which the two have been under observation are monstrously disproportionate. If geologists could start from the beginning with a certain knowledge that the earth cooled from the centre, and that the whole is in isostatic equilibrium, it would not be possible to be in doubt on such a subject as hot springs; but are not these two facts, as I might almost call them, still in dispute?

If we descend to the bottom of a mine on the Rand one is astonished at the coolness of the workings, as compared with what would naturally be expected from the rate of increase of underground temperature that is usually assumed, that is, 1° F. for every 50 or 60 feet; and it is a well-established fact that in many mineral countries, like Minas Geraes in Brazil, the rate of increase is very small. A study of the British Association Reports on underground temperature leaves one with a sense of despair: how are such divergent results to be sorted out and explained? If one is to regard the earth as a rigid structure,

[1] Rev. O. Fisher: "Physics of the Earth's Crust," 1899, p. 148.
[2] Sollas: Pres. Address, British Association, Bradford, 1900.

I have always thought an explanation impossible, but accepting the principle of isostacy, the whole matter appears simple and the irregularities such as would necessarily be produced. For, regarding the earth as a body that will respond to the smallest stress, provided that it lasts long enough to make itself felt, we see a natural cause for constant differential movement in the outer layers of the globe. Rock is carried from the mountains and deposited in the sea as sediment, ice weighs down the Poles, and even the waters of the ocean in the ages seem to heap up at different places and produce an additional weight on the crust. The differential movements caused by this accommodation to varying stresses leads to the formation of folds and faults; and while these are developing, some of the motion is translated into a certain amount of heat. This has been for many years our stock explanation of the origin of the heat in the hot springs of the Colony, which occur for the larger part in the folded mountain ranges, and I do not see any vital impediment to pushing this principle somewhat further in order to explain volcanic action as the result of earth-movements.

In my recent survey of the Division of Willowmore I found evidence of large movements which had affected the rocks near the surface of the ground. The movement was a tearing one in two directions, north and south, and east and west, and followed certain lines which were separated by a considerable distance; where the two sets crossed each other some very wonderful effects were produced, the most remarkable being the brecciation of enormous masses of quartzite belonging to the Table Mountain Series. In one instance, at Land Kraal, in Baviaan's Kloof, there was in sight a mass of this crush-breccia a cubic mile in extent, but how much more of it was underground it was impossible to estimate. The rock was in places coarsely brecciated, in others ground to fine rock-powder like pounded glass; it was either quite loose and friable, or cemented together with silica or iron compounds.[1] One cubic inch of such a rock in the fresh state requires a load of twenty tons to crush it up, but I am utterly unable to form an idea of the force requisite to crush up even the amount that one could see and measure at Land Kraal; it must have been stupendous. This case is very much more wonderful than any amount of contortion, because the latter is aided by solution, and a very moderate temperature and pressure will suffice to bend up the most resistant rock, provided that it is allowed to remain under their influence for a sufficient length of time. Had this enormous force been concentrated over a less extensive area, and had the rock contained a flux or been composed of a less resistant material than quartzite, there is little doubt that the brecciation would have been converted into fusion and a volcano would have been formed. The distribution of the volcanoes, too, under this mode of origin would have closely imitated that which we find in some actual volcanic areas, the

[1] These crush-breccias will be described in the forthcoming Annual Report of the Geological Commission, Cape Town, 1904.

Galapagos Islands for instance, in which the principal craters lie on points where two sets of fissures cross each other.[1]

The idea that lavas are remelted portions of the crust is an old one,[2] but seems to have been abandoned for the assumption that volcanoes bring up to the surface material that has never been there before, or at any rate since the crust became solid. A rediscussion of the whole of the phenomena of volcanoes on the principles of isostacy seems urgently called for, if only to settle the following questions:—(1) Why do not volcanoes bring up the heavy metals from the interior? (2) Why is the temperature increase measured in stable areas like the Witwatersrand, which would seem to indicate the normal increase, enormously exceeded in some areas, if these are not heated up by differential movements of the crust? (3) Why cannot a force that is sufficient to crumble up a resistant, infusible rock like quartzite, melt one which is fusible and produce a volcano?

The bearing of these speculations on the question of hot springs is to endeavour to show that there is some reason for the explanation that I have been giving for the origin of their heat; for if it be found that volcanoes do not get their material from the primordial magma, then the question of original water will be ruled out. What water the lavas do contain will on this hypothesis be simply that which was once held up in its interstices when solid, with the addition of any that the breaking of the rocks may bring them into communication with.

In this connection it is interesting to notice what very large underground conduits must exist which discharge their waters in the bottom of the sea. We have very few large springs in the Colony, the largest being that at Uitenhage; there are, however, large tracts of country similarly situated in respect to their geology, superficial area, and rainfall, which do not contain anything like so large an output of spring-water. Boreholes also are continually tapping large sources of water without lessening the flow of neighbouring springs, and it seems certain, though difficult of perfect demonstration, that a large part of the water that sinks underground does find an outlet in the bottom of the sea. On the coast we have several fountains that emerge below high-water mark; for instance, all along the sandy coast east of Cape Agulhas. An inverse case occurs also at Eastbourne in England, where an increased pumping from wells situated a mile from the sea brought the salt-water soaking through the greensand.[3] In the Colony, however, we do not have to deal with porous rocks; all underground seepage, outside the infinitesimally slow one through the substance of the rock, takes place through fissures. Conceive now a system of

[1] See C. Darwin, "Observations on Volcanic Islands," in "Geological Observations," 1851, p. 116; and also "More Letters of C. Darwin," 1903, vol. ii, p. 143.

[2] C. E. Dutton: "High Plateaus of Utah," 1880, p. 125.

[3] It would be interesting to know in this connection whether increased pumping from the boreholes that were put down in granite near the sea along the Swedish coast would bring the salt water through the crevices. See C. R. Markham: Geogr. Journ., vol. x (1897), p. 465.

fissures through which, on the one hand, the underground water of a continent passed downwards; and on the other, a system beneath the sea connecting with the first, in which at one time fresh water, at another salt water, infiltrated, according to the mutual pressure exerted by each. Then imagine a differential movement in the crust: the land fissures would be disconnected, and the sea-water would press downwards along the established lines of flow until stopped by the rock in the zone of the movement which had become melted by pressure and friction. This crude explanation would account for the water in lavas, and for their occasional high content in sodium-chloride, that is to say, each volcanic line in which the rock was melted up by earth-movements, if near the sea, would be enclosed on either side by a system of fissures which had long been the conduits for considerable bodies of water, on the one side sending down fresh, on the other salt water. One would think that if this was actually the case, the water once reaching the molten rock would be instantly returned along the way it came in the form of superheated steam. But underground fissures are intricate; they wind upwards and downwards, and the water usually percolates by a system of syphons which will work one way but not the other. Capillarity also comes into play, and, as Daubrée has shown,[1] this works only one way, namely, towards the hotter portion of the rock that contains the capillary interstices. Thus we have the water forced into the zone of molten material, and what little can escape does so in the form of hot springs.

The final result of this line of reasoning is that the water that was pressed into the molten surface of the globe by an atmosphere consisting of the whole of the present hydrosphere is still there, and cannot escape, because, apart from the still doubtful occlusion of the water, this primordial magma is so covered with later deposits that it never has an opportunity of coming to the surface and cooling itself sufficiently to allow the water-vapour to escape. We must look to the veins of quartz, filled with the heavy metals like gold, for the evidences of the very slight extravasation of this primordial water in bygone ages, and we must suppose that deep beneath the surface, far below the zone from which the volcanoes derive their material, such extravasation is now going on, but that it can never be felt at the present surface of the globe. The gold-bearing hot springs of Nevada may be regarded either as an exceptional case of the primordial water having come into connection with the surface system of water supply, or, what is more probable, that the hot springs traverse a mineralized area in which the precious metal had already been deposited, and from which the water has leached out its unaccustomed burden. The reason for considering the latter the more probable is that it seems to me that if the water is the primordial vapour condensed, the heat at which it exists in the interior is a function of the depth, and by coming to the surface it would pass through layers each of which would be heated according to its depth; the water would therefore arrive above ground at the

[1] "Géologie Expérimentale," 1879, p. 258.

temperature of the surface-rocks, and not in a heated condition at all; but if it is water that has soaked in originally from the surface, and has got into the neighbourhood of deep displacements of the rock-crust, then we have a source of energy that is capable of being dissipated to draw upon for our supply of heat, and hydrostatic pressure to bring it back to the surface. We have not been forgetful of the presence of radium in the waters and deposits from hot springs, but as yet there are no results to communicate from South Africa.

IV.—Notes from the Geological Laboratory of Birmingham University. On a Convenient and Simple Method of making Geological Models.

By T. Stacey Wilson, M.D., B.Sc., F.G.S.

Many ingenious methods and materials have been used for the making of geological models, to show the internal structure and outcrop of a stratified sequence, to furnish maps and lines of section, and to indicate the direction and effects of faults.

Such materials and methods as those of Mr. Sopwith, while most instructive and interesting, are powerless to deal with problems of curved strata, and no material has yet been found by which satisfactory stratigraphical models can be made of folded districts. Such a material must have several properties:—

1. It must be easily made into large plastic sheets of even thickness and of distinguishable colour.

2. It must bend readily and adapt itself sweetly to any surface to which it may be applied.

3. Successive layers must adhere together fairly quickly and quite firmly.

4. The material should set into a rigid but not brittle mass in the end, and yet not be too hard, so that it can be carved readily, or if necessary moulded into any required shape.

5. It would be an advantage if it was cheap.

Casting about for such a substance I have found one which satisfies a good many of these requirements. Not only does it allow of the building up of models out of definite stratigraphical elements in exact imitation of the natural geological structure, but it may possibly be of use in solving certain obscure structural problems. It is also likely to be of considerable use to teachers and students, as models can be built up by or before a class, and it may even have some applications outside geology itself.

The material used is *felt* of various colours, steeped in *melted paraffin wax* that has a melting-point of about 110° F.

The solid paraffin is melted slowly over a spirit-lamp or, better, in a jacketed saucepan or water-bath. Layers of felt are soaked in the melted paraffin and then squeezed fairly dry. The low melting-point allows of this being done by hand. Layers of coloured cloth may be used for thinner beds.

The layers are then superposed one on another to the desired thickness. They adhere together, and the composite mass may be cut with a knife to any shape required. The best tools for further shaping are gouges and chisels, and for the smaller work a sharp penknife, the material having the consistency of rather hard cheese.

On account of the ease with which the waxed felt can be cut the surface of a model can be carved into a much better representation of the relief of a country than is the case with wood or other materials, and outcrops can be rendered in a much less conventional manner than hitherto.

Faulting can be shown by cutting the model clean through along any given line and joining the severed edges together after heating them slightly; they reunite with the utmost ease into a solid block, which can be carved into shape as before.

Folding may be produced in two ways. Either the complete thickness of several layers may be kept warm and bent as a whole into the desired shape; or else, and this is always necessary when complicated folding has to be rendered, a basal model of the fold types may be carved in wood or cast in plaster, and the waxed felt laid on it and fitted in layer by layer. The surface is, of course, worked up afterwards with the knife or gouge.

Obviously the faults of folds and faults, unconformity, and thrusting can be readily dealt with on the same lines.

A modification of the method must be employed in cases where it is important to deal with beds of varying thickness or those which thin out altogether. This method is also of great use in treating a complicated country such as that to be immediately referred to. For this purpose wool-clippings from a carpet factory, or ordinary felt scraps cut up and teased out, are folded in muslin, soaked in melted paraffin, squeezed out, and then spread out into a layer of the requisite thickness, pins having been previously driven into the base on which one is working, of a height corresponding to the thickness of the stratum. Sculpture is carried out as before.

In order to show the application of this process to the modelling of a particular district it will be most convenient to describe the actual making of a model which I made in 1901 to illustrate a paper on the Harlech district by Professor Lapworth and myself, read before the Geological Section of the Birmingham Natural History and Philosophical Society, March 28th, 1900.

1. The lowest bed on the series dealt with was taken as the floor of the district, and the depth of its base below a convenient plane or base-level (parallel to the sea-level) was calculated at a sufficient number of points in the map to permit of the drawing of contour-lines on the bed so as to give the general character of the folding and faulting.

2. A vertical scale was chosen and contour-lines showing a depth of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ inch, etc., below base-level were drawn on the surface of a block of wood.

3. This surface being taken as the base-level, holes were bored with a bradawl along the contour-lines to depths of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ inch and so on.

4. With a gouge and chisel the surface of the block was now cut down to the bottom of the holes, as is done by a sculptor in roughing out his marble.

Thus a model of the floor of the district is obtained with the gentle rise and fall of its folds and the abrupt drop of its faults.

It is quite evident that a similar base might be built up with cardboard or wax sheets, or modelled in clay, or cast in plaster, or obtained in a less laborious way than the carving of a wood block. The only essentials are rigidity and accuracy.

5. On this carved surface the successive geological formations were built up to scale by means of layers of differently coloured paraffin wax or waxed felt of the proper thickness.

6. In order to ensure the first layer being of the proper thickness the following method is employed. Pins with small heads (entomological pins) a little longer than the thickness of the stratum (or cut to the requisite length) were driven in all over the wooden base. A convenient way of securing the right height was to take a strong metal pencil-case, remove the lead, and draw back the stop till the lead chamber was just the required depth. On inserting the pins' heads into the lead chamber the pencil-case was used to drive the pins in exactly the right distance with the minimum expenditure of time and trouble.

7. The wood is next thoroughly wetted to prevent the paraffin sticking to it, or it may be covered with wet tissue paper, and the coloured wax is spread over the model to the level of the pin heads. Small strips of wet stiff paper or pieces of tin should be inserted along the fault planes so as to give sharpness to the edges of the strata there.

8. As soon as the first layer sets the pins are removed and more pins inserted in the same way to give the thickness of the next stratum of coloured wax. To strengthen the model some of the layers should be put on with waxed cloth or felt in sheets, but this, though desirable, is not absolutely necessary.

9. Where a bed crops out on the surface the coloured wax is carried a little beyond the area occupied by the bed, as shown on the geological map.

10. When all the layers have been put on and have set fairly firm the surface is modelled with the gouge and penknife so as to show the hills and valleys. If this could be done quite accurately, and if the structure and thicknesses were quite correctly rendered, it is evident that the surface of the model should exactly correspond with the country. In practice, however, both the known contour of the country and the known outcrops of the beds are utilised for making the surface of the model approximately accurate.

Before beginning the modelling of the base of a country it is best to indicate by long pins the position of the chief landmarks in the area dealt with. These can be maintained in position as guides throughout the whole process, and removed when the model is finished.

Slight modifications of this process which might easily be devised will obviously render it applicable to problems related to intrusive and volcanic rocks.

V.—The Average Composition of the Igneous Rocks.[1]

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

The average composition of the igneous rocks is a point of considerable interest in its relation to the problem of their differentiation, and several attempts have been made to solve it by the collation of analyses. Thus, Mr. Clarke estimated the American rocks to average 59·77 per cent. of silica (which may be taken as representative), and Mr. Harker came to very similar conclusions as regards the British rocks, obtaining 58·46 as his figure. The process followed was to add up the results of all the obtainable analyses and take their mean. If each class of rock analysed occupied the same average amount of space—if, for example, the basic intrusions were approximately equal in bulk to the acid ones—such a process would give results of considerable value. As it is, however, very little consideration will show that unless due weight is attached to the relative abundance of the different classes, the results will be very far removed from the truth. Even in Britain, where the development of igneous rocks is comparatively insignificant compared to the sedimentary ones, there are quite enough exposures of the different types to demonstrate this fact. If a geologically coloured map be examined, and the nature of the various patches of igneous rock be enquired into, the immense preponderance of granite becomes obvious, even though the basaltic lavas make a great show on account of their horizontal extension. In fact, the Dartmoor granite mass, if it be assumed to extend to a depth of only one mile, would probably suffice to weigh down the scale against all the other non-granitic igneous rocks combined. Yet, on the method indicated above, the smallest dyke would be of something approaching equal account, even if a number of analyses of the Dartmoor rock were included.

In other parts of the world where igneous rocks are far more largely developed than in England, the predominance of granites is even more striking. In Africa and Australia there are many single granite masses which are exposed at the surface over areas of not only hundreds but thousands of square miles. The Matopo granite mass of Rhodesia, forming the hills now famous as the burial-place of Mr. Rhodes, covers a horseshoe-shaped tract of country certainly not less than 5,000 square miles in extent; in fact, it may be two or three times as much, as only its northern and north-eastern limits are yet known with certainty. And this is only one of many; in fact, out of the 250,000 square miles covered by Southern Rhodesia and the adjacent territories, it is certainly safe to say that 100,000 are granite, while there is scarcely any other class of igneous rock with even a single outcrop large enough to be visible if inserted in its true proportions on an ordinary map.

The district immediately surrounding Bulawayo may be taken as representative. I have mapped, in the course of nearly two years' work, an area of 2,000 square miles with as near an approach to

[1] Read at the Southport Meeting of the British Association.

accuracy as can well be attained with the present imperfect topographical maps. By dividing the map into small squares an estimate is readily made of the areas covered by the different rocks, with the following result:—

	Square miles.
Sandstones, probably Tertiary (including some lava-flows) ...	215
Metamorphic rocks	730
Plutonic igneous rocks	1,055
	2,000

It will be seen that the plutonic rocks outbalance all the other rocks put together. They comprise portions of four masses, of which one is chiefly syenite (with 63 per cent. of silica) covering 15 square miles. The others, with a combined area of 1,040 square miles, are granite with a silica percentage probably averaging about 70 per cent. It must not be thought that basic rocks are absent; they are, on the contrary, well represented by numerous dykes of dolerite and basaltic flows. We shall, however, be making a generous allowance for them if we suppose there are 1,000 dykes a mile long and five feet wide, with 10 square miles of basalt 20 feet thick. We will further suppose that these rocks contain about 50 per cent. of silica. There are a few intrusions of porphyrite and orthophyre, but they are of little importance and may be reckoned as allowed for amongst the dolerites.

Now let us see what results these figures lead to. We will assume that each dyke and plutonic mass extends vertically to sea-level, that is to say, goes down about a mile. (Bulawayo stands at an elevation of 4,500 feet above the sea, and much of the district is higher.) We have therefore :—

Rock.	SiO_2 per cent.	Area, sq. miles.	Depth.	Volume, cubic miles.
Granite ...	70 ...	1,040 ...	1 mile ...	1,040
Syenite ...	63 ...	15 ...	1 mile ...	15
Basalt ...	50 ...	10 ...	20 feet	1
Dolerite ...	50 ...	nearly 1 ...	1 mile	
			Total	1,056

Multiplying each silica percentage by the volume of the respective rock, adding up the products and dividing by the total volume, we obtain an average of 69·88 for the whole. Whatever composition is assigned to the granites, the general average will, in fact, approach it within a few parts per thousand. We thus arrive at the conclusion that if all the other rocks of the area were to be fused into the granite masses the difference they would make would be quite imperceptible lithologically, and scarcely noticeable in a chemical analysis. Such a result would, I believe, hold good for the entire African continent and certainly for the whole of Rhodesia. There is nothing to indicate that a different conclusion would be reached in any other extensive area where the plutonic rocks are adequately represented, and there is accordingly reason to believe that granite substantially represents the magma from which even the most basic rocks have been developed by some process of differentiation.

VI.—The Salt Deposits of Dax and the Pyrenees.

By P. W. Stuart-Menteath, Assoc. R. S. Mines.

On the rail to Biarritz the roots of the Pyrenees first appear at Dax, and are accompanied by those ophites and thermal springs which are special features of the entire chain. Vast deposits of salt, to whose first development I contributed, have added an important industry to the resources of this ancient capital of *Aquæ Tarbellicæ*, where the exact harness depicted on Roman medals is still characteristic of every cart. Beneath the existing ditch of the Roman fortifications rock-salt was accidentally discovered by a boring for mineral water, and the salt is now worked at three miles to the south-east, and is indicated by springs for a distance of seven miles. The deposit is known to be about 100 feet in thickness, but is of unknown depth beneath the existing borings.

Along the entire outskirts of both sides of the Pyrenees similar salt deposits abound, and they are often similarly accompanied by igneous rocks.

The salt formation of Dax is distinctly limited by the valley of the Adour, which here ceases to wander among the sands of the plain, and is suddenly and sharply diverted along a tectonic depression, running towards the Pyrenees in a south-west direction. Precisely parallel to this course, in the Cretaceous and Tertiary rocks of the Pyrenees, there runs, at a dozen miles to the north-west, the most remarkable example known of a tectonic valley sunk beneath the ocean. The Gouf de Capbreton, sinking with steep sides to over 3,000 feet beneath the even bottom of the Atlantic skirt, and affording evidence of igneous rocks in its surroundings and in the irregularities of its floor, is a perfect analogue of the neighbouring tectonic portion of the Adour. One is disposed to attribute the salt deposits of the Pyrenees to an episode in the past history of such valleys, whereby they were upraised, with salt lagoons in their irregular hollows, and with rapid evaporation of the brine by volcanoes such as accompany salt lakes of Eastern Africa. The disposition of Pyrenean salt accords fairly with such a theory; but matters of engineering importance are not usually decided by any royal road of first impressions, however plausible or fascinating.

Still more important than the salt of Dax are those thermal springs which, along ten miles of the tectonic valley of the Adour, form a western limit to the salt by an emanation of over 5,000 tons daily of mineral water at a temperature of 147° Fahrenheit. This water, by impregnating the mud of the Adour, excites a growth of *confervæ*, diatoms, and other organisms, that may develop to even half the weight of the whole material. They transform the complex mass, with production of nascent oxygen from the carbonic acid that accompanies the abundant nitrogen which bubbles from the springs. Such actions, as explained by Bischof, doubtless originate the powerful therapeutic action of the Dax mud baths. One may attribute to such mud the variegated marls which accompany the salt deposits and which closely resemble those of the Trias formation. A classical investigation of the Iceland springs, by Bunsen, proves that such variegated marls are in active production beside volcanic rocks at the present day. And beside the Baignots establishment at Dax a limestone containing fossils of the Upper Chalk is transformed to dolomite and traversed by the hot springs. But although the springs can furnish by their constituents and effects a satisfactory explanation of both the salt and all its accompaniments of Triassic *facies*, it would be rash to ignore the splendid investigations of Ochsenius on the relations of sea-water to salt deposits throughout the world. Wherever and whenever I have heard the Triassic theory of Pyrenean salt expounded by its foremost representatives, they have ignored such helpful assistance. It is therefore useless to urge their attention to the fact that either the origin from springs or the origin from sea-water can equally be advanced as alternatives to the arbitrary assumption of wedges of Trias introduced by paradoxical contortions that are demonstrably absent in many cases with which they deal.

The thermal springs of the Pyrenees were long since analyzed by Filhol, and their accompanying rocks patiently interpreted by Leymerie. These eminent observers, in 1866, showed me a carbonaceous metorite whose fall was witnessed, and whose fragments are preserved in the Museum of Toulouse. They furnished me with specimens of its material, and assured me that a portion of its substance had yielded the formula of *humus*. Filhol explicitly remarked to me that it apparently carried vestiges of the life of the original body to which it belonged. I had previously suggested to fellow-students the convenient theory of meteoric origin for every residual difficulty of geology in general. Personally invented theories are thus often crystallized by a fascinatingly confirmatory apparent fact. The practical geologist notes and discards such suggestions in every excursion. Of course, it was practically impossible to ascertain whether the organic matter was originally present or was introduced in the hot meteorite from the soil into which it penetrated deeply when it fell.

I have found the main problems of the Pyrenees to be conveniently represented at Dax. The abundant fossils of the Tertiary plain here meet the similarly abundant fossils of the outermost Cretaceous, so that the relative dispositions are defined by independent evidence of every kind. Desiring to leave something for later observers, I would nevertheless remark that the problems are even here less easily and rapidly solvable than recent innovators have found them to be at points where none of the means of solution available at Dax have troubled the even course of their decisions.

Hitherto the entire work of the observers most familiar with the Dax district has shown that the apparently Triassic marls and salt are independent of any special horizon of the Cretaceous fundamental rocks, and it has proved equally impossible to identify them with any special horizon of the Tertiary. It is only certain that they closely accompany the igneous ophites (diabase or dolerite), and that they are arranged on lines that exhibit remarkable independence towards the general disposition of the visible rocks. The salt deposits of the neighbouring portion of the Pyrenees exhibit a similar independence, and the latest theory—that they are shovelled from the mountains by vast processes of superficial *charriage*—is a recognition of the general result of observation thus admitted. It coincides practically with the view of Dufrenoy, of anomalous and eruptive origin, for which I have long vainly claimed respect.

But in the treatment of salt deposits it is impracticable to rely on those details of arrangement which are regularly advanced as conclusive by representatives of the new theoretical geology. Every mining engineer is aware that salt is practically plastic and is in nearly every salt-mine subject to contortion by hydration of anhydrite as well as by squeezing. In such recognition of experience the observations of practical engineers, such as Crouzet and De Freycinet, are valuable at Dax, while much other evidence is obviously out of court. The doctrine that the upper gypsum of a salt-mine must be due to a different sea, and therefore to a different formation, because sea-water deposits gypsum first and salt last when boiled down in a pot, was gravely expounded at Cardona by a foremost creator of the *charriage* theory in the Pyrenees and elsewhere; but such views merely exhibit ignorance of the elements of the problem as revealed by Bischof, Bunsen, Ochsenius, etc. Crouzet and De Freycinet plausibly argued that the salt was bedded between horizons about the junction of the Cretaceous and Tertiary as known in their day. Subsequent observation tends to prove that it frequently fills hollows on the surface of the Cretaceous and beneath the Tertiary, the latter being of any age from the Lower Eocene to the Upper Miocene, and probably even to Recent, according to the local circumstances of its deposition above the salt. Of course, no practical geologist would affirm that Triassic salt may not also exist. I have found it existing as the cause of salt springs at Camou, Arrigorriaga, and other places. But the actual Trias of the Pyrenees is singularly unsuited to the purposes of the theorist, and he consequently compares the Pyrenean beds he would class as such to that of Germany and Lorraine. Yet in these last neither bipyramidal quartz, nor arragonite, nor oligist, nor ophite are cited, and it can hardly be argued that gypsum is peculiar to any special formation.

Such being the general situation of the problem, it should be added that the best exposed and most clearly related salt deposits of the Pyrenees are, along the whole Spanish slope, decisively of Eocene or Oligocene age. The attempts of theorists to deny this at Cardona are conclusive regarding the character of their observations, while at every point they have treated on the French slope they have admittedly urged the contrary of what they to-day propound.

The main difficulty at Dax and elsewhere lies in the thick mantle of marine, fluviatile, and æolian sands which cover the surface of the plain, and, accumulating to even hundreds of feet in thickness, drowns the ancient valleys and extends across the plateaux of the Pyrenean roots. These sands are so obviously undistinguishable in detail, and so certainly misleading as regards their age at special points, that they have been selected as a favourite quarry of evidences for the existence of Pliocene man. In the Appendix to the French edition of Lyell's "Antiquity of Man" an example is cited from Biarritz as clearly beneath the Pliocene *Sables des Landes.* In thirty pages of the Bul. Soc. Ramond of 1878, together with a section of unusual detail, I proved that the remains in question were from modern peat, and later than beds which have since supplied me with a tooth of *Elephas primigenius.* At both Biarritz and throughout the Landes, the sand classed as Pliocene is separated from the underlying Tertiary and Glacial Diluvium by a remarkable Brick-clay, similar to that of Portobello, near Edinburgh. This clay is described as strangely anomalous in position, because it always appears to overlie the Sables des Landes, for the simple reason that it *does* overlie them, as amply proved by local observers. At Biarritz it caps the hill beside the Negresse Station, while the coarse Glacial Diluvium lies beneath it to the margin of the Negresse lake. Blown sands above this supposed Tertiary have furnished the human remains of Biarritz and Dax, whose real age is consequently indeterminate, but trifling. My conclusions were stigmatized as lamentable, but my facts have remained unquestioned, and the Pliocene man in question is regularly cited like his colleague of the Lisbon Congress, who was condemned as spurious both at Lisbon and at Paris by the judges specially selected to report upon the facts. In the Bull. Soc. Géol. of 1896 I have further dealt with the Sables des Landes, and I was in agreement on the point with the regretted Munier-Chalmas. Their Pleistocene age is admitted in the last edition of De Lapparent's treatise.

For further details I must refer to the first volume of the "Mémoires pour servir à l'explication de la Carte Géologique détailée de la France" (1903), published by the Ministère des Travaux Publics, in which ample references to my original papers, and a tabulation of the fossils of the Pyrenean Trias which finally rewarded persistent search, are conveniently arranged for every scientific library.

In the first place, I succeeded in finding beside the salt-mines of Villefranche (near Biarritz) abundant and unsuspected deposits of the fossils previously classed as Neocomian, and which are now admitted to represent the base of the Upper Cretaceous of the Pyrenees. This formation further supplied me, south of Irun, with sixteen species of Cephalopoda of the Cretaceous horizon of *Ammonites inflatus*, comparable to that of Portugal, and in the middle of rocks mapped as Trias. In all the Western Pyrenees this formation rests unconformably on all previous rocks, and is in direct contact with the Trias, Jurassic, etc., by a bitumen or lignite horizon representing an ancient land or coast surface. To this bituminous horizon one can attribute the important bitumen of Bastennes, near Dax, which was formerly worked by an English company to supply the earliest Parisian asphalt, and is largely described in Ure's Dictionary. It flowed into Tertiary beds in the neighbourhood of an ophitic intrusion, and supplies beautiful moulds of the Tertiary fossils in black asphalt, in great abundance beside the ruins of the old workings at Bastennes. At Tercis, near Dax, the same horizon of abundant Greensand fossils forms the lowest visible beds above the variegated marls which contain ophite, salt, and gypsum. But *from beneath* these variegated marls there outcrops, at Le Hour, at a trifling distance to the south-west of the salt-mine, a thick band of dolomitic limestone and breccias, alternating with beds of ash, and pinched between extensive outcrops of ophite. This limestone is absolutely identical with the Muschelkalk, which I have found fossiliferous from St. Michel to Ascain, along many miles of the nearest Pyrenees. It is strangely identical with the most typical Muschelkalk of the Hartz, it presents both the peculiar dolomitic breccias and the blue and green *Aerinite* which characterize Triassic beds accompanying ophite at Camarasa in Catalonia, and it abounds in moulds of Gastropods, etc., such as peculiarly characterize the Muschelkalk of the Pyrenees. In a former paper I denied this identity, because the most characteristic portions of the rock had been largely removed by quarrying; but having found them by repeated later visits, I can recognize the identity in both character and relative situation of this typical Muschelkalk. This rock was found to be fossiliferous by Crouzet and De Freycinet, and its fossils classed as Tertiary; Raulin and others classed it as Cretaceous; Jacquot compared it to the Muschelkalk in 1888; M. Seunes declared its fossils to be of the infra-Lias in 1890. As both at Le Hour, Ascain, and many other localities, it is beneath a considerable thickness of Keuper marls, and as the fossils habitually resemble those of the Muschelkalk, the last-mentioned determination is inadmissible and misleading. The real infra-Lias, with *Estheria minuta*, fish spines, and other remains, I have found at Elduayen, Villabona, etc., and it is different in appearance, as well as closely connected with the Lias, containing *Gryphæa arcuata* at Narvarte in the Bastan.

At Dax we have consequently the Trias with salt, gypsum, etc., rising in ridges and bosses from beneath all later rocks, and these outcrops are occasioned by the presence of igneous intrusions that have given rise to abundant thermal springs charged with salt. Obviously this machinery can transfer the salt and gypsum to any depressions or lagoons formed even to the present day, and we have consequently a sheet of salt and gypsum laid down in the extensive depression which borders the tectonic valley of the Adour. This sheet appears to date from the latest vicissitudes of the district, and certainly from later than the last upheaval of the Pyrenees. Wherever we find similar machinery of Triassic bosses below, igneous intrusions breaking and dislocating that Trias, springs conveying its contents to the surface, and tectonic irregularities and barriers occasioned by the movements of the Pyrenees, we may naturally find salt deposits of any age later than the Trias. The detection of their presence, and the estimation of their depth and extent, is a problem special to each particular district, and depending on the entire geological history which can be worked out on the spot.

The vast sheets of gypsum and salt that extend from Olot to

Logroño along the Spanish side of the Pyrenees are clearly deposited from evaporated lagoons formed during the uprise of the chain in Tertiary times. The salt deposits of the French Pyrenees are of a more local and varied character. There is a general contrast between the two series which reflects the general contrast between other features of the two slopes. In the salt deposits of the Pyrenees one finds every variety of lagunar character on the Spanish side, and every variety of tectonic and local character on the French side. Among the French deposits one may trace actual craters of explosion filled with salt, old valleys filled with spring deposits, and small accidental hollows that have preserved patches of salt water in rising from the sea. Sunk valleys, like the Gouf de Capbreton, have naturally preserved sunk deposits, when buried beneath Tertiary accumulations; and the ancient surfaces of the Cretaceous formation and of the Oligocene land are naturally marked by such vestiges of their irregular uprise from the sea—especially where the innumerable igneous bosses, that have visibly traversed the Upper Cretaceous of the Pyrenees, have roughened the surface and given rise to later fracture and irregular denudation. As salt and gypsum can only resist solution under peculiarly favourable circumstances, it is certain that such solution must have produced extensive dislocation. In the mountains of Persia and South America, gypsum is over 1,000 feet in thickness across distances of over 50 miles. No borings have yet fathomed the salt and gypsum of the Pyrenees, although 1,082 feet has been reached at Salies du Salat without signs of change. Such facts are a mere suggestion of what observation might yield if not referred to one current theory.

Not only the whole of the varied phenomena in question, but even such local chemical productions of gypsum in the Flysch as are visible near Biarritz at Croix d'Ahetze and elsewhere, have been treated as characteristic of the Trias formation. In the Alps, as in the Pyrenees, the gypseous beds of the Trias have been credited with all the salt and gypsum of later beds of every age. The stratigraphy which results from attempting to unite Oligocene and Triassic beds into one formation is naturally astounding.

Round Biarritz, more conveniently than at Dax, the diversity of the gypseous and red clays classed as Trias by Parisian geologists may be verified. At Laduch, west of Villefranche, the fossiliferous base of the Cretaceous may be seen resting on the gypseous marls of the Villefranche salt-mine. At Caseville similar red clays, with ophite and gypsum, are distinctly intercalated between the fossiliferous Danien and Lower Eocene, and at Fontarabia they are inclined at only 15° to the horizon. Beside the Negresse Station the red brick-clay, of post-Glacial age, is now largely worked, and is above the Glacial Diluvium that descends to the level of the lake, while over it there is nothing but the modern blown sands of the spurious Pliocene man. At Croix d'Ahetze the similar gypsum and clays, formed by decomposition of iron pyrites in the Flysch, thickly cover the almost horizontal surface of a quarried sheet of fucoidal Flysch limestone. All the diverse formations thus enumerated, as well as superficial red clays formed by decomposition in quarry fissures and ancient drains, have been gravely classed as Trias by the creators of the *charriage* theory in the Pyrenees and the Alps. And it matters nothing that the disposition of the real Trias in the neighbouring mountains is as flatly opposed to their theory as it is possible to imagine.

The presence of the Muschelkalk at Dax and other points of the sub-Pyrenean plain immediately beneath the base of the Cenomanien is curious as evidence of the absence of the entire series between that horizon and the Keuper marls. But in the whole Western Pyrenees I have found these intermediate rocks to be largely represented at one point and entirely absent at another, in the most irregular and closely contrasting fashion. The explanation lies in the extensive transgression of the Cretaceous, which is attested by the lignites that alternate with Gault fossils between Ascain and St. Pe, and at Hernani, Cestona, etc., and which, with abundant *Orbitolina concava*, rest directly on the Trias south of Roncesvalles. Extensive and irregular denudation appears alone to fit the facts. Such denudation implies that the Pyrenean area was, in Lower Cretaceous times, as irregular and mountainous as it is to-day.

The best examples of the Muschelkalk can be seen in the valley of the Bastan above Elizondo, and at Urdax and the basin of St. Jean Pied de Port. It alternates with sheets of ophite that usually overlie it and occupy the place of the Keuper. It is thrown into repeated strips by faults that let down bands of Cenomanien fossiliferous limestone, forming long canal-like intercalations, as in the Alps of Gosau. Both the faults and the ophitic intrusions are consequently of an age later than the Cenomanien. A desire to class the ophites as Triassic, on grounds of micrographic theory, has long hampered the recognition of the facts.

The salt of the Dax mine is arranged in lenticles coinciding in both dip and strike with the Muschelkalk and the ophite which adjoins it. I have found the same coincidence with the ophite in the similar salt mass of Bassussary, near Biarritz, and it has been ascertained in the mine of Villefranche. In the last two cases the disposition is directly across the strike of the Cretaceous rocks, and in the earlier workings at Dax, described by M. Genreau, the disposition was similarly independent of the Cretaceous.

The lesson derivable from the Pyrenean salt-mines is that of the extreme danger of hasty generalization, and of the necessity for studying each particular case as it is studied in the practice of the mining engineer. It affords a striking warning against the facile assumption that old rocks must be superposed by superficial transport from a distance, because apparently insuperable difficulties seem to exclude their intrusion from beneath. The most experienced geologists have, after repeated observation, classed the Dax Muschelkalk as Cretaceous or Tertiary. When that rock is recognized as Triassic it does not follow that it is superposed on later beds. Its relations are merely such as are constantly recognizable within the dislocated and contorted area of the Pyrenees, and these complex relations can be recognized as extending to Biarritz and to Dax. The latest observations on the Carpathians and the Eastern Alps amply establish the protrusion of the Klippen from beneath, and the latest surveys of Algeria prove that, where the plastic Trias is in question, local and unsuspected intrusion and protrusion have no such limits as are assumed in the theory of *charriage*.

It is more than thirty years since I first discovered the decisive example of Cretaceous gypsum at Croix d'Ahetze. Since then I have found decisive examples of the production of gypsum, in place, in rocks of any age from the Muschelkalk to the Tertiary. Yet in both the Alps and the Pyrenees the assumption that gypseous beds represent the Trias is the selected and regular basis of stratigraphical paradoxes which claim to reverse geology. It has been as easy to ascertain the truth as in the case of the Pliocene man, but no single observer has cared to verify the facts. The latest theory rests upon the assumption that salt and gypsum are of fixed age. It has thus selected for its basis precisely those materials which are, both chemically and mechanically, plastic and transferable to such a degree that any stratigraphical inference founded upon them must be essentially arbitrary. At Dax, Biarritz, and Cardona the opposition between fact and fancy can be recognized.

VII.—The Zoning of the Culm in South Germany.

By Dr. J. H. Parkinson.

"Ueber eine neue Culmfauna von Königsberg unweit Giessen, und ihre Bedeutung für die Gliederung des rheinischen Culm." Von Herrn Harold Parkinson aus Halstead (Essex). Zeitsch. d. deutsch. geol. Ges., Jahrg. 1903, Heft 3, pp. 1–46, pls. xv, xvi.

"On a new Culm Fauna at Königsberg near Giessen, and its significance for the division of the Rhineland Culm."

It has been suggested to me that a brief résumé of an illustrated article published last year in the *Zeitschrift der deutschen geologischen Gesellschaft* might be of general interest. The article in question embodies a piece of research work undertaken at the instance and under the direction of Professor Kayser, of Marburg, who during the Summer of 1900 observed in the neighbourhood of Königsberg, not far from Giessen, a bed of rock differing palæontologically and petrographically from the surrounding Culm slate. The rock, a slaty breccia with a considerable limestone content, furnished even on cursory examination a fauna deviating considerably from that generally associated with the Culm. Type-fossils of the Posidonia Slates (the "Culm of Herborn"), such as *Posidonia Becheri*, *Orthoceras striolatum*, and *Goniatites crenistria*, were not met with, but on the other hand Crinoid stems together with fragments of large *Producti* and of Trilobites of the genus *Phillipsia* appeared plentiful.

In order to obtain a fuller knowledge of the fauna of this remarkable niveau, Professor Kayser, under whom I was at the time studying, most kindly handed over to me its further examination; consequently, in the Autumn of 1902, I devoted several weeks to the study of the Culm rocks in the neighbourhood of Königsberg, and especially to the collection of fossil remains from this particular bed. The general composition of the Culm in this locality is similar to that elsewhere in Hessen, that is to say, directly over the late Devonian diabase lies a thin zone of flinty slate, accompanied here and there by small beds of limestone; next above occur the well-known greenish-grey Posidonia slates (as at Herborn); and, still higher, darker slates, much resembling those used for roofing—indeed, about half a mile east of Königsberg they have actually been quarried for this purpose. To these slates belong the fossiliferous beds which form the subject of this article; above them are found the beds usually known as Culm Grauwacke.

Passing at once to the occurrence of the slaty breccia, it should be stated that the beds were recognised in this neighbourhood at two or three distinct spots. At one they lay horizontally among the roofing-slates already mentioned, several outcrops occurring on the side of the roadway connecting Königsberg with the village of Frankenbach. Though I only succeeded in finding *fragments* of organic remains here, this was by no means the case at the second spot, where the breccia-bed occurs under conditions more favourable for observation. Here, directly north of the township, either it forms a small fold, the limbs of which incline gently west and east, and are interrupted by a fault of inconsiderable extent, or, as I am inclined to think more probably the case, we have to do with the outcrops of *two* breccia-beds separated from each other by grauwacke-slates. One is the more inclined to the latter opinion, because the larger outcrop (about 7 yards long and 1½ feet thick) is characterized by a deep brown coloration, due to the presence of iron and manganese compounds, wholly lacking in the smaller, which moreover possesses greater limestone content, less thickness and greater hardness, in these respects resembling the beds already referred to as occurring eastward of this spot; only in the former of these outcrops do fossil remains occur at all abundantly. A third but unfossiliferous bed of the rock was also observed at no great distance.

This slaty breccia is not, however, confined to the neighbourhood of Königsberg. Dr. Drevermann, assistant in the Geological Institute at Marburg, first called my attention to its occurrence near Battenberg on the Eder, about 30 miles north of Königsberg, and there I succeeded in locating five or six outcrops, with, however, only few organic remains, and those in most fragmentary condition.

I had to rely, therefore, chiefly on the material collected at Königsberg, the examination of which was rendered additionally difficult by the fact that the fossils occurred almost always as casts and moulds, and in a most crushed and distorted state. Though much of the material, therefore, was from a palæontological standpoint valueless, I was able to attain to the specific determination of the following forms with tolerable certainty :—

A Comparison of the Culm Fauna of Königsberg with that of the Rhine District, the Harz, and England, also with the Fauna of the Carboniferous Limestone of Belgium.

The Culm Fauna of Königsberg, etc.	Carb. L., Belgium. E'troeungt Beds.	Carb. L., Belgium. Tournai Beds.	Carb. L., Belgium. Visé Beds.	Culm of Rhine Schiefergeb.	Culm of Harz and Magdeburg.	Culm of England.
Phillipsia Eichwaldi, Fischer, var. *Hassiaca*, n.var.			*	*		
P. gemmulifera, Phillips			*			
Griffithides seminifer, Phillips			*			
Bellerophon reticulatus, M'Coy			*			
Loxonema cf. *acuminata*, Goldfuss			1			
Pleurotomaria cf. *pisum*, De Kon.			*			
P. cf. *sublævis*, De Kon.			*			
P. cf. *subvittata*, De Kon.			*			
P. blanda, De Kon.			*			
P. cf. *subgranosa*, De Kon.			*			
Conocardium aliforme, Sow.			*			
Aviculopecten, sp. 1						
Aviculopecten, sp. 2						
Scaldia globosa, De Kon.			*			
Nucula gibbosa, Fleming			2			
Macrodus cf. *reticulatus*, M'Coy			*			
M. squamosus, De Kon.			*			
M. multilineus, De Kon.			*			
M. cf. *bistriatus*, Portlock	*		*			
Productus giganteus, Martin			*			
P. punctatus, Martin			*			
P. semireticulatus, Martin		*	*			
P. scabriculus, Martin	*		*			
P. plicatilis, Sow.			*			
P. mesolobus, Phill.		*	*			
P. fimbriatus, Sow.			*			
P. pustulosus, Phill.	*	*	*			
P. costatus, Sow.			*			
P. cf. *cora*		*	*			
P., sp. 2						
Chonetes papilionacea, Phill.			*			
C. Hardrensis, Phill.			* 1	*	*	*
C. Buchiana, De Kon.			*	*		
C. Buchiana, var. *interstriata*, Davidson						
C. cf. *Dalmaniana*, De Kon.			*			
Leptæna rhomboidalis, Wilckens	*	*	*	*		*
Orthothethes crenistria, Phill.	*	*	*	*		*
O. sp.						
Orthis resupinata, Martin	*	*	*			
O. Michelini, L'E'veillé		*	*			*
Spiriferina insculpta, Phill.		*	*			
Spirifer cf. *trigonalis*, Martin			*			
Athyris squamosa, Phill.		*	*			
A. planosulcata, Phill.		*	*			
A. Royssii, L'E'veillé	*	*				
A. cf. *expansa*, Phill.						
Camarophoria, sp.						
Fenestella plebeja, M'Coy	*		*			
Hemitrypa oculata, M'Coy		*	* 1			
Archæocidaris Regimontana, n.sp.						
Pleurodictyum Dechenianum, Kayser				*		*
P. sp.						
Zaphrentis, sp						
Asterocalamites scrobiculatus, Schloth.				*	*	
Crinoidal remains						
Plant remains						

1 Occurs in the Waulsort Beds. 2 Mourlon (Géol. de la Belgique, ii, p. 41) mentions the occurrence of this species in Belgium, but does not give the horizon.

The foregoing list contains no single species in common with the Cephalopod Limestone of Erdbach-Breitscheid,[1] universally recognised as the lowest niveau of the Culm in South Germany. Only eight of the enumerated fossils, moreover, have been found in the next succeeding horizon, i.e. in the Posidonia Slates of Herborn and Aprath (among them the English forms *Chonetes Hardrensis*, *Leptæna rhomboidalis*, *Orthothethes crenistria*, *Orthis Michelini*, and *Pleurodictyum Dechenianum*), nor are the best known species of the Posidonia Slates of Germany and of the Culm Measures of England found at Königsberg. We must conclude, therefore, that we have to do with a new fauna of the Culm, so far as these localities are concerned.

Crossing the Rhine, however, we meet with a remarkably corresponding fauna in the Carboniferous Limestone of Belgium. This limestone is now divided into three main horizons, those of Étroeungt (transitional between the Upper Devonian and the Carboniferous), Tournai, and Visé. Only eight Königsberg forms occur in the lowest, 12–13 in the central, but no less than 40 in the uppermost of these; in other words, 83 per cent. of the species found at Königsberg are also met with in the Visé horizon of the Carboniferous Limestone, amongst them many forms which are in Belgium confined to this niveau, such, to name no others, as *Productus giganteus*, *P. plicatilis*, *P. punctatus*, *P. fimbriatus*, *Chonetes papilionacea*, and *Griffithides seminifer*. We are consequently undoubtedly justified in regarding the slaty breccia of Königsberg as the equivalent of the Visé horizon of the Carboniferous Limestone. This result affords us a means of zoning the Culm on the basis of the division of the Lower Carboniferous in Belgium. In the Rhine district two different Culm faunas have up to the present been recognised, that of Erdbach-Breitscheid and that of Herborn, Aprath, etc. The Cephalopod Limestone of Erdbach-Breitscheid has been shown by Holzapfel to be the equivalent in age of the Étroeungt beds in Belgium, identical or similar *Prolecanites* occurring in both. Recently, too, Dr. Drevermann has described a similar fauna from Ratingen, on the right side of the Rhine. The Marwood and Pilton beds of North Devonshire, which are of transitional character, are possibly also of similar age. Since the Königsberg breccia must be regarded as the equivalent of the Visé horizon, and at the same time lies stratigraphically higher than the Posidonia Slates, the latter must be regarded as approximately corresponding to the beds of Tournai, i.e. to the middle division of the Carboniferous Limestone, and the same must also be true of the Posidonia Slates of the English Culm Measures. We may summarize the results arrived at in the following table:—

Zones of the Culm on the Right Bank of the Rhine.	Zones of the Carboniferous Limestone of Belgium.
3. Slates with the Königsberg breccia.	3. Visé horizon.
2. Posidonia Slates of Herborn, etc.	2. Tournai horizon.
1. Limestone of Erdbach-Breitscheid and basal flinty slate.	1. Étroeungt horizon.

[1] Cf. Holzapfel, "Die cephalopodenführenden Kalke des unteren Carbon von Breitscheid-Erdbach bei Herborn," Dames und Kayser, Paläont. Abt., Bd. v, 1889.

A further consequence of this discovery must be the removal of that very great series of compact conglomeratic Grauwacke-beds so common on the right bank of the Rhine and elsewhere—in Devonshire, for example [1]—from the Culm to the Upper Carboniferous, thus reverting to the view held some years ago by H. von Dechen and R. Ludwig. This follows from the fact of their lying near Battenberg still higher than the Königsberg strata, shown to be the equivalents of the Visé horizon, i.e. of the Upper Carboniferous Limestone, and that the expression 'Culm' can only be employed to express equivalence with the Lower Carboniferous. We must look upon the Grauwackes, containing the well-known flora (*Lepidodendron, Archæocalamites,* etc.), as an equivalent of the Millstone Grit of England and the Flötzleere Sandstein of Westphalia.

It remains only to be added that the originals of the fossils mentioned in this sketch are preserved in the museum of the Geological Institute of the Imperial University at Marburg.

VIII.—Note on the Marbela Manjak Mine, Trinidad.

By R. J. Lechmere Guppy.

I HAVE been favoured by James Wilson, Esq., with samples of material from the Marbela Manjak Mine. They are—

No. 1.	Clay from	No. 1 Gallery,	75 feet deep.	
No. 2.	,,	No. 2 ,,	127	,,
No. 3.	,,	foot of shaft,	150	,,
No. 4.	Sand-rock.			

There is no essential difference between Nos. 1, 2, and 3, and No. 4 only differs in being harder, not liable to disintegration by water, and in containing more arenaceous and less argillaceous matter than the other samples. Calcareous matter in all the samples is from 15 to 20 per cent., and consists almost entirely of shells of Foraminifera. There is a considerable amount of sulphur, chiefly as pyrites, greatest perhaps in No. 3, and fragments of Manjak [2] occur in No. 1.

In appearance there is much resemblance between this material and that of the Naparima oceanic beds, though the latter is generally of a lighter colour. But on examination a very considerable difference is found to exist between the two formations. Both are extremely fine-grained substances, indicating deposition in some depth of water. But the proportion of argillaceous and arenaceous matter in the Marbela samples is very much greater than in the oceanic beds. This betokens in the former case the greater nearness of land and the influence of rivers. In the Marbela samples the sandy matter mostly occurs in the form of lumps or irregular small

[1] Ussher: "The Culm Measure Types of Great Britain"; London, 1901.

[2] Manjak is a substance originally found in Barbados. It is geologically coal, but chemically a form of bitumen. It is described in Schomburgk's "History of Barbados," pp. 551, 569; and (as coal) in Proc. Sci. Assoc. Trinidad, 1877, p. 110 (see Guppy on Coal, etc., Proc. Vict. Inst. Trinidad, p. 507).

masses or patches. The Foraminifera are all of species found in the oceanic beds. This might indicate that the deposits were laid down on the ocean border, occupying a position intermediate between the truly oceanic deposits and the shore. The fossils frequently show signs of decay and wear—this is particularly noticeable in the case of *Pulvinulina pauperata*. A very noticeable difference is that the material of the oceanic beds when washed yield a residue consisting almost entirely of Foraminifera (chiefly *Globigerina*), while that of the Marbela deposit consists mostly of small pieces of slaty-looking and ferruginous materials, the foraminiferal fauna being much scantier than that of the oceanic beds, and it shows no relation either to that of the Pointapier beds or to that of Sangregrande.

As the Marbela Mine is in the Nariva Series (see my paper in Geol. Mag., 1900), this series is possibly newer than the oceanic beds, and was formed during the upheaval of the latter, being partly composed of material derived from the oceanic beds. I admit that this opinion is chiefly conjectural—it is in opposition to that of Messrs. Harrison and Jukes-Browne. The conditions generally of the Marbela deposit would suit a depth of water of 100 fathoms or less, and thus it would appear that the Manjak was deposited or formed on a bottom of that depth. It is easy to conceive that the heavy tropical timber brought down by the rivers might sink to that depth. Moreover, such timber is susceptible of being borne along by currents in the same manner as clastic material generally, and hence we find it in the same region as finely-grained arenaceous and argillaceous deposits derived from the degradation of the continent. This explanation further admits of application to the case of Barbados.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom.

The Cretaceous Rocks of Britain. Vol. III: The Upper Chalk of England. By A. J. Jukes-Browne, with contributions by William Hill. 8vo; pp. x, 566, plate, illustrations. (London, 1904. Price 10*s.*)

The Geological Survey are to be congratulated on completing their Official Report on the Cretaceous Rocks of England, for with the publication of this third and last volume the results of many years' work have been given to the public. It is to be regretted that an account of the Irish and Scottish Cretaceous rocks was not included. This volume deals with the White Chalk alone, and of the White Chalk the upper portion only. The beds dealt with are defined by the authors as 'Upper' Chalk, and consist of the following zones:—Zone of *Holaster planus*, of *Micraster cor-testudinarium*, of *Micraster cor-anguinum*, of *Marsupites testudinarius*, of *Actinocamax quadratus*, of *Belemnitella mucronata*, and of *Ostrea lunata*. Since the description of the Chalk Rock by W. Whitaker in 1859, the 'Upper' Chalk of the Survey has generally been defined as all that part of the Chalk which overlies that rock wherever it can be identified. Mr. Whitaker's Chalk Rock, which possesses a typical structure and is characterised by a peculiar fauna, occurs towards the upper part of the *Holaster planus* zone, but in this memoir the whole of this zone is included in the 'Upper' Chalk. Other hard beds, similar in lithological aspect to the Chalk Rock but devoid of the peculiar fauna, occur, especially in the zone of *Terebratulina gracilis* of the Dorset coast. Precise limits to the various zones have been defined in the series of papers recently published by Dr. Rowe, by means of the distribution of the fauna; and generous recognition of the work of that author and his colleague, Mr. Sherborn, has been accorded by the authors themselves, as well as by the Director, Mr. Teall, in his prefatory remarks.

We need therefore merely remark on the new zone of *Ostrea lunata,* which is founded on the admirable paper published by Mr. Brydone, and on the unpublished researches of Mr. Clement Reid, on the Trimingham area in Norfolk. This small but interesting area consists of beds of Chalk, lying upon the strata of the *mucronata*-zone, and characterised by a fauna comparable in many respects with that of the Chalk of Rügen and Maestricht. The occurrence of a small oyster in great profusion has led to the adoption of *Ostrea lunata* as the distinguishing name for the zone. Personal observation, however, would have shown that the oysters occur only in one of the beds.

After defining the various zones the authors discuss the typical fossils, special attention being called to the forms of the genus *Micraster,* whose value, first pointed out by Mr. C. J. A. Meÿer, was fully worked out by Dr. Rowe. Condensed diagnoses of these forms and rough sketches of the ambulacral areas and of the labral plates are supplied.

Chapters iii to xx deal with the description of the beds proper, and contain a vast amount of valuable material concerning the various exposures from Devon to Yorkshire, especially with regard to the inland areas, not yet subjected in many cases to critical zonal division by means of their fossils. It is unfortunate that Dr. Rowe's paper on the Yorkshire coast was not published in time for quotation, the Yorkshire chapter being the poorest in the volume.

A sketch of the "Upper Chalk in France" occupies chapter xxi, and allows of easy comparison with the corresponding beds in England. Some interesting remarks communicated to the authors by M. Grossouvre, who has zoned the Chalk of France with reference to the Cephalopod fauna, are quoted. M. Grossouvre writes: "The classification established by the evolution of the Ammonite-faunas represents, in my opinion, the ideal theoretical classification or standard for comparative purposes, to which all regional classifications should be referred for the purpose of correlating and synchronising the strata of different countries. . . . . On the other hand, for the practical purpose of establishing the stratigraphy of the Cretaceous series of any given country, we shall be obliged to found it upon the study of the special fauna which the beds contain. Thus, where Micrasters and Echinocorys are the predominant fossils, we must base our zones on the succession of different species of these Echinoderms; elsewhere the Hippurites or other shells may furnish the requisite data. But when the various local or regional classifications have been thus established, and we wish to compare them with one another, then they can be referred to the standard stratigraphical scale which I propose to establish by means of the succession of Ammonite-faunas."

Mr. Hill continues his series of observations on the microscopic structure and components of the Upper Chalk in chapters xxii and xxiii, the lists of Foraminifera being supplied by Frederick Chapman. Mr. Hill finds the microscopic structure of the typical Chalk Rock from Dorset and Wiltshire so characteristic that it is hardly possible to mistake it for chalk from any other horizon. A slice cut from the rocky chalk at the base of the *H. planus*-zone at Pinhay shows all the characteristics of Chalk Rock; and where the Chalk Rock is absent, as in Kent, Surrey, and Sussex, and the zone of *H. planus* consists of rough, lumpy, and nodular chalk, the nodules near the base of the zone present a similar structure to that of the Chalk Rock. On the other hand, the Chalk in which *Holaster planus* has been found in Norfolk, Lincolnshire, and South Yorkshire, differs entirely in structure both from the Chalk Rock and from the nodular chalk of this zone.

The authors find from an examination of the bathymetrical conditions prevailing during the formation of the Upper Chalk that there is distinct evidence of a shallowing of the chalk sea, during the deposition of the *Holaster planus*-zone, succeeded by a gradual deepening which culminated possibly during the deposition of the *Marsupite*-zone, again to be succeeded by a progressive shallowing up to the final passage of the Chalk into the Tertiaries. While not presuming to affix a definite limit to the depth of the sea during *Marsupite* times, the diagram accompanying the Report suggests 700 fathoms as the probable extent of the depression. Dr. Smith Woodward's researches among the fishes of the Chalk have shown that "the majority of the deep-sea fishes of the Cretaceous period are more or less closely related to the Scopeloids and Berycoids, which still form so conspicuous an element in the abyssal fauna." They possess luminous organs.

We are glad to notice that chapter xxv is devoted to "Economic Products of the Chalk," a subject omitted in vol. ii. The officers of the Geological Survey have exceptional opportunities for amassing this kind of information, which is not only of importance to the public but tends to the completeness of their work. We looked in vain in vol. ii for a sketch of the important industry in Portland cement, which occupies so large a business feature in the Medway area, and it is but briefly mentioned in vol. iii.

The "Physical Features of Chalk Districts" forms an interesting chapter, and the "Water Supply from the Chalk," even in so condensed a form, is of great general importance. In this latter chapter the views of Dr. J. C. Thresh on the "Saline Constituents of Chalk Waters" receive especial attention and criticism. Appendix I contains critical remarks on some species of fossils by Messrs. E. T. Newton and A. J. Jukes-Browne, and a list of fossils from the Chalk of England, compiled from various authors. We do not propose to say anything about these lists beyond asking on whose authority *Uintacrinus westfalicus*, Schlueter, is quoted on pp. 8 and 503. Dr. Rowe in his careful papers has nowhere attached a specific name to this Crinoid, nor has Dr. Bather, in whose hands the bulk of the material has been for years, done so. The matter is still *sub judice*, and those who, without special knowledge and without seeing the material, have definitely identified the English specimens with the form from Westphalia, have incurred the grave responsibility of introducing into our lists yet another name at present meaningless and confusing.

The volume concludes with a Bibliography, in which we are glad to see an old friend, the Rev. J. Townsend, who wrote on Wiltshire in 1813, and who is the special subject of a note as to the interest of his book on p. 193.

This memoir on the Cretaceous rocks of Britain, projected in two volumes, has been concluded in three, and will form a companion to Mr. H. B. Woodward's memoir on the Jurassic rocks. Of the indefatigable energy and trouble taken by the authors we have had abundant evidence, and of the selfless co-operation of their colleagues, still more. We congratulate Mr. Jukes-Browne and Mr. Hill on the completion of their labours, which cannot fail to tend to that progress which is ever continuous in geology.

II.—A Text-book of Geology: intended as an Introduction to the Study of the Rocks and their Contents. By W. Jerome Harrison, F.G.S. 8vo; pp. vii, 350. Fifth edition. (London: Blackie & Son, 1903.)

We welcome the fifth edition of this handy guide to geology, not simply because it is the work of a painstaking and enthusiastic worker, but because it is a thoroughly reliable introduction to the science. Although the greater part of the work remains as in the last edition (noticed in the Geol. Mag. for 1897, p. 329), revisions of names of fossils and other revisions or additions have been made here and there. In the Appendix there is added a Table showing the range in time of the principal genera of fossil invertebrates. The examination papers in geology comprise some of the later questions set by the Board of Education. The work is one eminently suited to the requirements of those working for examination, though we believe that the halcyon days for students and teachers, for examiners and assistant examiners, under the Board of Education are over!

There are a few slips which might be avoided in a subsequent edition.

P. 15. The Thames does not discharge into the English Channel, but into the North Sea.

P. 274, fig. 2. *Nucleolites dimidiatus*, Phil., a well-known Corallian species, is enumerated amongst the fossils characteristic of the Chalk.

P. 264. Waterhouse-Hawkins' incorrect restoration of *Megalosaurus* might with advantage be replaced by Marsh's figure of *Ceratosaurus*, which was most probably identical with our Jurassic Dinosaur, and was no doubt (judging by its skeleton) *bipedal*, having *very small fore-limbs*, only of use in seizing its prey (see Geol. Mag., 1896, p. 392, Fig. 3).

REPORTS AND PROCEEDINGS.

Geological Society of London.

April 13th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read :—

1. "The Discovery of Human Remains under the Stalagmite Floor of Gough's Cavern, near Cheddar." By Henry Nathaniel Davies, Esq., F.G.S.

Gough's Cavern opens at the base of the cliffs on the south side of Cheddar Gorge. Various human and animal remains have been discovered at different times in the clearing out of parts of the main cavern. The principal deposits are a stalagmite-like travertine overlying cave-earth, and the latter at one place encloses a tabular limestone block surrounded with flint chips. During draining operations it was necessary to excavate part of a fissure running northwards out of the vestibule of the cavern, when a human skeleton was found, associated with flakes, scrapers, and borers of flint, embedded in cave-earth, which overlay a lower bed of stalagmite and was overlain by a second bed five inches thick. The skeleton was nearer the top than the bottom of the deposit, and the remains excavated comprise the skull, the bones of an arm, a leg, and part of the pelvic girdle. The other bones were allowed to remain *in sitû* and may now be seen. The position of the skeleton was that which would have been assumed by a drowned man. Interment is out of the question because of the narrow and ship-shape of the fissure, which was choked up with undisturbed débris and calcareous deposits. The stature of the man was 5 feet 5 inches; he was of muscular build, with prognathous jaws, a straight thigh, and a thick dolichocephalic skull. The animal remains found in the cave-earth of other parts of the Cavern, and held by the author to be contemporaneous with that in the fissure, are those of mid and late Pleistocene age; and this evidence, together with that from the position of the skeleton, the shape of the cranium, and the form and workmanship of the flakes, points to a period towards the close of the Palæolithic or the opening of the Neolithic age.

2. "History of Volcanic Action in the Phlegræan Fields." By Professor Giuseppe De Lorenzo, of the Royal University of Naples. (Communicated by Sir Archibald Geikie, Sc.D., Sec.R.S., V.P.G.S.)

In an introductory section the author sketches the general geological structure of the district around Naples, and shows the disposition of the chief lines of fracture by which the Triassic, Cretaceous, and older Tertiary formations were traversed previous to the commencement of volcanic activity in this part of Italy. He recognizes three chief periods in the volcanic history of the district.

I. The eruptions of the first series took place under the sea during the Pleistocene period. Their surviving products can be grouped in two distinct divisions, each recording a different eruptive phase. The older of these (*a*) is represented by the piperno and grey pipernoid tuffs of the Campania, which extend under the broad plain into the valleys of the Apennines. These deposits consist of grey trachytic tuff, with scattered black scoriæ, and with a varying proportion of non-volcanic sediment washed down from the hills. The vents whence they were ejected are now no longer to be traced, as they have been obliterated or covered up by later accumulations. The piperno, well developed at the foot of the hill of Camaldoli, has given rise to some difference of opinion as to its nature and origin. The author is disposed to regard it as a trachytic lava with schlieren, the dark lenticles being made up of such minerals as augite, ægerine, and magnetite, while the lighter matrix is felspathic (anorthose) with a spherulitic structure and microlites of ægerine and augite.

The second phase (*b*) of the first eruptive period is represented by ashes, lapilli, pumice, and sands, intercalated with marine shell-bearing clays and marls, and also with conglomerates and breccias, these coarser kinds of detritus overlying them and varying in thickness according to their proximity to or distance from the vents whence the materials were ejected. The accumulations of this epoch were pierced through in the artesian boring at the Royal Gardens, Naples, where they were 330 feet thick.

II. Above the records of the first volcanic period lie those of the second—the yellow tuff, which forms the most wide-spread and most characteristic of all the volcanic formations of the Phlegræan Fields. It is a yellow or cream-coloured, compact, well-stratified aggregate of trachytic detritus, through which are scattered fragments of tuff and lava. Its average thickness exceeds 300 feet. That it was a submarine accumulation is shown by the occurrence in it of oysters, pectens, and other organisms. Owing to the general uniformity of its lithological characters, the yellow tuff has not furnished any satisfactory evidence of a definite order of succession in the eruptions to which it was due. In spite of prolonged denudation and of successive later volcanic vicissitudes, it is still possible to recognize some of the separate vents from which the tuff was discharged, such as the islet of Nisida, the hills of Posillipo, Vomero, Capodimonte, and Camaldoli and Gauro.

III. After the discharge of the yellow tuff from numerous cones and craters scattered over the sea-floor where the Campi Phlegræi now extend, the volcanic tract appears to have been upraised into land, and to have been thereafter exposed to a prolonged period of subaerial denudation. But the volcanic activity was not extinct, for a number of vents made their appearance and discharged a succession of fragmental materials, which differ from the yellow tuff in showing both macroscopically and microscopically a greater variety of composition, and in the proofs which they furnish of a succession of eruptions both in space and time and a gradual southward shifting and diminution of the vigour of the eruptive energy. The largest and most ancient of the volcanoes of this latest period is that of Agnano, the crater of which is built up of layers of pumice, ashes, lapilli, soft grey tuff, and beds of scoriæ. Not improbably it was from this eruptive centre that the trachy-andesitic lava of Caprara issued. Other volcanoes of the same series are Astroni, Solfatara, the two small vents of Cigliano and Campana behind the northwestern slopes of Astroni, the last-named example showing three concentric rings, within the innermost of which a beautifully perfect little crater marks the last efforts of this vent. The crater-lake of Avernus belongs likewise to the latest group, and perhaps it was the water percolating from this basin to the thermal springs of Tripergole which, in September, 1538, gave rise to the explosion that built up Monte Nuovo, the youngest of the cones of the Phlegræan Fields.

CORRESPONDENCE.

THE BASE OF THE KEUPER IN SOUTH DEVON.

Sir,—In replying to Dr. Irving's article in your April number, I must preface the same by regretting my use of the term "dolomitic" which somehow crept in; but which, I think, hardly amounts to a "caricature" of his description. I would further add that I never doubted the existence of the fault at the Chit rock.

On the main issue I still hold that the Otterton Breccias are not again brought up on the east side of the river Sid; and that the beds here described as such, occupy a much higher horizon, being separated from the former by a considerable thickness of red sandstones. On this point, however, I am willing to wait—with an open mind—the results of other observers who may choose to devote their attention to this matter. Alex. Somervail.

Torquay N.H. Society.
16*th April*, 1904.

MARINE FOSSILS IN UPPER COAL-MEASURES.

Sir, — On the 23rd April I found in the Craigmark Burn, Dalmellington, Ayrshire, some marine shells in the Upper Coal-measures. They occur in a cliff on the right bank of the stream, about half a mile up from the village of Craigmark. The cliff is about 30 feet high, its upper part composed of dark shale, and its lower part of lighter-coloured shale with nodules and bands of 'curly' ironstone. About the middle of the cliff there is a 9 inch band of bituminous shale with fish-remains, and in the centre of it the marine band occurs.

The fossils are dwarfed and starved-looking, but from their perfect preservation they have evidently lived on the spot where now found, and occur with a few indistinguishable plant-remains. The following are the species I collected:—*Productus semireticulatus*, var., largest one ½ inch, but generally much smaller; common. *Athyris ambigua*, largest ⅜ inch; scarce. *Lingula mytiloides*, rare, and very small. The late R. W. Skipsey many years ago found marine shells in the Coal-measures near Coatbridge, but the specimens were of fair size.[1]

The marine shells I obtained on the 23rd April appear to be pretty high up in the coal strata; and in the stream and on the side of the glen may be seen the Gillyhole Coal, at this part converted into columnar carbonite four feet thick by a small Trap sill; it is one of the finest examples of a 'burnt coal' bed in the west of Scotland. In the same glen there is also a small sill which has assumed a spheroidal structure. I saw no specimens of *Carbonicola* or any other Coal-measure shells in the marine band. I am sending some specimens to the British Museum.

MONKRIDDING, KILWINNING. J. SMITH.
25th April, 1904.

OBITUARY.

PROFESSOR CHARLES EMERSON BEECHER, PH.D.

BORN OCTOBER 9, 1856. DIED FEBRUARY 14, 1904.

(WITH A PORTRAIT: PLATE X.[2])

BY the death of Professor Beecher, American palæontology and geology have sustained a great loss, and one which is also sincerely felt by many friends and fellow-workers in England and on the Continent. Although only 47 years of age, he had attained to a high degree of eminence in his University as a teacher and lecturer, whilst his published researches, especially on Trilobites, the Merostomata, and Phyllocarida, entitled him to the first rank as an original investigator in palæozoology; nor had he neglected the higher forms of extinct life, as is shown by his reconstruction of Dinosaurs in the Peabody Museum at Yale.

Charles Emerson Beecher was born at Dunkirk, New York, Oct. 9th, 1856. He was educated in the High School at Warren, Pa., and graduated at the University of Michigan, taking his B.S. in 1878. During the ten succeeding years he was engaged as an assistant to the veteran geologist, Professor James Hall, upon the staff of the Geological Survey of the State of New York, and many specimens now exhibited in the State Museum at Albany testify to his ability as a collector and his skill in developing and mounting invertebrate fossils.

Professor Beecher was appointed in 1888 to the charge of the invertebrate fossils in the Peabody Museum, under the late Professor

[1] Trans. Geol. Soc. Glasgow, vol. ii, p. 52.

[2] For permission to reproduce Professor Beecher's portrait we are much indebted to Mr. J. McK. Cattell, of *The Popular Science Monthly* Garrison on Hudson, New York, U.S.A.—EDIT. GEOL. MAG.

CHARLES EMERSON BEECHER, Ph.D.,

Yale University.

O. C. Marsh, and in 1889 he received the degree of Ph.D. from Yale University for his memoir on the Brachiospongidæ, a remarkable group of Silurian sponges. In the July of this year he made his first geological trip to the far West, being sent by Professor Marsh to join a party of collectors in Converse County, Wyoming, where he remained till September. During this trip he obtained one of the largest complete skulls of *Triceratops*, now in the Yale Museum. Shortly after this Professor Marsh arranged for Dr. Beecher to visit England and make studies in the British Museum, accompanied by the late Dr. Baur. [Here he made the writer's acquaintance, and became an intimate friend and correspondent respecting their mutual studies upon the Arthropoda.—H. W.] He also, with Dr. Baur, visited France and Germany. During the preparation for his degree at Yale, Beecher had taken geology under the late Professor Dana, and in 1891–92, when the latter was ill, Professor Beecher conducted the classes in geology for him. In 1892 he was made Assistant-Professor of Historical Geology in the Scientific School, holding the post till 1897, when he was appointed Professor of Historical Geology and a member of the Governing Board in the Sheffield Scientific School. On March 10th, 1902, he was made University Professor of Palæontology at Yale.

Professor Charles Schuchert writes:—"In 1893 there was discovered in Lower Silurian shales near Rome, New York, a thin band not more than one-fourth of an inch thick, in which nearly all the Trilobites (*Triarthrus* and *Trinucleus*) preserve antennæ and legs. Trilobite legs had been known before in a few isolated and very imperfectly preserved specimens, and from a series of about 250 sections cut from more than 3,000 enrolled individuals of a species found near Trenton Falls. Antennæ had not previously been seen. This important discovery by a local worker induced Professor Beecher to take out several tons of the shale, and later many hundred individuals were developed by mechanical means to show the ventral anatomy. But few can appreciate the great amount of time and the remarkable skill required to free these Trilobites from the adhering black shale, and to Beecher we owe our detailed knowledge of the ventral anatomy of *Triarthrus* and *Trinucleus*. He published thirteen papers on these very primitive Crustacea, including a classification in which all Trilobites are arranged in three orders." [Special mention should also be made of his enlarged models of the appendages of *Triarthrus*, and of the great *Stylonurus Lacoanus*, which are most valuable and instructive for Museums.—H. W.] "He was at work on an extensive treatise on these forms, in which he proposed to bring together all that is known regarding their anatomy. Unfortunately, this work had not progressed beyond the mechanical stage of preparation of material and the making of drawings."

In 1899 Professor Beecher succeeded the late Professor O. C. Marsh as curator of the entire geological collections in the Peabody Museum at Yale, and became a member of the Board of Trustees of that Museum. He also held the position of Secretary to the Board, and was a member of the Executive Committee. He was elected a member of the National Academy of Sciences, a Foreign Correspondent of the Geological Society of London, and a Fellow of the Geological Society of America. In 1900 he was elected President of the Connecticut Academy of Arts and Sciences, and filled the office for two years.

"In 1899 he presented his entire collection of fossils, containing upwards of 100,000 specimens, to Yale Museum. The gift was without conditions, and was given 'in grateful recognition of the honours and favours conferred upon me during my connection with the University.'

"Although Professor Beecher was interested in stratigraphic and descriptive palæontology, he published almost nothing in either branch of the science. Of stratigraphic and faunal papers he has five. Of new species apparently not more than thirty-one were described by him. Besides these he proposed seven new genera and seven new orders.

"His most philosophic paper, and the one which he himself thought best, is entitled 'The Origin and Significance of Spines. A study in evolution.' He states here that all spinose species when young are devoid of spines, and are derived from non-spinose ancestors. Forms attaining the limit of spine differentiation leave no descendants, and out of spinose types no new types are developed.

"Charles E. Beecher's scientific writings amount to about sixty-five in number. His standing among biologists and palæontologists was high, and he was the leader among the students of Brachiopoda and Trilobita. His palæontological work at Yale was essentially of a biological and philosophical character. As a preparator of fossils he had no equal, and as a collector was one of the best. He had the artistic temperament, and made most of the illustrations for his publications. He was a slow and very careful worker. Those who knew him well saw in him an enthusiast, but his exuberance was always held in check by his judicial qualities, which character made him also an excellent counsellor. He travelled extensively, read wisely, was a lover of the English masters and of Herbert Spencer's philosophy. He was orderly in his work, and, as he had the 'museum instinct' well developed, he made one of the best of museum curators."—*Professor Charles Schuchert.*

His past students bear the highest testimony to his worth as a teacher in science, both as a lecturer and as a demonstrator in the laboratory. As a friend, all who knew him appreciated his many excellent qualities and his sterling worth.

[Kindly favoured by Miss Lucy P. Bush from the *Yale Alumni Weekly*, New Haven, Conn., March 2nd, 1904.]

SIR CLEMENT LE NEVE FOSTER, D.Sc., F.R.S.

Born March 23, 1841. Died April 19, 1904.

In the death of Sir Clement Foster we mourn the loss of a geologist the most distinguished in this country for his scientific and practical knowledge of metalliferous mining, and of all matters relating to stone quarries and slate-mines.

The second son of Peter Le Neve Foster (for many years Secretary of the Society of Arts), he was born at Camberwell, and received his early education at Boulogne and Amiens. He then studied successively at the Royal School of Mines and at the Mining College of Freiberg, in Saxony, and eventually took the degree of Doctor of Science at the University of London.

In 1860 he was appointed an Assistant Geologist on the Geological Survey, working for a few years in the Wealden area and among the Carboniferous rocks of Derbyshire. Conjointly with his colleague William Topley, the now classic paper "On the Superficial Deposits of the Valley of the Medway, with remarks on the Denudation of the Weald," was read before the Geological Society in 1865. The authors sought to prove that old gravel of the Medway occurs 300 feet above the present level of the river, and that, granting this to be the case, there was no difficulty in admitting that the present features of the Wealden area were sculptured by rain and rivers. Later on Foster was part author of the Memoir on the Geology of North Derbyshire (Geol. Survey, 1869). He retired from the Geological Survey in 1865, not without much personal regret at leaving the congenial and active field-work of that institution; he retired simply because the prospects of earning a reasonable income were too remote. He now devoted his attention especially to mineralogy and mining—lecturing on these subjects in Cornwall, and examining several important mineral districts in different parts of the world. He brought before the Geological Society notes on Celestine in Egypt (with H. Bauerman), and an account of the Caratal goldfield in Venezuela. In 1872 he was appointed an Inspector of Mines under the Home Office, and served for about eight years in the south-west of England. The results of his observations on mines in Cornwall and Devon were brought before the Geological Society and before local Societies in Cornwall. In 1880 he was given charge of the North Wales district, and resided at Llandudno until his retirement from the Home Office in 1901. Meanwhile, on the death of Sir Warington Smyth, Foster was appointed in 1890 to the professorship of mining at the Royal College of Science, a post which he held until the time of his death. The work of his later years is largely embodied in the Reports on Mines and Quarries issued annually by the Home Office. He was author also of an important treatise on "Ore and Stone Mining," of which five editions have been issued, and only last year he published an excellent handbook on "The Elements of Mining and Quarrying."

His wide knowledge and the charm of his personal character made him known and beloved by a large circle of friends, while his services on committees and as a juror were in frequent request. His last important function was as a member of the present Royal Commission on Coal supplies. He was elected a Fellow of the Royal Society in 1893, and last year the honour of knighthood was conferred upon him.

MISCELLANEOUS.

Mr. W. W. Fisher, in a paper "On the Salinity of Waters from the Oolites" (*Analyst,* Feb., 1904), remarks that the study of these waters leads to the general conclusion that the uncovered beds of limestone yield calcareous waters of a hard character, while the deep beds, and especially the beds covered by clay, yield saline or alkaline supplies. In his opinion the alkalies are normal constituents of the strata from which the waters are obtained. The chemical argument appears absolutely destructive of the hypothesis that the constituents are derived from the infiltration of sea-water. The alkaline carbonates probably owe their origin to the decay of organic matter originally deposited in and with the rock material, part of which still remains, and from which the products of decomposition have not been removed by the circulation of underground waters. It is precisely in situations where there is little or no movement possible that saline waters are met with.

"Notes on Mining in Ireland" are contributed by Mr. G. H. Kinahan (Trans. Inst. Mining Engineers, 1904). He sums up what is known of the iron, silver, copper, and tin ores, of gold, and also of salt, steatite, fuller's earth, pyrophyllite, and molybdenite.

Mr. D. A. MacAlister, in dealing with "A Cross-Section and some notes on the Tin and Copper Deposits of Camborne" (Trans. Roy. Geol. Soc. Cornwall, vol. xii), remarks that while all the lodes produce both tin and copper ores, those in the killas yield mainly copper, and those in the granite mainly tin. In the Camborne areas the lodes are ore-bearing fissures in the vicinity of elvan dykes, and they must be regarded as having been a later product of the same magma as that which gave rise to the elvans. The lodes indeed appear to be influenced in the direction of their underlie by the elvans, and like them they appear to converge in depth. The richest tin zone in a series of ore fissures bears a fairly definite position with regard to the surface of the granite, being more or less parallel to it, and bending with it. The lodes are not uniformly productive to the deepest points reached by mining. Generally speaking, the conditions assisting the deposition of cassiterite from its solutions were more favourable near the periphery of the granite than those nearer their source, and solutions reaching the cooler regions near the contact deposited the whole of that cassiterite which they had managed to retain in the upward journey. The author deals with the secondary enrichment of lodes that may accompany denudation of the area, and this appears to especially affect the copper ores. In conclusion he is hopeful that with modern engineering methods there will be a revival in Cornish mining.

Mr. T. V. Holmes calls attention to "Some Greywethers at Grays Thurrock, Essex" (*Essex Naturalist,* vol. xiii). They were met with in the old Thames Valley drift, and were probably derived from the Woolwich and Reading Beds.

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JULY, 1904.

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A Supplement of 46 pages is presented with this Number of the Magazine.

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NEW SERIES. DECADE V. VOL. I.

No. VII.—JULY, 1904.

ORIGINAL ARTICLES.

I.—On the Discovery of Silurian Fossils of Ludlow Age in Cornwall.

By Upfield Green, F.G.S.

THIS is merely a brief note to record the discovery of fossils of undoubted Silurian age in the "Black Slates with limestone lenticles" which occur on the shore and in the cliff at Fletching's Cove, near Porthalla, and at Porthluney, near Gorran, in Cornwall.

For many years the most careful search in these beds for fossils has been unsuccessful beyond minute ossicles of crinoids and indeterminable fragments of Orthocerata. I have spent many weeks each year hunting for fossils, often alone, but sometimes in the company of Dr. Barrois, Mr. Teall, Messrs. Vassell, Sherborn, Howard Fox, and others, and beyond finding the well-known Brachiopoda in the quartzites of Gorran and Carne, our search has seemed almost in vain. Some four years ago, however, Mr. Sherborn found in the Black Slates of Fletching's Cove an impression, which he identified as a fragment of *Serpulites longissimus*, J. de C. Sow., of Ludlow age. This fragment is now in the Museum of Practical Geology. This Spring, in company with Messrs. E. Dixon, of the Geological Survey, and Mr. G. T. Prior, of the British Museum, I paid my usual visit to Cornwall, and was rewarded by finding at Porthluney in these Black Slates a limestone lenticle which contained Orthocerata in quantity. It was only on the 6th June that I showed this to Mr. Sherborn, who at once took it to Mr. G. C. Crick, who recognised two of the fossils therein contained as comparable with *Actinoceras baccatum*, H. Woodw., and *Barrandeoceras holtianum* (Blake), together with other fragments also of Upper Silurian age. These two Cephalopods taken together with the *Serpulites* stamp the rock as of uppermost Silurian, probably Ludlow age. The specimen is in the British Museum (Nat. Hist.).

I think I may now venture to state that we have at last succeeded in establishing a definite fact in the geology of this part of Cornwall, thus fixing a base-line for the rocks intervening between it and the

Taunusian beds of Looe and Fowey. These rocks I propose to correlate with the Gedinnian of the Continent in a subsequent paper.

I may mention that at Looe I have at last found the most characteristic fossil of the Taunusian series, *Onychia* (*Kochia*) *capuliformis,* Sandberger, as well as *Spirifer mercurii* (Gosselet).

II.—An Eocene Outcrop in Central Africa.

By Captain P. S. Lelean, R.A.M.C., F.R.C.S. Eng.

(With a Map in the text.)

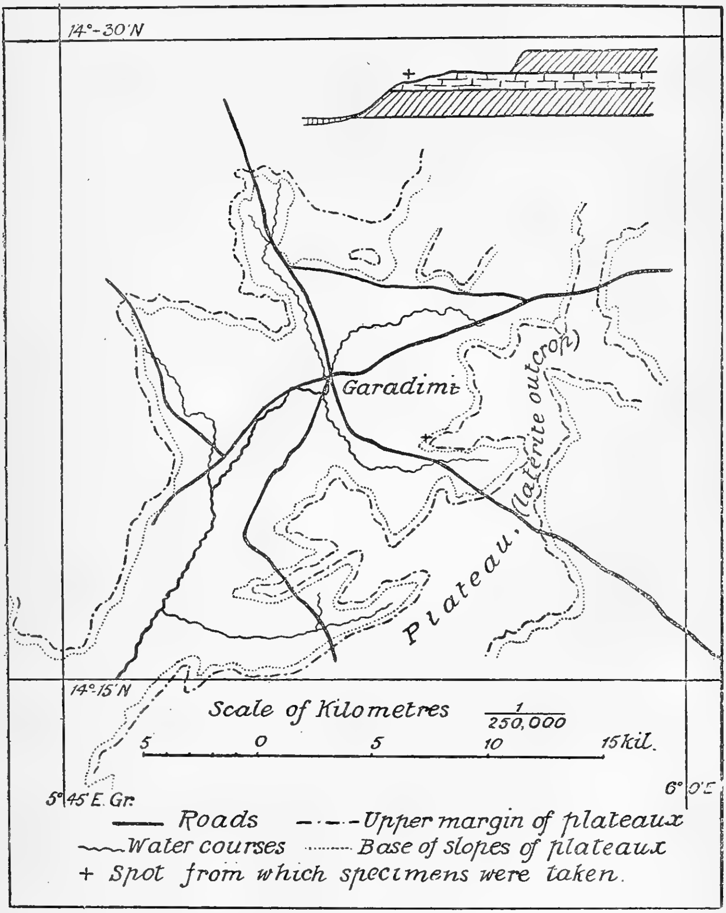
AT the heart of Africa lies a vast area, so remote, so inaccessible, and hence so little known, that for the explorer it possesses a fascination all its own. The interests of the geologist have perhaps received less recognition than those of his fellow-scientists from the pen of the traveller; and there must be much that he would wish to know lying hidden in these distant regions awaiting discovery and publication. There is thus an encouragement to make known any facts which may throw light upon the geological structure of those parts, however small the contribution may be.

While serving recently with the Anglo-French Boundary Commission (Niger–Chad) we found an outcrop of a fossil-bearing stratum in the region of the Sokoto, having, as shown in the accompanying map, giving its latitude and longitude, a position near the verge of the Great Sahara Desert. On my return, the specimens secured were submitted to the palæontologists of the British Museum, one of whom, Dr. F. A. Bather, has kindly drawn up the description which follows in a separate paper. For me it only remains to give a few particulars of the general and localized formation to supplement his account.

Generally, the country consists of sandy plains, roughly estimated as lying some 500 or 600 feet above sea-level. These plains are traversed by watercourses, which contain running water only for some five or six weeks in the year, the rainfall of 535 mm. lasting during three months. A permanent water-supply is obtained by deep wells, which in some places reach a depth of 400 feet before tapping a constant source.

From the plains rise hills in isolated masses or in chains, with abrupt slopes, often almost precipitous, and with summits ending at from 300 to 400 feet in plateaux of remarkably uniform height, unbroken by further elevations. These hills consist mainly of laterite, marl, and limestone, but in places are found outcrops of syenitic granite; among minerals are some calcite, a little quartz, and considerable quantities of mica.

The accompanying map, kindly furnished by Capt. C. St. Foulkes, R.E., shows to the east of Garadimi a plateau with the characters described. Its steep sides are covered by boulders and detached rocks of all sizes, and the formation is of laterite throughout. From this plateau a long promontory reaches out towards Garadimi, falling abruptly for some distance to merge into a spur composed entirely of fossil-bearing limestone, whence at the spot marked + were obtained remains of Mollusca, Echinoidea, and Foraminifera, which, according to the determinations by Dr. Bather and Mr. R. Bullen Newton, suggest a Middle Eocene age for the rock. This spur was evidently more resistant than the promontory; it was less than 200 feet thick, and between it and the general plain level below lay



another stratum of laterite, while the limestone itself was markedly stratified. Similar discoveries of fossils ascribed to the Middle Eocene period have been made by the French at Zinder, some 300 miles to the east of Garadimi, and have been commented on by Professor A. de Lapparent.

III.—Eocene Echinoids from Sokoto.

By F. A. Bather, M.A., D.Sc., British Museum (Natural History).

(PLATE XI.)

It is fortunate that Captain Lelean not merely discovered these fossils at Garadimi in Sokoto, but that he had enough sense of their importance to spend some time and trouble in their collection, and that now he has generously presented them to the British Museum. The collection includes four echinoid tests, five natural casts of Mollusca, and a few rock-specimens containing *Operculina* and other Foraminifera. The Mollusca, so far as their state of preservation admits, have been determined by Mr. R. Bullen Newton as: 3 *Lucina* cf. *gigantea* Deshayes, 1 *Voluta* cf. *cithara* Lamarck, and 1 undetermined Gastropod. The Echinoidea were partly covered by an impure limestone closely adherent to the test. The portions not so covered were in many places considerably worn, and the calcite was split by cracks, probably due to alternations of temperature, and rendering it very difficult to follow the course of the sutures. The appearance of these and the other specimens shows clearly that they have been lying on the surface of the ground for some time, and, in fact, Captain Lelean informs me that they were not picked out of the solid rock, but from the talus at the foot of the cliff. The notable variations in the matrix of the different specimens are thus accounted for. None the less it will be seen in the sequel that all the specimens are consistent with the ascription of a Middle Eocene age to the mass of limestone from which they were derived. Of the four echinoids, two have been determined as belonging to the genus *Plesiolampas* and two to the genus *Hemiaster*. In each case there is a larger and better preserved specimen referred to as A, and a smaller one referred to as B.

[The MS. of this paper was sent in on March 14th, 1904. After the proof had been received, Captain Foulkes, R.E., kindly presented to the British Museum a further collection of fossils from this region. It included two more specimens of the *Plesiolampas*, referred to as C and D; and twelve more of the *Hemiaster*, lettered according to their decreasing size from C to O. The accompanying label reads: "In bed of indurated chalk running into grey limestone underlying laterite. Found near road just above Tamaské, where it descends from plateau." These specimens have confirmed the main conclusions already set down, while affording a wider basis for the diagnoses. Beyond this, a few allusions or illustrations are all that it has been possible to introduce at this more than eleventh hour.—June 9th, 1904.]

Plesiolampas Duncan & Sladen, 1882.

Pal. Ind., ser. xiv, vol. i, pt. 3, Foss. Ech. W. Sind, pp. 9, 54, pls. i, xiii–xv (non *Plesiolampas*, Pomel, 1883, "Genera des Ech.," p. 62).

The two specimens agree entirely with the diagnosis of this genus of Cassidulidæ (subfam. Echinolampadinæ) as drawn up in the above-quoted work, and as repeated in P. M. Duncan's "Revision of the Echinoidea" (J. Linn. Soc. Zool., xxiii, p. 193; 1889). They have not the crenulate and perforate tubercles of *Oriolampas* Munier-Chalmas. They differ, however, from the six species which Duncan & Sladen described from the Eocene of Sind, and I am unable to find any other valid species of the genus. Pomel's Cassidulid genus of the same name would, if accepted, belong to the Echinanthinæ. *Conoclypeus rostratus* R. Tate, 1894, was referred by its author to *Plesiolampas* in 1898 (J.R. Soc. N.S. Wales, xxxi, p. 412), but Mr. J. Lambert in the same year showed that it was an *Echinolampas*, and named it *E. Tatei* (Rev. Crit. Paléozool., ii, p. 164). Even if *Palæopneustes conicus* Dames, 1877, could, as Duncan suggested, be referred to *Plesiolampas*, it could not possibly be related to the present species, which I therefore propose to describe as

Plesiolampas Saharæ, n.sp. (Pl. XI, Figs. 1–5.)

Diagnosis.—Outline oblong, rounded in front, slightly rostrate behind; margins tumid; dorsal surface in transverse profile slightly conoid; length 100,[1] width 87–91, height 51–53. Ambulacral areas raised; petals do not reach margin, posterior pair being most remote, their greatest width from 11 to 16, interporiferous area not quite twice width of poriferous; pores conjugate and sloping adactinally. Peristome deeply sunk, transversely elongate, eccentric in front. Periproct at extreme actinal margin. Ornament of tubercles sunk in scrobicules of thrice their diameter, irregularly scattered on dorsal surface, more regularly crowded actinally.

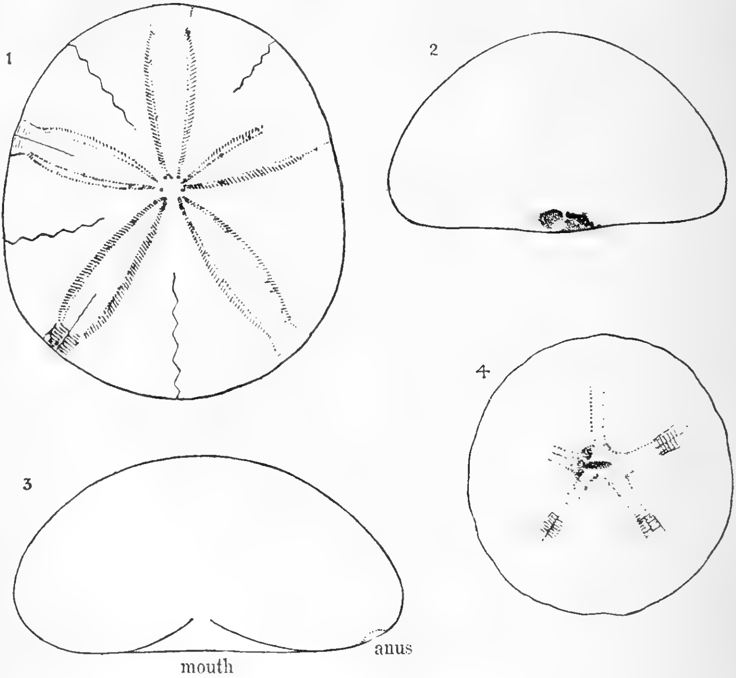
Description of specimen A (B.M. registered E 4824).—Test almost complete, rubbed on left side, fractured in other places. This is the holotype.

General Form.—Ambital outline approaches an oblong, with gentle curve in front, passing into wide curves on the sides, which are further apart posteriorly, then more tapering behind and very slightly truncate. Margin tumid, very slightly rostrate behind. Actinal surface deeply sunk round peristome, to fully 5 mm. below base-plane,[2] otherwise gently convex. Peristome slightly eccentric in front, circa 24 mm. from anterior vertical plane. Height of ambitus above base-plane, circa 10 mm. in front, circa 7 mm. behind. Total length, 52·3 mm. Greatest width, 45·6 mm. at circa 28 mm. from anterior vertical plane. Here also is the vertex, 27 mm. above base-plane. Dorsal surface slightly conoid in transverse profile; in longitudinal profile, slopes down with a sharper and more convex curve anteriorly than posteriorly. (See Text-figures 1–3, p. 294.)

Apical System.—Slightly anterior to vertex, its centre being circa 23 mm. from anterior vertical plane. The 4 gonopores are circular and about equal; posterior pores 1·9 mm. apart, anterior pores 1·25 mm. apart. Oculars and their pores minute and almost indistinguishable. As usual in the genus, the 4 genital plates are fused,

[1] In the diagnoses relative measurements are given in hundredths of the length; in the descriptions the actual measurements are given in millimetres. Here length = 36–60·5 mm. The radii and interradii are numbered on Loven's system.

[2] The base-plane is the flat horizontal surface on which the denuded test assumes stable equilibrium in its natural posture. The anterior vertical plane is at right angles to this and to the sagittal plane, and parallel to the transversal. The height of the vertex or any other part should always be measured from the base-plane.



Plesiolampas Saharæ.

FIG. 1.—Outline and petals of abactinal surface of A.
,, 2.—Outline of A from posterior end.
,, 3.—Outline of A from left side, showing position of peristome as though in section.
,, 4.—Actinal surface of B, roughly indicating peristome and incipient phyllodes.

All figures are natural size.

and all the space within the gonopores is filled with hydropores; the madreporite does not, however, extend backwards between the posterior oculars. (Pl. XI, Fig. 2.)

Ambulacra.—At the ambitus and on the tumid margin of the actinal surface the whole ambulacral area is slightly raised; within the petals the raising is almost confined to the interporiferous area, the poriferous areas being slightly depressed along their outer borders. The petals do not reach the ambitus, the posterior pair being the most remote from it. Angle included by rays II and IV, 135°; by rays I and V, 60°. The petals widen equably to near their ends, then close in slightly; the actual measurements are:—

	III.	II & IV.	I & V.
Length of petal ...	20·7 mm.	20·0–21·6 mm.	24·0–25·0 mm.
Greatest width ...	6·9 mm.	8·0– 7·5 mm.	8·4– 8·0 mm.
Width at distal end	5·0 mm.	4·3 mm.	5·3 mm.

Structure of petals:—In all lateral petals the posterior poriferous area curves more than the anterior (Pl. XI, Figs. 4 and 5). In ray IV, at the widest part of the petal, the width of the interporiferous area is 3·8 mm., while that of the poriferous area is 2·1 mm.; the widths of both diminish slightly towards the apex and more slightly towards their distal ends. The inner pores of an area are almost circular, the outer pores pyriform on the surface but becoming more circular deeper down, as is seen when the surface has been worn. This appearance is connected with the distinct conjugation of the pores. In the interporiferous area the sutures between the ambulacrals are almost at right angles to the perradius, with a tendency to slope adactinally from it. In the poriferous areas the adactinal slope of the suture is conspicuous, the angle contained by the two regions of the suture being 150°. Number of pore-pairs in petals: III, circa 48; II and IV, circa 51; I and V, circa 60. But there are a few slight irregularities: thus, in the anterior poriferous area of ray IV, reckoning from the distal end of the petal, the outer pores are missing from sutures 1, 3, 4, 6, 7, 8, the inner pores remaining normal, except 3 and 4, which are diminished; outer pore 5 is larger than usual (Pl. XI, Fig. 4). Occasional atrophy or suppression of a pore occurs in the other rays.

From the contracted ends of the petals the ambulacra widen again towards the ambitus, and then lessen in width towards the peristome, widening slightly just before they reach it. The series of double pores of the petals changes very rapidly, if not quite abruptly, into a series of minute single pores which appears to continue the inner row of the double pores. It passes over the ambitus on to the actinal surface of the test; as it approaches the peristome the pores increase in size, and at the oral end of the ambulacrum appear to be some half-dozen supplementary pores on each side, forming a rudimentary phyllode. This is more clearly seen in B (Text-fig. 4). but the structure in A seems to have been similar.

Interradials.—In the upper part of the abactinal surface, the sutures between these plates are straight; in the lower part the sutures have a downward bend in the middle. The number of ambulacrals abutting on a single interambulacral is about 7 half-way down a petal, fewer nearer the apex, and more at the distal end. The arrangement of the interradials on the actinal surface cannot be distinguished.

Peristome.—Not fully exposed, but enough matrix has been worked away to show that it is about 1·5 mm. in front of the middle line, transversely elongate, narrow antero-posteriorly, and deeply sunken.

Periproct.—At extreme margin of actinal surface, invisible from above; longitudinally elongate, oval or subpyriform; circa 7·7 × 4·2 mm.

Ornament.—Small primary tubercles, varying slightly in thickness, non-crenulate, imperforate, sunk in a scrobicule of thrice their diameter, to such a depth that their summits are flush with the general surface; irregularly disposed on abactinal surface, both on interambulacral and interporiferous areas, at distances varying from about half the width to twice the width of the scrobicule; more regularly disposed in rows on actinal surface, very slightly wider, and crowded so that the space between them equals about one-third the width of the scrobicule. Miliary granules, crowded and often confluent, fill all spaces between the scrobicules, and tend to form a slightly defined scrobicular circle; they cover the ridges dividing the conjugate podial pores; between periproct and peristome they are larger, and seem here to cover a median tract from which tubercles are almost, if not wholly, absent. (Cf. Pl. XI, Figs. 1 and 3.)

Specimen B (B.M. regd. E 4825).—Much smaller than A, but of the same general shape: length 36·8 mm., width 35 mm., height 17·5 mm. The length and height, however, have been much reduced by erosion of the test, which has also caused the excavation around the peristome to appear relatively less than in A, while the periproct can scarcely be distinguished.

[Specimens C & D (B.M. regd. E 4833 and E 4834).—From Tamaské. C, which is fairly well preserved, has length 60·5 mm., width 55 mm., height 32 mm. This indicates a slight increase in relative width and height with age. Otherwise C agrees closely with A. Its measurements are taken into account in the diagnosis. D is a mere fragment, but shows the ornament so much more clearly than the other specimens that it has been selected for figuring (Pl. XI, Figs. 1, 3). On the actinal surface, the tubercles are in places more crowded than shown in the figure.]

Relations to other species.—Generally speaking, *Plesiolampas Saharæ* is stouter, wider, more tumid at the margin, and more loftily domed than any of the Indian species described by Duncan & Sladen. Thus, *P. elongata* is much narrower and flatter; *P. prælonga* is much more elongate, more rostrate, and has narrower poriferous areas in the petals; *P. ovalis* is also more rostrate, and has relatively shorter and narrower petals; in *P. rostrata*, which has wide petals, scarcely convergent distally, the periproct is more elongate and removed from the margin, while the low test slopes gently from the vertex to the margin and has a slight posterior ridge; the outline of *P. polygonalis*, though somewhat reminiscent of *P. Saharæ*, is nearer a pentagon, and is wider in front instead of behind, the low upper surface is gently domed, the petals narrow and very slightly convergent; *P. placenta* is the nearest to our species and particularly resembles B, but, as compared with the unworn A, it is much thinner and flatter, while its ornament is said to be larger and scantier on the actinal surface, the reverse of *P. Saharæ.*

Evidence as to age.—All species of this genus previously described are found in Sind. *P. elongata* comes from the Strata below the Trap, which appear to be at the base of the Tertiary. The other species, some of which are more like *P. Saharæ,* come from the top of the Ranikot Series, which is thought to be Lower Eocene. There are in *P. Saharæ* no signs of more advanced evolution such as might suggest for it a later date.

Hemiaster Desor, 1847.

Ann. Sci. Nat. (3), viii, p. 16.
Syn. *Trachyaster* Pomel, 1883, Genera des Ech., p. 38.

There has been much discussion and uncertainty about the limits of this genus, and a summary of the position in the year 1889 is given by Duncan (Revision of Echinoidea, p. 225). However the genus be dismembered, it should retain as genotype the species described by A. Brongniart (1822) as *Spatangus bufo,* which was the first in Desor's list, and was subsequently referred to by him as characteristic of the genus. For present purposes it is unnecessary to consider whether or not *Abatus, Tripylus, Ditremaster,* and many other forms at one time or another placed with *Hemiaster,* should be left in the genus. The only one with which the specimens before us have anything to do is *Trachyaster.* In the genotype and other characteristic species of *Hemiaster,* the apical system is compact and ethmophract (the madreporite bounded posteriorly by genitals 1 and 4), and the compact nature of the system was recognised in Desor's revised diagnosis (Synopsis, 1858, p. 367). In certain species that would otherwise fall into *Hemiaster,* the apical system is ethmolysian (the madreporite extending backwards between genitals 1 and 4 and oculars I and V). For such species the genus *Trachyaster,* proposed by Pomel, was adopted by Cotteau (1887, Paléont. franç., Terrains Tert., Échinides Éocènes, p. 400). Duncan and Sladen (Ann. Mag. Nat. Hist. [6], ii, p. 329; 1888) rejected this genus for reasons partly bibliographic, partly morphological. Their objections of the former class were, however, based on an incomplete acquaintance with Pomel's writings, many of which were not accessible in this country till the death of their author. They stated, in fact, that the genus had been proposed without any genotype; and it is true that in the section of his work first published (1883) Pomel merely said "Le type est fossile du miocène supérieur." But from the 2e Livraison, p. 108 (1888), it is clear that the species intended was *Trachyaster globulus* Pomel, which was figured as *T. globosus* in the plates, first issued in 1887. There can therefore be no technical objection to the acceptance of Pomel's name. If there were, one would merely fall back on Cotteau's diagnosis and the genotype *T. Heberti* Cott. But Duncan & Sladen further maintained that, as had already been shown by Mr. V. Gauthier, the ethmolysian apical system was merely a stage of development, connected by imperceptible gradations with the ethmophract stage, and that an individual might be ethmophract in youth and ethmolysian in old age. An objection of this nature could be brought against almost any character, except the few which may have arisen *per saltum.* When, however, a slowly evolving character affords the only distinction, and when the intermediate stages are many, as in the present case, it certainly does not seem advisable to base a generic division upon it alone. As a provisional subgeneric denomination for ethmolysian Hemiasters with four gonopores, the name *Trachyaster* has its conveniences. In such a sense, then, we may say that the specimens from Garadimi belong to *Trachyaster.*

Now according to the usual diagnoses, the only distinction between *Trachyaster* and *Linthia* (Desor, 1853, genotype *L. insignis* Merian) is that *Linthia* has a lateral fasciole passing beneath the periproct. The fact that in the majority of fossils it is very hard to distinguish this lateral fasciole is no argument against its taxonomic importance. But the researches of Mr. Alexander Agassiz seem to show that a lateral fasciole is the remains of what was once a single fasciole enclosing both petals and periproct, the latter structure being nearer the apex in early stages. As the periproct passes downwards from the apex, we may suppose that it carries the posterior region of this primitive fasciole downwards with it; and then that the peripetalous fasciole is recompleted above the periproct by a secondary posterior half. Whatever may be the function of the fasciole, it is reasonable to suppose that it is interfered with by this transportation; hence the appearance of a new fasciole in its place. Therefore one might anticipate for the lateral fasciole an early disappearance; and that there is actually such a tendency seems to be indicated by the frequent tenuity of the lateral fasciole and by the suppression of portions of it, producing the 'diffuse' state recognised in many well-preserved specimens. The lateral fasciole may therefore be regarded as a degenerate and disappearing structure, and as such it seems an unsafe character on which alone to base a distinction between two forms so extraordinarily alike as *Trachyaster* and *Linthia.* This was the opinion of Duncan (1889).

Fortunately there is another character, far more fundamental and far more constant, and this lies in the heteronomy of interradius **1** on the actinal surface, as described by Lovén (Études sur les Echinoidées, pp. 50, 51; 1875), and as first introduced into the formal diagnoses by Duncan (1889). According to these two authorities, the heteronomy in *Hemiaster* is of normal type, that in *Linthia* of ancient type. It is greatly to be regretted that so little attention has been paid to this feature by palæontologists, and that it is impossible to judge from either descriptions or drawings how far the normal and ancient heteronomies coincide with the absence and presence respectively of a lateral fasciole. Specimens of *Hemiaster bufo* in the British Museum (registered 34662) from the type-locality, Havre, show normal heteronomy. It is desirable that the genotype of *Linthia* also should be examined on this point. Till that has been done, we must be content to follow the diagnoses of Duncan in this respect also.

On the preceding interpretation of the genera, the specimens from Garadimi belong to *Hemiaster*. While the peripetalous fasciole of A is visible quite clearly in places, the most minute and prolonged scrutiny has failed to reveal any trace of a lateral fasciole. Considering, however, that its absence might just conceivably be due to the weathering of the specimens, I investigated the structure of the actinal surface, with the result that in B there was traced normal heteronomy of interradius **1**. Among the Tamaské specimens, several show the lateral fasciole passing beneath the periproct, and would therefore be referred to *Linthia* by most palæontologists. But they all have distinct normal heteronomy (Pl. XI, Fig. 12). Therefore I place them in *Hemiaster*. At the same time I have thought it advisable, for the reasons given above, to compare them with species of *Linthia* as well as of *Hemiaster* (*Trachyaster*). Finding nothing under either name with which they could be placed, I venture to refer them to

Hemiaster sudanensis, n.sp. (Pl. XI, Figs. 6–13.)

Diagnosis.—Ethmolysian, with 4 gonopores (= *Trachyaster*). Outline elongate subovoid, with slight posterior truncation and deep anterior sulcus. Length 100;[1] greatest width, at level of apical system, which is eccentric in front, from 95 in young to 87 in adult; greatest height, at about 65 from anterior margin, from 63·7 to 71·8, average 68·6. Posterior truncation slopes upwards and inwards, so that periproct is visible from above. Posterior interradius subcarinate above, inflated on actinal surface. Margins of actinal surface rounded, so that ambitus is at one-quarter the height above base-plane. Summit depressed. Anterior ambulacral groove increases in depth towards margin and continues to peristome. Paired ambulacra increase in depth to one-third their length from apex, and then decrease to almost flush at ends of petals; II and IV subtend 110°, length of petals about 53 to 45, adult number of pore-pairs in series 26–28; I and V subtend 60°, length of petals about 32 to 39, adult number of pore-pairs in series 19–21. Pores conjugate, mostly elongate, outer twice length of inner. A line of miliaries on the intervening ridges. Peristome depressed anteriorly, with a projecting labrum. Periproct broadly lanceolate, more pointed above. Primary tubercles crowded on dorsal surface, larger on actinal surface, intermingled with secondaries on ambulacra I and V; bosses finely crenulate; scrobicular areas depressed, with circle of miliaries on abactinal surface, but with an inner raised rim on actinal surface. Miliaries closely set on all intervening space.

Description of the specimens.—A (B.M. registered E 4826) is well preserved, with some adherent hard marly matrix; the test,

[1] See footnote, p. 293. Length here = 21–32·3 mm.

however, is abraded on the actinal surface and on the right posterior quarter of the upper surface; this is the holotype. B (E 4827) is much more abraded, as well as cracked; C to O (E 4835–4846) are mostly well preserved, but G is crushed.

General Form.—The subovoid ambital outline is cut into by the anterior groove to a depth of 2·3 mm. in A, and 1·8 mm. in B, and is flattened posteriorly by a truncation about 9 mm. wide in A, 6·5 mm. in B. Length of A, 30·5 mm., of B, 25 mm.; greatest width, A, 26·6 mm., B, 22·1 mm.; greatest height, A, 21·9 mm., B, 18·2 mm.; distance of vertex from the anterior vertical plane in A, 19·5 mm., but since the test is here eroded, it may have been further back, as in B, where the distance is about 16·5 mm., the ratios to length = 100 being A, 64, B, 66. In determining the vertical anterior plane, ambiguity arises from the fact that the specimens are not bilaterally symmetrical, but all project forward more on the right; one must therefore measure from where this plane cuts the sagittal plane.[1]

Summit depressed. Interradii swollen, all forming a strong convexity, as seen in transversal section, then falling away rapidly to the ambitus, which is at one-quarter the height above the base-plane. In this species the base-plane[2] is touched solely by the swollen plastron; and, owing to the asymmetry above noted, equilibrium is attained in these specimens only when they have fallen over to the right; in measuring, therefore, the sagittal plane must be fixed at right angles to the base-plane. The vertex lies just opposite the middle of the posterior petals; from it the sub-carinate interradius curves gently down to the summit of the posterior truncation.

Actinal surface.—Plastron inflated, especially posteriorly, with a tendency to carination. Margin equably rounded, except posteriorly in median line, in ambulacra I and V, which are slightly depressed, and in anterior sulcus. (Pl. XI, Fig. 12.)

Apical System.—Gonopores 4, conspicuous, circular; anterior pair smaller than posterior, and closer together. Genital plates of each side abut, pushing outwards oculars II and IV; but ocular III comes between the main portions of genitals **2** and **3**. Genital **2**, however, stretches backwards in a madreporite, between and far behind genitals **1** and **4**, also separating oculars V and I, while genital **3** sends a broad tongue down to the madreporite. The system is therefore compact and ethmolysian. Ocular pores very small. The centre of the system, or apical pole, is 13·8 mm. from anterior vertical plane in A, 12·4 mm. in B. (Pl. XI, Fig. 7.) In E is an abnormality, gonopore **2** being on the left of ocular III.

Ambulacra.—Anterior feebly developed; attains a width of 4 mm. in A. In the proximal 5 pairs of plates the pores are not distinguishable; in the next 7 pairs they are minute and wide apart;

[1] Since noting the asymmetry in *Hemiaster sudanensis*, I have detected it in specimens of the genus from widely separated localities and horizons. It can be no mere individual abnormality.

[2] See footnote, p. 293.

after that none are distinguishable. Pore-pairs, not conjugate, slightly oblique, the outer pores being adapical and depressed in a slight peripodium.

The paired ambulacra are relatively deeper and wider in B than in A, suggesting that B was female and A male. They are almost straight, subpetaloid, and asymmetrical, the anterior half of II and IV, the posterior half of I and V, becoming the narrower towards the apex. II and IV subtend 110°. Length of petal, in A, 13·5 mm. (distance to margin along curve being 19·5 mm.), in B, 11·3 mm. (distance to margin, 14·8 mm.). Greatest width in A, 3·8 mm. at about 4 mm. from distal end of petal; in B, 3·5 mm. at about 5·3 mm. from end. Width at distal end of petal, 2·3 mm. in A, 2·1 mm. in B. Deepest part of petal at 6 mm. from apical system. Poriferous areas broad, extending almost to outer margin of ambulacrum, especially on posterior side. Pores conjugate; elongate, except 2 adapical pairs in the posterior half, 7 adapical pairs in the anterior half, and the extreme distal pair, all of which are circular. Outer pore of each pair slightly more distal and twice length of inner pore. Height of ambulacrals, ·6 mm. in A, ·5 mm. in B. In A the pores lie in the distal half of each plate, and the proximal half is marked with a line of six miliaries; B differs in having the pores nearer the middle of the plate. Each series contains 28 pore-pairs in A, 26 to 27 in B. Interporiferous area narrow (·75 mm. in A) and slightly grooved. (Pl. XI, Fig. 10.)

Ambulacra I and V subtend 60°. Length of petal, in A, 10 mm., in B, 8·3 mm. Greatest width at about half the length, 3·2 mm. in A, 3·4 mm. in B. Width at distal end of petal, 2·2 mm. Each series contains 21 pore-pairs in A, and 19 in B; of these the 3 proximal in both specimens, the 3 distal in B, and the extreme distal in A are circular. In all other respects these ambulacra resemble II and IV.

Interradials.—As previously stated, B affords evidence of normal heteronomy in **1**. The number of petal-ambulacrals abutting on an interambulacral of **1** in A is 6. The small labrum is succeeded by two large sternals, which swell up to the median line; at the end of the sternum, about 15·5 mm. from the peristome in A, the interradius curves gently round to the margin, where it meets the posterior truncation. These structures are more clearly shown in the Tamaské specimens (Pl. XI, Fig. 12).

Peristome.—In A the transverse diameter is 3·2 mm., the sagittal, 1·6 mm. The anterior sulcus is continued right up to its anterior margin, which is 7·6 mm. from the anterior vertical plane. Anteriorly and laterally is a slightly raised rounded rim. Posteriorly, the labrum projects over the opening, and is raised about 1·4 mm. above the level of the anterior lip. (Cf. specimen I; Pl. XI, Fig. 12.)

Periproct.—Vertically elongate, broadly lanceolate, more pointed above, situate at upper end of posterior truncation, at about 11·5 mm. above base-plane in A, with length 4·8 mm., and width 3·3 mm.

Ornament.—Primary tubercles best preserved on the sides of the anterior groove, where they are larger, and on its floor, where they are smaller. They appear to have covered thickly the whole dorsal surface. On the actinal surface they are rather larger, and, on the periplastronal ambulacra, are interspersed with secondaries. The bosses are low, rounded, and where well preserved finely crenulate. No signs of perforation can be traced, but this is not enough to prove that the tubercles were not slightly perforate. Traces of the peripetalous fasciole are clearly seen in A, crossing the anterior groove at 15 mm. from the apex, and at the end of petal V, well beyond the poriferous area; also, less clearly at the end of petal IV. There is not the smallest trace of any other fasciole, but all regions where such might be expected are crowded with tubercles.

[On the other hand, all the Tamaské specimens, except the crushed and abraded G and N, show the lateral fasciole distinctly. It is linear, but incised, continues the line of the peripetalous fasciole from the ends of petals II and IV, till opposite the ends of petals I and V; here it dips to nearly the base of the posterior truncation. The posterior tract of the peripetalous fasciole leaves the main line about the middle of interambulacral series **1***b* or **4***a* respectively, runs parallel to petals II and IV, then parallel to the lateral fasciole, till it reaches the ends of petals I and V, whence it cuts straight across the carina of 5 (Pl. XI, Fig. 13).]

Relations to other species.—The number of species of *Hemiaster* is large, but the majority are either distinctly ethmophract, or, if ethmolysian, have less than 4 gonopores. Taking those that remain, it appears that our species differs from them all in the greater elongation or narrowness of the adult test, and from most also in the deep excavation of the ambitus by the anterior sulcus, while, from the few that have this character, it differs in the shallowness of the same groove near the apex. One or other of these features, combined with others mentioned in the diagnosis, separates it so definitely from all species of *Trachyaster* type, that detailed comparison is needless.

In general form the Sokoto fossils approach more nearly some species of *Linthia*, and, in view of a possible confusion, the differences may be pointed out. Thus *Linthia bisulca* Peron & Gauthier has petals more equal in size and a smaller posterior truncation; Cotteau's figure of this (Pal. Franc., tom. cit., pl. lxxx, fig. 5) shows neither the heteronomy said to characterise *Linthia* nor that found in *Hemiaster*. In *L. Cotteaui* Tournouer and *L. dubia* Cotteau, the posterior truncation is vertical and the periproct invisible from above; in the latter also it is transversely elongate. *L. Pomeli* Cotteau is rather elongate, but the angle subtended by ambulacra II and IV is greater, and petals I and V are much longer. *L. Ducrocqui* Cotteau is somewhat elongate, but width : length : : 95 : 100; the posterior truncation slopes downwards and inwards so that the periproct is invisible from above; the pores are circular and not conjugate; for this species also Cotteau's figure (tom. cit., pl. lxvi, fig. 3) does not show ancient heteronomy. *L. sindensis* Duncan & Sladen has a greater slope to its posterior truncation, and width : length : : 103 : 100. No other species of *Linthia* seems to present greater resemblances than do those mentioned.

Evidence as to age.—The genus *Hemiaster*, in its typical ethmophract form, ranges from Cretaceous times to the present day, but the ethmolysian form did not appear, so far as we know, till the Eocene period. These specimens therefore confirm the view that the stratum from which they came is of Tertiary age. More than this it were not safe to say.

General Geological Conclusions.

The fossils collected by Captain Lelean had already been determined by Mr. Bullen Newton and myself, and the importance of their discovery recognised, before I learned that attention had previously been drawn by Professor A. de Lapparent[1] to similar fossils collected in the same district by French officers. The following are the main facts recorded by him.

Echinoids, which may or may not have been of the same age, were collected by the late Captain Pallier near Zinder [450 km. W. of Lake Chad, and about the same distance E. of Sokoto], but have since been lost. Subsequently Captain Gaden collected at Tamaské, 400 kilometres west of Zinder [and apparently not far from Garadimi], a Nautilus allied to *N. Lamarcki* of the Calcaire grossier, five casts of *Nerita* (*Velates*) *Schmideliana*, belonging to the variety characteristic of the Middle Eocene, and four Echinoids determined by Mr. Victor Gauthier as one *Plesiolampas* sp. nondescr., one *Leiocidaris*, badly preserved but clearly of Tertiary age, and two specimens of *Linthia* "so closely resembling *L. Ducrocqui* Cotteau, of the Eocene limestone of Saint-Palais (Charente-Inférieure), that it is hard to separate them from it." It appears that the *Plesiolampas* and *Leiocidaris* are not well enough preserved to be capable of description; otherwise Professor de Lapparent would doubtless have included in his paper a recognisable diagnosis. I have, therefore, thought it advisable to publish a description of the excellent specimens brought home by Captain Lelean. As for the specimens of *Linthia*, it occurred to me that Mr. Gauthier might have had before him the same species as that found by Captain Lelean and described above as *Hemiaster sudanensis*. But, for the reasons already given, I am unable to consider our specimens as resembling *L. Ducrocqui*, or even as belonging to the genus *Linthia*.

[Examination of the Tamaské specimens presented by Captain Foulkes necessitates no modification of the preceding remarks.]

It is therefore interesting to find that, just as the French and English observers in the field independently made similar discoveries, so the palæontologists of the two countries have independently arrived at similar conclusions, each confirming the other.

To French observers are also due other recent discoveries, which throw much light on the geological history of the present specimens. The occurrence of *Plesiolampas*, a genus hitherto unknown outside Sind, suggests a continuous westward extension of the Eocene Indian Ocean; and this idea is confirmed by an Egyptian fossil of the same

[1] "Sur les traces de la mer lutétienne au Soudan," C.R. Acad. Sci. Paris, cxxxvi, pp. 1118–1120; 11 May, 1903; and "Sur de nouveaux fossiles du Soudan," tom. cit., pp. 1297–8; 2 June, 1903.

age, identified by Mr. Gauthier as *Plesiolampas*. That a large part of the intervening area was filled by the Lutetian sea is proved by the occurrence of *Nautili* and Echinoidea, believed by Captain Gaden to be of the same species, at Zinder and in Damergu, where the beds are more marly. Professor de Lapparent further recalls the occurrence of *Echinolampas* of Lutetian age at Dakar [near Cape Verde], and supposes the inward extension of an Atlantic Gulf on this side. If the Eocene limestones and marls ever extended northwards, they have now been denuded, and in their stead are found outcrops of Cretaceous rock, which have in Damergu yielded to Captain Gaden an ammonite allied to the Turonian *Mammites* and *Vascoceras*, while 450 km. north of Lake Chad, at Bilma, Colonel Monteil found an echinoid of Maestrichtian age, described by Mr. V. Gauthier[1] as *Noetlingia Monteili*. This fossil also indicated a connection with north-west India. The same connection may have remained open for several geological ages; and while, on the one hand, the Lutetian sea may have extended northwards over Bilma and even into the Libyan desert, so on the other hand the Cretaceous rocks may pass southwards and underly the Lutetian of Sokoto and Damergu.

The modesty of the English officers of the Niger-Chad Boundary Commission will be the less offended, and my own awkwardness the less exposed, if Professor de Lapparent will permit me to borrow his concluding paragraph, all but one word: "Je crois devoir terminer en exprimant une vive gratitude à l'égard des vaillants officiers qui, sous un ciel de feu, au milieu de fatigues et de préoccupations de toute sorte, ne négligent pas de recueillir au passage, pour le plus grand bien de la Science . . . . , des documents d'un pareil intérêt."

DESCRIPTION OF PLATE XI.

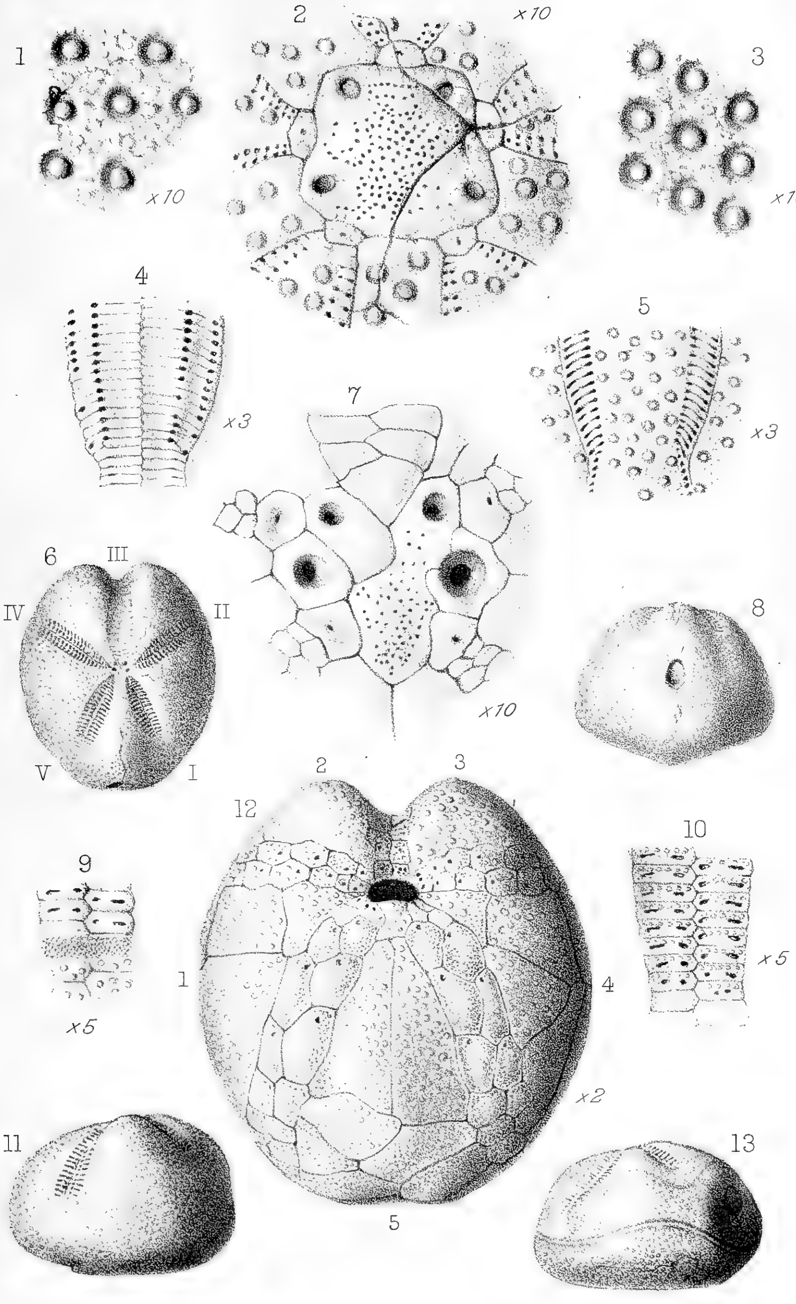
Plesiolampas Saharæ.

Fig. 1. Tubercular ornament on an interradius of abactinal surface of D: × 10 diam.
,, 2. Apical system of A: × 10 diam.
,, 3. Tubercular ornament on an interradius of actinal surface of D: × 10 diam.
,, 4. Distal end of petal IV of A, surface abraded: × 3 diam.
,, 5. Distal region of petal III of A: × 3 diam.

Hemiaster sudanensis.

Fig. 6. Abactinal surface of A: nat. size.
,, 7. Apical system of A: × 10 diam.
,, 8. Posterior view of A: nat. size.
,, 9. Distal end of petal V of A, showing fasciole: × 5 diam.
,, 10. Distal region of petal II of A: × 5 diam.
,, 11. Left side view of A: nat. size.
,, 12. Actinal surface of specimen I, mainly to show normal heteronomy: × 2 diam.
,, 13. View of H from left posterior interradius, to show peripetalous and lateral fascioles: nat. size.

[1] Bull. Soc. Geol. France (4), i, p. 189; 1901. See also A. de Lapparent, C.R. Acad. Sci. Paris, cxxxii, p. 388; 1901.



G. M. Woodward del. et lith. West, Newman imp. London.

Eocene Echinoids from Sokoto.

IV.—Note on a new Fossiliferous Limestone in the Upper Culm Measures of West Devon.

By Inkermann Rogers, and E. A. Newell Arber, M.A., F.L.S., F.G.S.

At the present time we are only fully acquainted with the geology and palæontology of one division of the great Carboniferous Series developed in Devon and the adjacent counties, the Lower Culm Measures. This division, while representing only a small fraction of thickness of the Culm Measures as a whole, is of special interest both lithologically and palæontologically, as was shown by Messrs. Hinde & Fox[1] in an admirable paper published in 1895. Above the limestones and cherts of the Lower Culm Measures lie the great thickness of sandstones and shales which constitute the Upper of the twofold primary division of these rocks instituted by Sedgwick & Murchison[2] in 1840. The Upper Culm Measures occupy an area of more than 1,000 square miles, and are of Upper Carboniferous age.

With the exception of the researches of the late Townshend Hall, and more recently of Mr. Ussher, comparatively little has been added to our knowledge of these beds since the days of Sedgwick & Murchison, and of De la Beche. An inquiry with regard to the palæontology, and more especially the palæobotany, of these rocks has, however, been in progress for some time past, with the result that sufficient material has been gathered for a contribution to the fossil flora of the Upper Carboniferous rocks of Devon, which it is hoped will be published shortly by one of us. While examining the sandstones and shales of this series, other discoveries have been made, incidental to the work of collection of plant-remains. Among these the discovery of fossiliferous calcareous nodules, and, in one locality, of a limestone band, seems to warrant special notice.

So far no limestones have been known to occur in the Upper Culm Measures. Even in the Lower Carboniferous portion of the Culm Measures the general absence of calcareous deposits is somewhat sharply contrasted with the Lower Carboniferous sequence developed elsewhere in Britain. Limestones do, however, occur in this series. They form inconstant and impersistent bands, seen at Swimbridge and Venn near Barnstaple, and in other localities, and are generally believed to underlie the Coddon Hill beds, though Mr. Ussher[3] is inclined to regard them as superior to the cherts. On the other hand, the only calcareous sediments known from the Upper Culm Measures are the calcareous shales and shaly nodules containing fish and Goniatite remains occurring at Instow, near the junction of the Taw and Torridge, which were described in 1876 by the late Townshend Hall[4] in the Geological Magazine.

The Instow beds lie, so far as we have been able to ascertain, near the base of the Upper Culm Measures, and, although the

[1] Hinde & Fox: Quart. Journ. Geol. Soc., vol. li (1895), p. 609.
[2] Sedgwick & Murchison: Trans. Geol. Soc., ser. ii, vol. v (1840), p. 633.
[3] Ussher: Proc. Somerset Arch. and Nat. Hist. Soc., vol. xxxviii (1892), p. 121.
[4] Hall: Geol. Mag., Dec. II, Vol. III (1876), p. 410.

district has been thoroughly searched by one of us, we have been unable to find any other calcareous rocks. Such deposits have also proved to be absent on the higher horizon in which the impure coal or culm occurs in the neighbourhood of Bideford. The thorough examination of these beds, which has been made during the collection of the plant-remains already mentioned, has not resulted in the discovery of any trace of a calcareous nodule.

More recently attention has been turned to yet higher beds in the Upper Culm Measures, which are stated by Mr. Ussher[1] to be somewhat dissimilar to the Culm Measures of the Bideford district, and which he has distinguished as the *Eggesford Grits.* In this work we have been assisted by a grant recently made to one of us by the Royal Society Government Grant Committee, and we may here express our great indebtedness for the removal of many difficulties by this means.

The Eggesford grits of Mr. Ussher consist of even-bedded sandstones and shales, and these may be studied in the fine coast-section between Portledge Mouth and Windbury Point, a district which may be conveniently termed the Clovelly district. This portion of Devon is practically unexplored geologically. With the exception of a brief notice of the Culm Measures near Clovelly, published by Conybeare[2] in 1814, there is, so far as we are aware, no evidence to show that it has ever been studied in detail. It may be pointed out that Conybeare makes no mention of any calcareous deposits, although such occur within a few yards of Clovelly pier. Pengelly[3] and Townshend Hall also overlooked these beds, although well acquainted with the district.

Calcareous nodules have recently been found in several localities along the coast to the west of Clovelly. They occur a short distance from Clovelly, also below Gallantry Bower (on the south-east side), and they have been found in association with the limestone described here near Mouthmill, and also beyond Mouthmill in Beckland Bay on the western side of Windbury Point.[4] They are found in certain beds of shale, usually of 1–2 feet in thickness, which alternate with the sandstones. The nodules are oval in form and of all sizes, a rather large nodule measuring nine inches or more along its greater axis. They effervesce freely with acid, and are crowded with casts of Goniatites, similar to those mentioned below, which are often preserved in calcite, although usually in rather indifferent preservation. The thickest of these conglomeratic beds is that associated with the limestone band at Mouthmill.

In one locality the nodular beds are overlain by a thin band of limestone,[5] which is of special interest as being the only limestone

[1] Ussher: Trans. Inst. Min. Engineers, vol. xx (1901), p. 362; see also the excellent geological map of Devonshire on pl. xvi.

[2] Conybeare: Trans. Geol. Soc., ser. I, vol. ii (1814), p. 495.

[3] Pengelly: Trans. Devon Assoc., vol. xvii (1885), p. 425.

[4] The Western Coast Section has not as yet been explored, but calcareous nodules have been found a short distance to the south of Hartland Point.

[5] The limestone was discovered by Mr. Rogers in August, 1903, when searching for plant-remains on my behalf.—E. A. N. A.

known in the Upper Culm Measures. Some 300 yards from Blackchurch Rock and Mouthmill, and about one and a half miles by the coast to the west of Clovelly, the even-bedded grits and shales, which in this neighbourhood consist of alternating beds of a few feet in thickness, are thrown into a well-preserved sharp anticlinal fold. This anticline differs from the others which are found all along this coast, by the fact that a *thick* bed of splintery shale occurs between the grits, and resting on this shale is an inconstant and impersistent band of limestone. The axis of the anticline lies roughly east and west. The crest is faulted with a downthrow of one or two feet, or perhaps more, to the north; the faulting being obscured in the lower portion. At the base of the anticline, a fine-grained sandstone is seen, similar in character to the other sandstones in the neighbourhood. Next in order comes the thick bed of shale, which is somewhat obscured below, and consequently its exact thickness is difficult to ascertain. It is probably more than ten feet thick. Near the top of the shale, on the northern side of the anticline, numerous calcareous nodules occur. These begin at a distance of two to three feet from the summit of the bed, the lower nodules being smaller and more scattered, whereas those near the top of the bed are larger and crowded together. On the opposite side of the anticline the nodules are equally prominent and abundant.

On the northern side, the highest bed seen is a dark-coloured limestone, from 9 to 20 inches in thickness, resting on the conglomerate described above. The limestone is also seen near the crest on the southern side of the anticline, where it is overlain by sandstones and shales of the usual type. It is, however, impersistent, and does not occur at the base of the anticline on this side, where the sandstones rest directly on the shales with nodules. A microscopic section of the limestone has been very kindly examined for us by Mr. Howe, who has confirmed the conclusion that this rock may be correctly termed a limestone. It may be also remarked that there appears to be here a gradual transition from an arenaceous rock with little or no calcareous material to a fairly pure limestone. Whether this is really the case or not, we must leave to those who possess a more special knowledge of petrology to determine.

The limestone and the calcareous nodules contain numerous casts of Cephalopoda and Lamellibranchs. We are indebted to Mr. Crick, and to Dr. Wheelton Hind, for the determination of the following species:—

Gastrioceras carbonarium (von Buch). *Dimorphoceras Gilbertsoni* (Phill.).
Gastrioceras Listeri (Martin)? *Orthoceras*, sp.
Pterinopecten (*Aviculopecten*) *papyraceus* (Sow.).

The same species of *Gastrioceras* were obtained by the late Townshend Hall from the calcareous shales at Instow, already mentioned; and his specimens are now in the Geological Department of the British Museum (Nat. Hist.).[1] These species have also been

[1] Registered numbers C. 1613 and C. 1613*a*, see Hinde & Fox, ib., p. 655, table ii.

found by us in the same beds at Instow quite recently. These, and two fish-remains from Instow, *Cœlacanthus elegans*, Newb., and *Elonichthys Aitkeni*, Traq., also in the British Museum[1] are practically all the determinations, with the exception of plant-remains, which have so far been made from the Upper Culm Measures of Devon.

In conclusion, we believe that the calcareous nodules and the limestone of the Clovelly district belong to a much higher horizon in the Upper Culm Measures than the Instow beds. Whether the nodules, now found in a number of scattered localities in the former, are really confined to a single bed, or occur on different, but not distant, horizons, we are unable to ascertain, as the severe folding, faulting, and crushing which the rocks have undergone render it rarely possible to trace any bed for more than a few yards. At any rate, the occasional occurrence of calcareous nodular beds seems to be in some measure characteristic of the Culm Measures of the Clovelly district.

It would seem that, in Devonshire, marine Cephalopoda such as *Gastrioceras carbonarium*, which are usually regarded as more restricted vertically than other palæontological types, have a considerable range in the Upper Culm Measures, occurring in what are probably the lowest and highest beds of that series. It may be also pointed out that the occasional occurrence of marine calcareous bands is an important point of agreement between the Upper Culm Measures and the Coal-measures of other British coalfields, more especially those of North Staffordshire[2] and South Lancashire.[3]

V.—On the Origin of certain Pegmatite Veins.

By J. Vincent Elsden, B.Sc., F.G.S.

During a visit to the South of Sweden in the Summer of 1902 I noticed the frequent occurrence in granite of pegmatite veins showing a succession of small but very regular foldings, which, however, did not affect the parent rock. In sett quarries where these folded veins existed the rift of the rock was perfectly regular on each side of the pegmatite, proving conclusively to my mind that the contortion of the veins took place prior to the consolidation of the main mass. The granite of this district occupies a wide area, and possesses a very uniform mineralogical constitution, although it varies much in texture between a rather coarse-grained granitite and a fine-grained, compact, gneissose rock possessing well-marked foliation. The pegmatite veins are fairly numerous, but are generally rather insignificant in width, occasionally thinning out to mere streaks not more than a few inches in thickness.

The origin of pegmatite veins has been much discussed, but most of the various theories hitherto advanced almost invariably attribute

[1] Registered numbers P. 6100, P. 5379, and P. 6268.
[2] Ward: Geol. Mag., Vol. II (1865), pp. 234 and 286.
[3] Hull & Green, Trans. Manch. Geol. Soc., vol. iii (1862), p. 348; and Hull & Salter, "Geology of the Country round Oldham," 1864, p. 64.

them to the infilling of cracks and fissures formed subsequently to the consolidation of the parent rock. Charpentier, in his examination of the Pyrenees in 1823, conceived the view that pegmatites are true fissure veins, injected by portions of the still fluid part of the magma from below. This view has been largely adopted by the French geologists, and also by De La Beche in this country, and by Naumann, Gümbel, and others in Germany. Such veins would seem to form the "Injectionsschlieren" of Reyer,[1] and are similar to what are sometimes termed contemporaneous veins. De Saussure, G. vom Rath, and others, however, maintained that these veins were deposits from watery solutions; while Forchhammer, Sandberger, and Credner advocated the theory of lateral secretion, involving the assumption that pegmatite veins are true fissures filled up with minerals leached out from the surrounding rock. Rosenbusch[2] associates pegmatite veins with drusy and miarolitic structures, or vein-like cavities filled up by secondary crystallisation, a view also briefly suggested by Teall.[3] Later observers have modified these theories with a view to the explanation of the marked acidity of pegmatite veins in comparison with that of the parent rock. Thus Brögger, in his well-known work on the rocks of the Christiania district,[4] found evidence to show that these veins represent true eruptive outpourings, the last *aufpressungen* of a differentiated magma basin. This view somewhat corresponds to the *hysterogenetische schlieren* of Reyer, or the *ausscheidungstrümmer* referred to by Kalkowsky[5] in his description of the pegmatites in the granulite of Saxony. Later observations of Messrs. Gunn, Hinxman, Barrow, Kynaston, Clough, Cunningham-Craig, and Wilson, in the Highlands of Scotland,[6] have led in the majority of cases to the conclusion that the pegmatite veins are subsequent intrusions, although in a few cases they are referred to as of segregative origin; but whether these segregations were of a magmatic type or merely the results of subsequent metamorphism is not always clearly indicated. Keilhau, writing in 1838 on the Christiania pegmatites, attributed them to simultaneous separations of the surrounding eruptive mass, and not to the filling up of fissures; but no one, so far as I am aware, has described evidence of the original existence of such veins in the form of acid streaks in a viscous magma, prior to consolidation.

The remarkable agreement in the characters of pegmatite veins in widely separated areas points to some general law governing their mode of origin. It is, therefore, somewhat strange that the views advanced concerning their formation should still remain so much at variance. It seems at least certain that the pegmatites of Blekinge province, in Sweden, present peculiarities which absolutely preclude the suggestion that these are subsequent fissure injections of the

[1] See Zirkel, "Lehrbuch der Petrographie," vol. i, p. 787 et seq.
[2] Mikroskopische Physiographie d. Mass. Gesteine, ii, p. 39.
[3] "British Petrography," p. 291.
[4] "Die Mineralien der Syenit pegmatitgäuge," etc., Leipzig, 1890.
[5] Zeit. d. d. geol. Ges., vol. xxxiii (1881), p. 653.
[6] See "Summary of Progress," 1899, 1900, 1901, 1902.

type described by Brögger in the Christiania district. Unfortunately, the time at my disposal did not allow an exhaustive examination of this large district, and my present remarks are written rather with the hope of eliciting further information than with any claim to the establishment of a final conclusion.

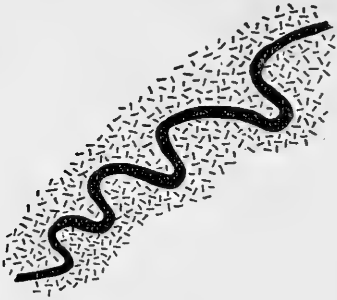


Fig. 1.—Contorted pegmatite vein in granite, Gungvala, near Carlshamn, Sweden. Scale, 1 inch = 2 feet.

At Gungvala, on the railway running inland from Carlshamn, I saw thin pegmatite veins, often not more than a few inches wide, sharply folded as in the accompanying diagram (Fig. 1). The amplitude of the folds is seldom more than a couple of feet, but

Fig. 2.—Folded pegmatite in a sett quarry, Gungvala, Sweden. The parallel lines are joint planes. Scale, 1 inch = 10 feet.

there is no sign that these folds influence the parent rock. A striking example is shown in Fig. 2, where the folds taper downwards, diminishing in amplitude, while the veins themselves contract in width. The junction between the granite and pegmatite is clean and complete, without any druses or other interruptions that could be discovered. As previously stated, well-defined rifts exist in the granite. These rifts run not only parallel to the joint planes, but also along well-defined though faint foliation planes in the granite, usually cutting transversely across the direction of the folded pegmatites. I do not, therefore, think it possible that there can be any mistake in the conclusion that the folding of the pegmatites occurred before the main mass crystallised.

In the Mörrum district, a few miles to the south-west, similar phenomena can be observed, but here the pegmatites are sometimes disposed in very regular planes, about six feet apart, parallel to the well-defined foliation in the parent rock. Whether these are uncontorted, or whether they owe their appearance to being cut transversely, viz., parallel to the axes of the folds, is not certain. At Matvik, on the coast, a few miles east of Carlshamn, I noticed similar veins of pegmatite, parallel to highly inclined foliation planes, dividing so as to enclose a 'horse' of the country rock, but without any disturbance of the regular foliation of the parent mass. Very striking relations between the folded veins and the foliation planes of the granite were seen at Külleron, to the west of Carlshamn. Here the appearance was as represented in Fig. 3. It is difficult to

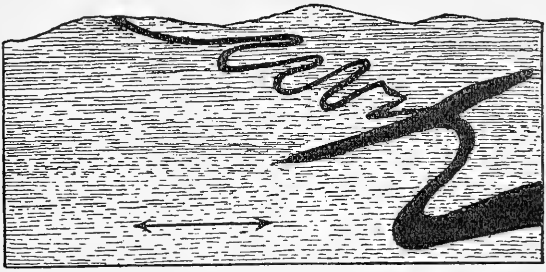


FIG. 3.—Contorted pegmatite in gneiss, Külleron, near Carlshamn, Sweden. The double arrow indicates direction of foliation of the gneiss. Scale, about $\frac{1}{50}$.

escape from the conclusion that the pressure which induced the foliation also operated in the production of the contortions in the pegmatites while the mass was still in a viscous condition. Nor can any theory of subsequent vein filling adequately account for the phenomena. It must be mentioned, also, that the pegmatite veins are not themselves foliated, which is probably to be attributed to the fact that the solidification of the veins took place subsequently, under different conditions from those prevailing during the crystallisation of the main rock, as I shall endeavour to explain later. This result might readily be produced if we assume that the foliation was produced by a gentle shearing force at a time when the minerals of early consolidation were already formed, while the substance of the veins still remained in a state of viscous fluidity. This would also account for phenomena noticed in the neighbouring island of Günon, where the foliation planes appear to be slightly deflected by contact with the margins of the pegmatites. Nearer Carlshamn I saw many other examples of similar contortions, as also in the district around Sölvesburg, from which locality, at Siritorp, I noted the appearance represented in Fig. 4.

The explanation demanded by these phenomena seems to be that the granite magma was traversed by streaks and bands of different composition from it. Now a streaky or banded magma can only occur in one of two ways. It may be due to the unequal mixing of the magma in the first instance, forming the so-called *constitutionsschlieren*, or *mischungsschlieren* of Reyer; or it may be caused by an originally homogeneous magma becoming streaky in the final stages of its existence in a molten state. With regard to the first of these causes, we are reminded of the phenomena observed in the process of glass manufacture, and of the difficulty experienced in obtaining glass free from striation or wreath. It would, however, be very difficult, on such an assumption, to explain why the striæ are so uniform in mineralogical character; so that we are driven to a consideration of the second hypothesis.

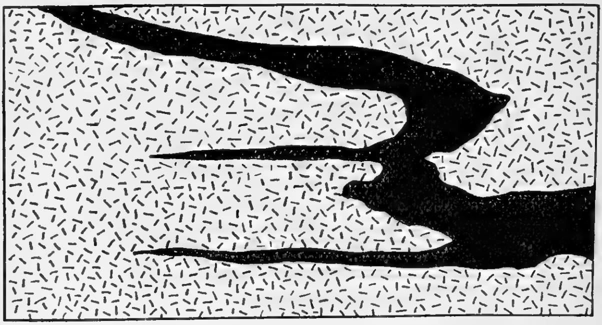


Fig. 4.—Pegmatite vein in granite at Siritorp, near Sölvesburg. Scale, 1 inch = 4 feet.

An examination of a number of thin slices prepared from the above-mentioned rocks throws light upon the order of the different consolidation phases. The normal rock has a simple constitution. Biotite and sphene are the chief products of the earliest crystallisation; while felspar, chiefly microcline, and quartz seem to have struggled together for the mastery in the final stages. Accessory minerals, such as occasional hornblende, some magnetite, apatite, and a little zircon do not occur in sufficient quantity to affect the character of the rock, and the same may be said of certain pneumatolytic minerals, of which chalcopyrite is the most conspicuous example. Dark basic secretions are abundant, and are distinguished, like the pegmatites, by evidences of considerable movement during consolidation. They are frequently drawn out into irregular elongated forms, and at Hasteryd they may be seen pressed out into lenticles along the foliation planes. These dark patches are typical quartz diorites, containing an abundance of well-formed brown hornblende, biotite, plagioclase, some orthoclase, and a little quartz. No microcline was observed in the slices examined. These dark segregations, therefore, differ essentially from the normal rock, and may be safely regarded as a result of the first phase of consolidation. The deformation of these basic secretions is in accord with previous observations in other localities,[1] and would be expected to occur under the influence of magmatic movements. Although these dark patches are usually regarded as true results of magmatic segregation, the *primären ausscheidungsschlieren* of Zirkel, it may be mentioned that Reyer and others regard even these as having resulted from an original imperfect mixing of a more or less heterogeneous magma. The junction between them and the normal rock is well defined, and in a slide showing the contact the transition is sudden from the diorite to the microcline granitite.

Passing now to the pegmatites, these are very coarsely crystalline mixtures of large microcline crystals and quartz, representing the pegmatite of Haüy, although there is not any conspicuous orientation of the quartz. Accessory minerals are not altogether wanting, and in some examples the pneumatolytic species seem to be more abundant than in the parent rock, a feature which was also noticed by Brögger in the Christiania district.

It is obviously conceivable that we might consider these veins to be a product of magmatic differentiation, which began with the consolidation of the dioritic patches, and concluded with the streaks and veins of pegmatite, something after the nature of the streaks of low freezing eutectic observed in some alloys. But it would be difficult on this assumption to account for the regular, wavy contortions, which could scarcely have been formed otherwise than in a still viscous mass. On the other hand, differentiation in a liquid magma of such a nature as to develop such streaks is at least purely conjectural. We do not yet know the limits of miscibility of silicate magmas, nor whether it is possible for a binary mixture, containing quartz and felspar, to segregate in distinct layers in the midst of an ordinary ternary granitic magma. At the same time, physical chemists are gradually extending our knowledge of the series of liquids which only mix in all proportions between certain well-defined limits of temperature,[2] as, for example, in the case of molten zinc and lead. But in the present state of our knowledge it would be unsafe to assume that a magma can become streaky by mere hysterogenetic differentiation.[3]

But another explanation is possible. The magma may have been subjected to an invasion by streams from contiguous areas. These currents, if regarded as the acid residuum forced out from regions where partial consolidation had already taken place, would be differentiated as regards the liquid which they invaded, and might

[1] See Frosterus, "Über ein neues Vorkomniss von Kugelgranit," etc.: Tschermak's Min. und Pet. Mittheilungen, xiii (1892), p. 177.

[2] See Findlay, "The Phase Rule," chap. xiv (1904).

[3] Cf. Morozewicz, "Experimentelle Untersuchungen über die Bildung der Minerale im Magma": Tschermak's Min. und Pet. Mittheilungen, xviii, pp. 232–3.

easily form such streaks as would, on crystallisation, form pegmatite veins. Slowness of diffusion in a viscous mass would prevent any appreciable mingling of the solutions, except perhaps at their margins. They would form thin bands, like a mixture of syrup and water, and they would suffer deformation and contortion in consequence of any magmatic movements to which they might be exposed. This would explain the formation of contorted bands in the midst of an uncontorted rock.

We have next to account for their coarsely crystalline texture, a feature usually taken to indicate slow cooling. Slowness of growth undoubtedly tends to the development of large crystals; for owing to the influence of surface tension it can be shown that in any solution in which crystals are forming, while the solution is supersaturated with regard to the larger crystals it may be unsaturated with regard to the smaller ones. The latter, therefore, may be resorbed and deposited upon the former, which will then continue to grow at the expense of their smaller brethren. But it may be taken as an established fact that the formation of large crystals depends upon other factors than the rate at which cooling takes place. Thus, at Öfvra Trensum, in the neighbourhood of Carlshamn, may be seen a well-marked irregular junction between a very fine-grained blue granite and a coarse porphyritic pink rock. These were evidently part of one and the same cooling mass, but the junction shows no relation to any conceivable isothermal planes. Variations in texture are, indeed, a common phenomenon in plutonic masses. It may be safely assumed that the pegmatites crystallised at a later stage than the parent rock. Whether we look upon them as true eutectic mixtures or not, the circumstances of their origin, as assumed above, would indicate a freezing-point lower than that of the main mass. Pressure probably plays an important part in crystallisation, but we are only beginning gradually to realise the direction of its influence. The experiments of Oetling[1] seem to show that the chief rôle of pressure is to promote superfusion. Now Tammann[2] has shown that the velocity of crystallisation increases with degree of superfusion up to a certain maximum, and then diminishes. The larger and more perfect crystals are formed near the minimum of superfusion. Another factor which comes into play is the number of crystalline nuclei present, upon which the influence of certain catalysers or 'agents mineralisateurs' must be considered. I am aware that the action often ascribed to these mysterious agencies has been called in question by some recent observers, notably by Lagorio and Morozewicz; but our knowledge of the ionic dissociation of fused salts is still so incomplete that for the present it would seem advisable to retain as a useful hypothesis the conception of catalytic action by such agents under certain conditions.

[1] "Vergleichende Experimente über Verfestigung geschmolzener Gesteinsmassen unter Erhöhtem und normalem Druck": Tschermak's Min. und Pet. Mittheilungen, xvii, p. 331.
[2] Zeit. fur physikalische Chemie, xxvi (1898), p. 307.

In the case of these pegmatites it is probable that the contraction of the parent rock on consolidation would diminish the pressure upon the still fluid veins. These would, therefore, at last consolidate under conditions of temperature, pressure, and also concentration, very different from those under which the main mass crystallised, and a marked difference in texture might then be expected.

On the whole, I am inclined to think that we have in these Blekinge pegmatites merely a local modification of Brögger's theory. The contorted pegmatites may indeed be the 'aufpressungen' of a differentiated magma; not, it is true, in this case, invading cracks and fissures of a consolidated rock, but streaming into the still fluid portions of a neighbouring molten mass. But while differentiation has thus played an important part in the process, it must not be overlooked that, if this view should prove correct, the final result was, to a still larger degree, due to the imperfect integration of a streaky magma.

VI.—The Jurassic forms of the 'genera' *Stomatopora* and *Proboscina*.

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

After many months' work at the Polyzoa in the British Museum, the author has been driven to the conclusion that the relationships of the Jurassic forms of the 'genera' *Stomatopora* and *Proboscina* have been misunderstood, and that consequently their present arrangement, as put forward in the British Museum Catalogue, is unsatisfactory.

A detailed examination of all the material available has resulted in the following conclusions:—

1. The division of the forms into the genera *Stomatopora* and *Proboscina* is unnatural.

2. The development of a colony (the *zoarium* of Polyzoa) is comparable with and follows the same laws as the development of the individual (the *zoœcium* of Polyzoa).

3. Therefore the diagnosis of a form, whether 'species' or 'circulus,'[1] is incomplete, and for practical purposes useless, unless the part of the zoarium with respect to its age is specified.

4. In the 'genera' *Stomatopora* and *Proboscina* the method of branching is of paramount importance.

It is intended to take each of the above conclusions and explain by what observations it has been reached, and to what rearrangement of the specimens it tends. To upset the existing order may seem revolutionary, but if by this means a natural grouping is arrived at, if evolutionary series are found, such as have been demonstrated among Brachiopods and Ammonites, if when a new form occurs it is found to fit into one of these series, then the orderly result will justify the radical alterations.

[1] J. W. Gregory: Brit. Mus. Cat. Jur. Bryozoa, 1896, p. 22; and Mem. Geol. Surv. Ind., 1900, ser. IX, vol. ii, pt. 2, pp. 17–22.

The first point, namely, the artificiality of the genera *Stomatopora* and *Proboscina*, has already been discussed by Gregory,[1] who, while admitting that the line which divides them is arbitrarily drawn, since it is obvious that the forms constitute a natural series, maintains that, if this be done, the genera *Berenicea*, *Reptomultisparsa*, *Idmonea*, *Diastopora*, *Entalophora*, and *Spiropora* must for similar reasons be merged. And since the retention of these genera is convenient for working purposes, he leaves them as they are. But he does not suggest, what the author believes to be the case, that these 'genera' are polyphyletic in origin, and that in some cases a given species of *Proboscina* may be at the head of a series of forms, the simplest of which are undoubted *Stomatopora*.

In such a case the series would form a natural genus parallel with, and having a common origin with, other series. These would constitute new genera, starting from the point at which they branched from the first series.

Given sufficient material, such series can be found, and in one or two cases have been found, by tracing the development of the different characters of a colony from the first zoœcium, and by this means finding genetic relationships.

And this question of zoarial development leads to the second proposition, namely, that the development of the colony is comparable with and follows the same laws as the development of the individual.

It was the observation of this fact that led the author to doubt the validity of the 'genera' under consideration, and the matter was fully treated of in a paper. This paper, however, was not published, because it was considered a poor thing to put forward an idea having such a destructive tendency without providing an alternative scheme whereby a natural classification could be constructed. And the latter would involve much further detailed work, some of which has since been done.

Cumings,[2] however, in January of this year, in a paper on the development of *Fenestella* and other Palæozoic forms, has in a masterly manner shown that the zoarium has a developmental history, exactly comparable with that of the individual. He says:[3] "The now generally accepted classification of the stages of growth and decline, proposed by Alpheus Hyatt, has never been consistently applied to a colonial organism, such as are the Bryozoa, nor to one whose ontogeny presents the retrograde metamorphosis which characterizes the latter class." He further proposes a nomenclature for the stages in the development of the colony analogous to the nepionic, neanic, ephebic, and gerontic, or the infantile, youthful, mature, and old-age stages, proposed by Buckman & Bather[4] as modifications of Hyatt's original terms for the individual. These

[1] J. W. Gregory: Brit. Mus. Cat. Jur. Bryozoa, 1896, pp. 14–22.
[2] E. R. Cumings: Amer. Journ. Sci., vol. xvii, pp. 49–78.
[3] Cumings: op. cit., p. 50.
[4] S. S. Buckman & F. A. Bather, "The terms of Auxology": Zooglischer Anzeiger, 1892, p. 421.

colonial stages he terms nepiastic, neanastic, ephebastic, and gerontastic, formed from the stem of the first terms suffixed with the termination *-astic*, from *τὸ ἄστυ*, 'the city.'

Cumings also terms the first-formed zoarium, which has hitherto been known as the 'primitive disc' in Cyclostomata and the 'ancestrula' in Cheilostomata, the 'protœcium,' analogous to the 'protegulum' and 'protoconch' in Brachiopods and Ammonites respectively.

Among the Jurassic forms of *Stomatopora* and *Proboscina*, it has been found that when any given character, such, for instance, as the ratio of the length of the zoœcium to its breadth, is followed from the first zoœcium until the last, that it has a progressive development, or anagenesis, reaches a maximum or acme, and often may be seen to have a retrogressive development, or katagenesis, in the ultimate branches of the zoarium.

To illustrate this point, some examples of the character mentioned, namely, the ratio of the length of the zoœcium to its breadth, are given below, the points of dichotomy of the zoarium being taken as fixed points, and referred to by the numbers 1, 2, 3, etc., No. 1 being the point in the zoarium marked by the first dichotomy, and so on. The numbers with the names are the British Museum register numbers of the specimens.

Specimen.	Ratio of length of zoœcium compared with its breadth at the 1st, 2nd, 3rd . . . n^{th} dichotomies.						
	1	2	3	4	5	6	7
1. *Stomatopora Waltoni*, No. 97,083 ... ... Cornbrash, Wilts.	$3\frac{1}{2}$	$4\frac{1}{2}$	3	$2\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2
2. *Stomatopora dichotoma*, No. 60,535... ... Cornbrash, Wilts.	$2\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{2}$	3	$2\frac{1}{4}$	2	2
3. *Stomatopora dichotoma*, No. 46,218... ... Bathonian, Ranville.	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{4}$	
4. *Stomatopora dichotoma*, No. B. 4,832 ... Cornbrash, Wilts.	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{1}{2}$	2	2	2
5. *Stomatopora*, sp. ... ... Cornbrash, Wilts.	$2\frac{3}{4}$	3	$2\frac{1}{4}$	2	2	2	
6. *Stomatopora Waltoni*, No. B. 2,287 ... Inf. Oolite, Gloucestershire.	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	2	2

The numbers in the above table, representing the length of the zoœcium (the breadth being taken as 1), are, of course, averages; for at each dichotomy are three zoœcia; and if n is the number of the dichotomy, the theoretical number of the zoœcia of which the average is taken will be $3\ (2^{n-1})$. Practically, however, the number is smaller, owing to the loss of certain branches.

The specimens whose zoœcial lengths are given in the table are chosen because they illustrate so well the regular changes of this character. Other specimens are more irregular, but all show to some extent a definite plan of development. In the first four cases given it will be seen that this character is anagenetic at first, and reaches its acme at the third dichotomy, after which it is katagenetic. The fifth example reaches its acme at 2, while the sixth is at its acme at the first dichotomy, and declines after the second.

As far as actual length is concerned, numbers 2, 4, 5, and 6 are practically the same, while No. 1 has much longer and No. 3 much shorter zoœcia than the rest.

This particular character was chosen only as an example. Other characters show a similar regularity in development, according to the part of the zoarium in which they are situated. Those which have been observed and treated in the same way as the length of the zoœcium are four, two zoarial and two zoœcial. The zoarial are the method of branching, which will be treated later, and the frequency of branching, which is measured by the number of peristomes between two dichotomies. The zoœcial are the shape of the zoœcium, and its ornamentation by transverse ribs.

Two characters which have been used by former workers have been found by the author so unpractical that they have been given up as useless; these are the height of the peristome and the punctation of the zoœcium.

The first of these, though doubtless an excellent character where the state of preservation of the fossil is such that its presence may be counted on, becomes useless in the fossils here dealt with, because in the majority of cases the whole peristome has been broken off, leaving it impossible to say whether this structure was high or low when the organism was alive.

Again, the appearance of the punctation of the zoœcium seems to depend to such a large extent upon the state of preservation of the zoœcial wall, that its presence is of little use for systematic work. Nor does it appear to show any variation during the growth of the zoarium.

The results obtained from the study of the development of the characters previously mentioned, namely, the frequency of branching, the shape of the zoœcium, and the transverse ribbing of the zoœcium, show that the rule in the majority of cases is as follows:—

1. *Frequency of branching.*—The number of peristomes between the first two or three dichotomies is small (nearly always 1 or 2), then suddenly increases largely, and finally becomes small again.

2. *Shape of zoœcium.*—Generally the zoœcia are either cylindrical or pyriform. In many of those forms which have cylindrical zoœcia throughout the greater part of the zoarium, the zoœcia between the first and third dichotomies tend to be slightly pyriform; while in those forms with pyriform zoœcia, the zoœcia between the first and third dichotomies are generally more pyriform than the rest.

3. *Transverse ribbing of the zoœcium.*—Ribbing, when present, is usually faint at its first appearance, becoming stronger later on, and in some cases becoming fainter again finally. The point at which the acme is reached varies a great deal.

The systematic value of any one of these characters and the amount that the consideration of them affects the question of species the author hopes to consider in a future paper; all that is wished at present is to demonstrate the importance of following each character through its own development in the zoarium, and by this means determining its value as an index to the relationship of one zoarium to another. The fact that each character has a developmental history makes it clear that the diagnosis of a form is incomplete, and for practical purposes useless, unless the part of the zoarium with respect to its age is specified.

The last point to be considered is the method of branching in the Jurassic forms of the two 'genera' *Stomatopora* and *Proboscina*.

In a single series of zoœcia, such as is typical in the genus *Stomatopora*, two ways of branching may be noticed, namely, lateral branching and dichotomy.

In lateral branching a new zoœcium arises from any point in a chain of old zoœcia, and generally diverges at a wide angle (see Diagram II, Fig. 1, p. 321). It is common in Silurian and Cretaceous forms, but has not been observed (except in one doubtful case) in any Jurassic form.

In dichotomy, which always occurs in Jurassic forms, two new zoœcia arise from the end of an older zoœcium, the angle at which they diverge varying from 180° to 20° or 30°, and varying in a definite manner. (See Diagram II, Figs. 2–9, p. 321.)

Dichotomy in the forms under consideration occurs in three types, one of which is intermediate between the other two. In that termed Type I the two new zoœcia are separate from one another throughout their whole length (Diagram II, Figs. 2, 3, 9, p. 321), only touching at their bases. In Type II they are contiguous throughout their length (Figs. 4, 5, 8); and they are contiguous for part of their length in the Intermediate Type (Figs. 5, 6, 7).

To a large extent correlated with the type of branching is the angle of divergence of the two new branches. This angle tends to diminish distally. But that it is not wholly dependent upon the type of branching may be seen in cases where the new branches diverge at an angle of as much as 60° after branching according to Type II (Fig. 5), while in other cases (Fig. 8) the two new branches may remain contiguous until they branch again. In the majority of cases, however, the angle of divergence and the type of branching are so closely correlated that for practical purposes they may be considered together.

Starting from the first zoœcium, which arises directly from the primitive disc, one or two zoœcia generally follow before the first dichotomy takes place. This in all *Stomatopora* and in a few *Proboscina* (e.g. *P. Cunningtoni*, Gregory, B.M. No. 23,852, zoarium marked 1) is after Type I with a wide angle nearly always 180° (Fig. 9). The second dichotomy in the great majority of cases is on Type I, with an angle of divergence of 120°. The angle of the next dichotomy is commonly 90°, of the next 60°, of the next 45°, Type I being still the mode of dichotomy.

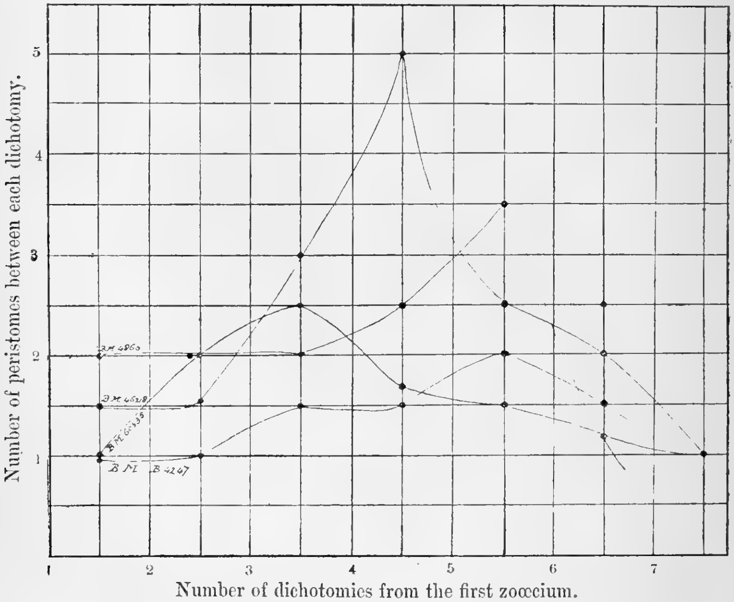
In primitive forms (e.g. *S. Waltoni*, Haime, B.M. No. B. 2,287) the branching never gets beyond Type I with a small angle. In the majority of forms, however, sooner or later the Intermediate Type of branching comes in, and in a great many forms this type is the final one. In a few cases of *Stomatopora*, and in all *Proboscina*, Type II is at some time or other reached, and remains the ultimate form of branching of the zoarium.

This sequence, namely, Type I—Intermediate Type—Type II, is invariably followed. For, although an individual dichotomy may occasionally occur of slightly more primitive order than its predecessor, it is only an irregularity, and the general scheme of development is in no wise obscured.

In more primitive forms this evolution in branching does not progress beyond Type I with a small angle.

In the commoner forms of *Stomatopora* the ultimate branches are formed on the Intermediate Type and on Type II.

Diagram I.—Curves showing the Frequency of Branching in Stomatopora.

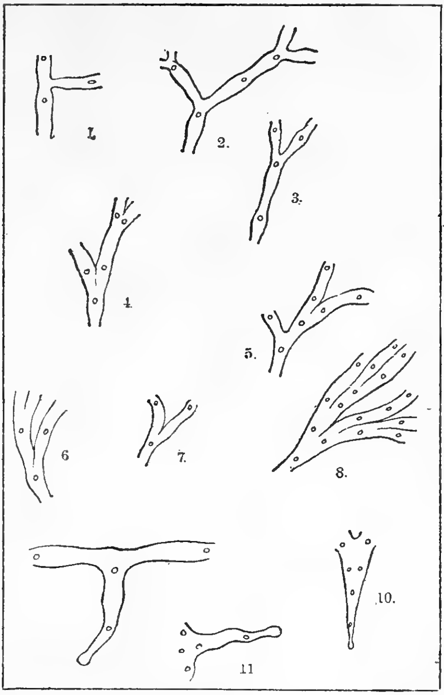


In a few forms of *Stomatopora* (e.g. B.M. No. B. 4,822) Type II occurs after a few dichotomies, while it comes in very soon in some primitive *Proboscina* (e.g. *Proboscina Cunningtoni*, Gregory, B.M. No. 97,617).

In typical forms of *Proboscina* the early stages have been so condensed, according to the law of acceleration (Tachygenesis),[1] that the first dichotomy is formed on Type II (Fig. 10). Sometimes

[1] A. Hyatt, "Bioplastology and the related branches of Biologic research": Proc. Boston Soc. Nat. Hist., vol. xxvi (1893), p. 77.

DIAGRAM II, to show the method of branching in Jurassic forms of the two 'genera' *Stomatopora* and *Proboscina*.



These figures are diagrammatic reproductions of pieces of specimens in the British Museum. The Museum register number is given with each.

FIG. 1. Lateral branching; B. 4,238. *Stomatopora granulata* (Milne Edwards): Chalk, England; loc. ? × about 5.

,, 2. Type I with large angle; B. 2,287. *Stomatopora Waltoni*, Haime: Inferior Oolite, Crickley Hill. Dichotomy 2. × about 4.

,, 3. Type I with small angle; B. 2,287, same specimen as the last. Dichotomy 8. × about 4.

,, 4. Type II with small angle; B. 4,247. *Stomatopora dichotomoides* (D'Orb.): Cornbrash, Wiltshire. × about 6.

,, 5. Type II with large angle, preceded by Intermediate Type with large angle; B. 4,832. Zoarium marked 2. *Stomatopora dichotoma* (Lamouroux): Cornbrash, Wiltshire. × about 6.

,, 6. Intermediate Type with small angle; B. 4,382, same specimen as the last, but the zoarium marked 1. × about 7.

,, 7. Intermediate Type with large angle; 60,536. *Stomatopora*, sp.: Cornbrash, Wiltshire. × about 6.

,, 8. Type II with an angle of 0°; 97,617. *Proboscina Cunningtoni*, Gregory: Cornbrash, Chippenham. × about 5.

,, 9. Type I with angle of 180°; D. 2,064. Zoarium marked 5. *Stomatopora dichotomoides* (D'Orb.): Cornbrash, Midland Railway Pit, Bedford. × about 13.

,, 10. The first dichotomy is after Type II with an angle of 0°; D. 7,185. *Proboscina*, sp.: Inferior Oolite, Crickley Hill. × about 7.

,, 11. The arrangement of the peristomes is irregular from the first; D. 1,843. *Proboscina Eudesi*, Haime: Inferior Oolite, Gloucestershire. × about 7.

a second dichotomy on Type II follows, but often the arrangement of peristomes is quite irregular after the first dichotomy.

In the most advanced types of *Proboscina*, e.g. *P. Eudesi*, Haime, B.M. No. D. 1,843, the arrangement of peristomes is irregular from the first (Fig. 11)—the arrangement typical for *Berenicea*, the next 'genus' in the series of which *Stomatopora* and *Proboscina* are the first two terms.

The absolute regularity of the sequence of these different types of branching and the condensation of the more primitive types in the more advanced forms show of how much importance this character is in determining the relationships of different forms. Moreover, it is worthy of notice that, while in the Jurassic forms of *Stomatopora* Type II is not very common, it becomes extremely common in the Cretaceous forms, though the sequence in these is considerably obscured by the superimposition of lateral branching upon the dichotomy.

In the case of the Cretaceous *Stomatopora* the lateral branching seems to be the reappearance of a character which was formerly present and has been lost, for it occurs in Silurian forms of *Stomatopora*, and is apparently absent in Jurassic forms.

Taking the type of branching as a character of primary importance, and following this and the other characters in their development from the beginning of the colony, series can be traced and natural relationships established. The true genera will probably be found to correspond to some extent with the present 'species.' But before this can be done at all satisfactorily it will be necessary to work through a great deal more material, carefully collected according to horizon and locality.

It is easy to represent graphically the evolution of the characters of two forms for comparison by means of curves. Diagram I, on p. 320, gives an example.

The writer of this paper, intending only to introduce his idea and method of dealing with this difficult group, as a means of establishing a natural classification, has purposely avoided entering into much detail, and confined himself rather to general statements. But illustrations are taken from actual specimens, and these may be seen in the British Museum. What is needed is more material which shall test the above propositions. What has been attempted is not arbitrarily to select a character and invest it with specific or generic importance, but by tracing the development of the character to assign it to its appropriate rank. The terms genus and species can then be applied with some meaning, and new forms, as they occur, will fall into their proper places in a natural scheme.

NOTICES OF MEMOIRS, ETC.

I.—The Geological Survey of England and important Coal-Developments in North Staffordshire.

LAST week the important announcement was made that the Dilhorne seam of coal had been recovered at the Klondyke pit No. 7, near Draycott Cross, Cheadle. For years sinking operations have been conducted with the object of winning what was known to be one of the most valuable seams of coal in the district, and considerable sums of money have been spent in the quest. It had always been held by old miners that although the Dilhorne seam did exist at Dilhorne, it did not exist in or about Cheadle proper. But from the inspection which was made of the Cheadle district about two years ago by Mr. George Barrow, F.G.S., of the Geological Survey, he came to the conclusion that the Dilhorne seam did exist at Cheadle, and that there was an area of some four square miles of it waiting to be worked.[1] This conclusion was borne out by Mr. Stobbs, the County Council lecturer in mining, from his examination of the fossils found in the strata overlying the coal-seams. In addition to these assurances, Mr. James Lockett, Chairman of the Cheadle Park Colliery Company, who has undertaken the researches that have at last proved successful, had the advantage of the observations which were made by his son, Mr. William Lockett, of the sections of strata which were penetrated by a borehole on the estate of the Cheadle Park Colliery, as well as in the Foxdale shaft and the Major Barn sinking, to assure him in his own conviction that the Dilhorne seam would be eventually won at the Draycott Colliery. Mr. Lockett commenced sinking from the Four-feet seam at the Draycott pit on January 1st this year. The difficult work of sinking through the water-bearing strata which lay beneath that seam has since been carried out efficiently, until on the 16th inst. the Dilhorne seam was reached, lying at a depth of 74 yards below the Four-feet seam and 150 yards from the surface, the seam at this point being about 5 ft. 1 in. thick and clean and bright. It is understood to be Mr. Lockett's intention to proceed with the opening out of the seam without delay, and it is expected that there will be an output from the Draycott Colliery within three years of a thousand tons a day. The land leased by Mr. Lockett amounts to 710 acres, owned partly by Sir Thomas Pilkington, Mr. F. Bolton, Oakamoor, and Mr. F. Mather, Betley, and if Mr. Barrow is right in his estimate there should be in the four square miles which comprise the Cheadle district a quantity of coal, taking the Four-feet and the Dilborne seams together, of from 20 to 25 million tons. In addition to this, there are two seams below the Dilhorne seam which have not yet been tapped. First, there is the 'cobble' vein, which is 2 feet thick, and then there is the Woodhead seam, 2 ft. 10 in. in thickness.

[1] [See "The Geology of the Cheadle Coalfield," by George Barrow, F.G.S., Mem. Geol. Survey, 1903, pp. 27, 28.—Edit. Geol. Mag.]

An encouraging feature about the new recovery is there is every indication of the seam being worked practically free from water. The coal is valuable for household purposes, and will be put upon all the principal markets, the pitbank being situated close beside the Cheadle Railway, to which sidings have already been laid down, and the colliery premises thus placed into communication within a very few miles of the North Staffordshire Railway Company's main line between Crewe and Derby.—*Colliery Guardian, May* 27, 1904.

II.—On the Ossiferous Cave-Deposits of Cyprus. By Dorothy M. A. Bate.[1]

PREVIOUS to 1901 no systematic search of the cave-deposits of Cyprus appears to have been attempted. The geology was studied by M. Albert Gaudry, who published an elaborate work in 1862 with a geological map, and Drs. Unger and Kotschy in 1865 also gave a geological map of the island, differing somewhat from their predecessor.

As long ago as 1700 the Dutch traveller Corneille le Brun (Van Bruyn) published an account of his wanderings in Cyprus and the Levant, and mentions having visited a bed of bones, supposed to be those of saints, not far from the Monastery of Haghios Chrysostomos. A drawing of one of these bones is given, which Dr. Forsyth Major has since shown to be that of *Hippopotamus minutus*.[2]

The author started in 1901 in expectation of discovering an extinct fauna in this ossiferous breccia, and this expectation was amply fulfilled, for no fewer than twelve ossiferous caves were found, five at Cape Pyla in the south-east and seven on the southern slopes of the Kerynia Hills in the north of the island.

Two caves (mentioned by General di Cesnola in 1877, at Cape Pyla, as containing *human* fossilised bones) were first visited by the author. The rock is here composed of Miocene (probably Helvetian) limestone, weathered to a very great extent, and full of marine shells and corals, as well as numerous Echinoids (*Clypeaster portentosus*), also met with in the Miocene limestones of Malta.

Here a number of caves were discovered in the cliffs, five of which yielded remains of *Hippopotamus minutus*.

The author then describes these caves in detail. The caves explored at Cape Pyla were: (1) The Red Cliff Cave; (2) the Great Anonymous Cave; (3) the Small Anonymous Cave; (4) Haghios Jannos; (5) Haghios Saronda. This is the cave to which formerly pilgrimages were made and candles burned in honour of the sacred remains of saints.

The cave-deposits of the Kerynia Hills are of uncertain geological age, no fossils having been obtained from the limestone rock of which they are chiefly composed. Professor Gaudry concludes that the rock is of Cretaceous age, and, therefore, the oldest sedimentary deposit in the island. The seven caves discovered were all on the

[1] Being the abstract of a paper read before the Royal Society, June 9th, 1904. Communicated by Dr. H. Woodward, F.R.S., F.G.S.

[2] Proc. Zool. Soc., June, 1902.

southern side of the range, between the Aghirdhir Pass and the village of Kythræa, in a low broken line of cliffs parallel with the main ridge. These are called the Kerynia caves, and are named—(1) Coutzaventis; (2) Haghios Chrysostomos; (3) Anoyero Spelios; (4) Dikomo Mandra; (5) Haghios Elias; (6) the Elephant Deposit; (7) the Western Cave.

Most of these caves have, by reason of long atmospheric erosion, partially or wholly disappeared, leaving the stalagmitic flooring containing mammalian remains unprotected and exposed often at a considerable distance from the face of the cliffs. But although many of them are now almost obliterated by the falling in of the roof and walls, the author points out that wherever this has happened the limits of the floor are sharply defined by the hard ossiferous deposit and the stalagmitic floor. In close proximity are caves still preserved containing precisely similar deposits.

The fauna of the caves is comparatively scanty, the only other important extinct form besides the dwarf elephant and hippopotamus being a new species of Genet (*Genetta plesictoides*), described in the Proceedings of the Zoological Society.

III.—Further Note on the Remains of *Elephas cypriotes*, Bate, from a Cave-Deposit in Cyprus. By Dorothy M. A. Bate.[1]

THIS paper is a continuation of one already published[2] "On the Discovery of a Pigmy Elephant in the Pleistocene of Cyprus," and enters into a detailed description of the teeth of this small proboscidean whose remains are now in the British Museum of Natural History.

The collection includes incisors, milk molars, and permanent molars. Several of the latter still retain their position in the jaws, and in some instances the teeth of both sides of the same individual were found.

The permanent incisor tusks of two forms, presumably belonging to males and females, were found. They differ from the same teeth of the Maltese dwarf elephants in being considerably compressed laterally. The largest specimen measures 29·7 cm. along the outside of the curve, with a maximum diameter of 3·7 cm.

Of the upper cheek teeth the third and fourth of the milk series, as well as the three permanent molars, are described in detail. There was a small third milk molar (mm. 2) implanted by a single root, but no specimen was collected.

Of the lower series, the third and fourth milk molars and the three permanent teeth were represented by numerous examples and are fully described.

An almost entire left ramus of one young individual and the symphysial portion of another are also described. The only limb bone obtained was the distal portion of a femur.

[1] Being the abstract of a paper read before the Royal Society, June 9th, 1904. Communicated by Dr. H. Woodward, F.R.S., F.G.S.

[2] Read before the Royal Society, May 7th, 1903; see Geol. Mag., 1903, p. 241.

A corrected ridge formula for the molars of *E. cypriotes* is furnished, which, exclusive of talons, will stand as follows :—

$$\div,\ \frac{5}{5},\ \frac{7-8}{7-8},\ \frac{7-8}{7-8},\ \frac{8-9}{8-9},\ \frac{11-12}{11-12}$$

Dr. Leith Adams gives *E. melitensis* as follows :—

$$\frac{3}{3},\ \frac{5}{5},\ \frac{8-9}{8-9},\ \frac{8-9}{8-9},\ \frac{10}{10},\ \frac{12}{12}$$

There appears to be a strong resemblance between the teeth of *E. cypriotes* and those of the Maltese and Sicilian pigmy forms, more especially *E. melitensis*, but the marked lateral compression of the tusks in *E. cypriotes*, which is a constant character in all the specimens so far obtained, would in itself be almost sufficient to distinguish this species from the other pigmy elephants of the Mediterranean region. There seems to be good evidence that *E. cypriotes* was isolated and subsequently differentiated at an earlier period than the other small Mediterranean species in Malta and Sicily, the zoological evidence giving considerable support to the belief that Cyprus became an island at an earlier period, an idea which is further strengthened by the fact that the whole island is surrounded by deep water, and is not connected with the neighbouring lands by submerged banks, as is the case with the Maltese Islands.

The Maltese pigmy species have been considered most closely allied to *E. antiquus* and *E. Africanus*. On the other hand, it seems probable that *E. cypriotes*, which shows no affinity to the African species, is connected rather with *E. antiquus* and *E. meridionalis*.

It may be remarked that the remains of *E. cypriotes* and of *Hippopotamus minutus*, with which it is associated, vary but little in size, whereas in the dwarf species of elephants and hippopotami from Malta and Sicily a considerable variation in size is observable, so much so indeed that molars may be seen intermediate in size connecting *H. melitensis* (=*minutus*), *H. pentlandi*, and *H. amphibius*.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 27th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read :—

1. "On a New Species of *Eoscorpius* from the Upper Carboniferous Rocks of Lancashire." By Walter Baldwin, Esq., F.G.S., and William Henry Sutcliffe, Esq., F.G.S.

The specimen described was found in an ironstone nodule occurring on a fairly well marked horizon, about 135 feet above the Royley Mine (or Arley Mine) coal-seam, at Sparth Bottoms, about half a mile south-west of Rochdale Town Hall. The nodules occur in a band of blue shale, in which are well-preserved remains of *Carbonicola acuta*, ferns *Calamaria*, *Prestwichia rotundata*, and *Bellinurus bellulus*.

The animal is well represented by both the intaglio and relievo impressions: these, however, only show its dorsal aspect. A description of the specimen is given, and it is referred to a new species. Dr. Peach is of opinion that, like the recent scorpions, the ancient species visited the sea-shore in search of the eggs of invertebrates left bare by the tides, and the association of this new scorpion with king-crabs at Sparth Bottoms is in favour of this view. The specimen has been presented to the Manchester Museum.

2. "The Genesis of the Gold Deposits of Barkerville (British Columbia) and the vicinity." By Austin J. R. Atkin, Esq. (Communicated by the Secretary.)

The gold-bearing area of Cariboo (British Columbia) is roughly confined within a radius of 20 miles of Barkerville, to the band of varied crystalline rocks known as the Cariboo Schists, generally assigned to the Lower Palæozoic group. The veins follow the strike but not the dip of the rocks, the gangue is similar to that associated with the nuggets in the placers, and the reefs show very little or no oxidized ore. While all the reefs carry gold in greater or less quantities, none have been found rich enough to account for the placer-gold. It is the opinion of the author that the placer-gold has probably been derived from the enriched outcrops of the veins which once existed above water-level. Such enrichment is due to two causes: firstly, the leaching-out of pyrites leaving the less soluble gold in lighter, honeycombed quartz; and, secondly, to actual enrichment by precipitation. This may be due to the solubility of gold in solutions of ferric sulphate, derived from the decomposition of the pyrites. While the enriched zone was being formed, the weathering of the surface kept removing the leached outcrop, and constantly exposing fresh surfaces to atmospheric influences. To the weathering of these outcrops the rich placers are attributed. Some of the nuggets in the latter show no signs of attrition, as though they had been carried to their present position enclosed in a soluble matrix which was afterwards removed. The denudation of the reefs and the deposition of gold in the gravels appear to have taken place in Tertiary times.

II.—May 11th, 1904.—Horace B. Woodward, Esq., F.R.S., Vice-President, in the Chair.

The Chairman referred in feeling terms to the grievous loss sustained by the Society in the death of Sir Clement Le Neve Foster, F.R.S., Professor of Mining at the Royal College of Science. He was elected a Fellow in 1863, and as early as 1865 he communicated to this Society, conjointly with William Topley, the now classic paper on the Medway Gravels and the Denudation of the Weald—a paper which had largely influenced the views of geologists on the physiography of the South-East of England.

The Chairman announced that the Council had resolved to award the proceeds of the Daniel-Pidgeon Fund for 1904 to Mr. Linsdall Richardson, F.G.S., of Cheltenham.

The following communications were read:—

1. "On some Quartzite Dykes in Mountain Limestone near Snelston (Derbyshire)." By Henry Howe Arnold-Bemrose, Esq., M.A., F.G.S.

At Snelston, 3½ miles south-west by south of Ashbourne, there is an inlier of Mountain Limestone surrounded by Keuper Marl. It is roughly elliptical in shape, the major axis extending for a distance of about half a mile north-north-east and south-south-west.

The limestone is generally massive, with a few chert nodules in the upper parts; the rock in many places has a broken appearance, and it contains small hollow spaces; and large portions of the limestone have been partly or completely dolomitized. The floor and faces of the quarry are traversed by vertical veins or dykes of calcite, fluor-spar, barytes, calcareous sandstone, and quartzite.

The quartzite of these 'dykes' is described microscopically. It consists of angular detritus, quartz-grains with enclosures, a few small grains of felspar, and a few shreds of mica. The grains are cemented by silica, and sometimes by calcite. The rock in contact with the dykes sometimes contains quartz in isolated bipyramidal crystals and granular aggregates. The silica is present in the limestone in two forms, which have had an entirely different origin.

Reference is given to examples of sandstone dykes hitherto described, and then the origin of the quartzite dykes at this locality is discussed. An important bed of sandstone was found by sinking for a well at Marston Common Farm; and the same bed is found also in a quarry about 800 feet south of the farm. The microscopic aspect of the rock is precisely similar to that of the dykes. It is at a period later than the Keuper that the silica which cemented the sandstone of the dykes and of the Common Farm appears to have been introduced.

2. "Phenomena bearing upon the Age of the Lake of Geneva." By C. S. Du Riche Preller, M.A., Ph.D., A.M.I.C.E., M.I.E.E., F.R.S.E., F.G.S.

Following up his investigations concerning the age of the principal Alpine lake-basins, the author has, during a recent prolonged stay on the Lake of Geneva, examined the low-level gravel-beds and other alluvia to the Rhone Valley, from Geneva to the Jura bar near Fort de l'Écluse, as well as the high-level gravel-beds of La Côte above Rolle and of the Jorat district above Lausanne, and, further, the rock-formations on both sides of the lake, in view of evidence of flexures as the primary cause of the formation of the present deep lake-basin.

After describing the phenomena around the Lake of Geneva, and comparing them with those around the Lake of Zurich, he is led to the following conclusions:—

(1) The low-level gravel-beds of the Rhone Valley near Geneva are, like the deep-level gravel-beds of the Limmat Valley near Zurich, fluviatile deposits of the second interglacial period, and were formed before the present deep lake-basin came into existence.

(2) The high-level gravel-beds of La Côte above Rolle and of the Jorat district above Lausanne are, like the corresponding deposits of the Uetliberg near Zurich, and of the Dombes and of Lyons, true Deckenschotter. Hence the term 'alluvion ancienne,' should, in its proper acceptation, only apply to the high-level deposits.

(3) The formation of the present deep lake-basin of Geneva was, like that of Zurich, primarily due to the lowering of the valley-floor by flexures of the Molasse and its contact-zones, posterior to the maximum glaciation, as evidenced more especially by the reverse dip of the old erosion terraces.

The author holds that the concord of evidence in the two cases strengthens the conclusion, already arrived at by analogy in his previous paper, that the Lake of Geneva, together with the other principal zonal lakes between the Alps and the Jura, was formed under similar conditions and at the same time as the Lake of Zurich, that is, towards the close of the Glacial Period; indeed, the phenomena in support of that view are, in the case of the Lake of Geneva, on a grander scale, more striking, and, if anything, more conclusive.

III.—May 25th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the occurrence of a Limestone with Upper Gault Fossils at Barnwell, near Cambridge." By William George Fearnsides, Esq., M.A., F.G.S.

The section in the great Gault pit worked by the Cambridge Brick Company at Barnwell is as follows:—

	Thickness in feet.
5. Surface-soil with gravel and Chalk Marl, disturbed	15 to 17
4. Dull leaden clay, almost devoid of determinable fossils but with a few phosphate nodules, etc.	39
3. Compact, well-jointed, homogeneous clay, with large ammonites of the *rostratus*- or *Bouchardianus*-type ...	3
2. Hard calcareous bed with *Inoceramus*, *Schlœnbachia varicosa*, and *Terebratula biplicata*.........................	0 to 1
1. Blue, well-laminated clay, with fossil fragments and pale phosphate nodules	4 seen

The limestone is variable in thickness, and is largely made up of comminuted shells of *Inoceramus*. It occurs in a series of flattened lenticles, a few yards in diameter and about a foot thick. It contains abundant phosphate nodules of at least three types—green, pale, and dark-brown in colour. Foraminifera are abundant, as also fragments of lamellibranchs, brachiopods, small gastropods, echinoids, and crustacea. A fibrous material, possibly chitin, chips of quartz, a little orthoclase, and glauconite are also recognized microscopically. The fauna is not markedly different from that of the underlying clay. A list is given which shows that this fauna has been recorded from the Upper Gault of Folkestone, and agrees most closely with that from Bed ix of Mr. Hilton Price's paper on that locality. As these fossils are obtained 40 feet below the upper surface of the Gault seen in the section, it is clear that the whole of the Upper Gault of Cambridge was not used up in the making of the 'Cambridge Greensand'; and this fact, together with the northward thinning of the Gault as it passes into the Red Chalk, necessitates a modification in the view commonly held as to the origin of this 'Greensand' deposit.

2. "On the Age of the Llyn Padarn Dykes." By James Vincent Elsden, Esq., B.Sc., F.G.S.

The paper produces evidence which seems to suggest that the bulk of the greenstone dykes of this area belong to an earlier period of eruption than has been generally assigned to them; and there is proof that some of them may even be older than the quartz-felsite of the Llyn Padarn ridge. The greater part, if not actually of Bala age, seem to have been intruded before the great post-Bala crush-movements, which produced the folding of the Lower Cambrian rocks of Llanberis, had entirely ceased. At the same time, the evidence does not exclude the possibility that some of the intrusions may be of later date. The evidence on which these conclusions rest is based mainly on the signs which the intrusions exhibit of having been considerably modified by earth-pressures, more especially in those portions which protrude into Cambrian strata. Petrographical considerations, also, make it impossible to separate these rocks from the diabase sills of Bala age occurring farther to the south and south-west of this area; and there is a strong presumption that they represent the last residuum of the magma from which Bala sills were derived.

The north-western portions of the dykes, enclosed in the older rocks of the Llyn Padarn ridge, are comparatively free from dynamic metamorphism; but when traced into the more yielding Cambrian grits and slates, they become structurally deformed and often so highly sheared as to be hardly recognizable as parts of the same dyke. It is suggested that such highly sheared greenstones as occur in the ridge are of still older date. One section is described in which a sheared greenstone is pierced by a tongue of felsite about 2 inches wide and 2 feet long. The felsite is undistinguishable from that of the rest of the ridge and on the borders of the greenstone. Full petrographical descriptions of the minerals of the rocks in their altered and unaltered state are given, the minerals being taken in the order of their consolidation, and the rocks considered in the 'dynamic' or crush-zone of the sediments and in the 'static' or pressure-zone of the Llyn Padarn ridge. These minerals are apatite; iron-ores altered to sphene and leucoxene, and to a mineral which is apparently perowskite; felspars belonging to the albite-anorthite series of one generation undergoing 'albitization,' and the formation of felspar-mosaic; two pyroxenes, one possibly rhombic and the other like malacolite, granulitized and associated with secondary albite in the crush-zones, or passing into amphiboles and chlorites; original amphiboles rare, but common as actinolite, tremolite, and asbestos alteration-products of pyroxene; biotite uncommon; chlorite; quartz; epidote; and calcite. In the least altered rocks the minerals are comparatively unchanged; then there is, first of all, molecular rearrangement under pressure without movement; next, mylonitization and recrystallization; and lastly, the whole rock becomes cataclastic, with partial or complete obliteration of its original structure. The gradual appearance of these features towards the east is proof that the deforming agency operated from that direction.

Mineralogical Society, June 7th, 1904.—Dr. Hugo Müller, President, in the Chair. The Rev. Mark Fletcher contributed a note on mispickel from Sulitjelma mine, Norway, containing about 1·32 per cent. of cobalt, and showing the forms [011], [012], [110]. —Mr. G. F. Herbert Smith exhibited a hand-refractometer of the Bertrand type in which the curvature of the focal surface has been reduced by means of a correcting lens, with a consequent improvement in the definition of the shadow edges.—Professor H. A. Miers gave an account, illustrated by numerous lantern slides, of the development of the Kimberley Diamond Mines. He traced the changes in the methods of working from the first surface diggings to the time when the blue-ground was brought to the edge of the pit by a 'cobweb' of wire ropes stretching from the numerous independent claims into which the mines were split up, and showed how the increasing difficulties involved in this method led to the final consolidation of the mines under Beit & Rhodes, and the initiation of the present system of mining, which consists in sinking shafts on the edge of the pit and running cross-cuts into the blue-ground. He referred finally to the recent discovery of blue-ground in the neighbourhood of Pretoria.

Palæontographical Society.

The annual general meeting of the Palæontographical Society was held at the Geological Society's apartments, Burlington House, on Friday, 17th June, Dr. Henry Woodward, F.R.S., President, in the Chair. The fifty-seventh annual report of the Council and the balance sheet were submitted for the approval of the members. The report began by alluding to the activity at present prevailing in the study of British fossils, and stated that the Palæontographical Society's Council continued to receive more offers of matter than they were able to accept for immediate publication. The volume for 1903 was unusually large, and was illustrated with no less than 48 plates. It comprised the concluding parts of Dr. Foord's Monograph of Irish Carboniferous Cephalopoda, and vol. i of Mr. Woods' Monograph of Cretaceous Lamellibranchia. It also contained instalments of the Monograph of Chalk Fishes, Carboniferous Lamellibranchiata, and British Graptolites, besides the first part of a new Monograph by Mr. Cowper Reed on the Palæozoic Trilobites of Girvan. The publication of this volume involved an expenditure of over £200 beyond the income received during the year. The report, indeed, showed a gradual decrease in the income of the Society during recent years, and referred to the necessity of filling the numerous vacancies caused by death with the younger students of fossils, on whom the future prosperity of the Society depends. The loss of the Treasurer, Mr. Robert Etheridge, of Dr. C. H. Gatty, and of Mr. William Vicary, was especially deplored. Dr. Henry Woodward, F.R.S., was re-elected President; Dr. George J. Hinde, F.R.S., was elected Treasurer; and Dr. A. S. Woodward, F.R.S., was re-elected Secretary. Bishop Mitchinson, Rev. G. F. Whidborne, Mr. W. H. Hudleston, F.R.S., Mr. T. Leighton, and Mr. A. Strahan, F.R.S., were elected new members of Council.

CORRESPONDENCE.

THE 'YOREDALE' ROCKS OF NORTH DERBYSHIRE.

Sir,—A few days ago I enjoyed the privilege of attending the excursion of the Geologists' Association to North Derbyshire, and I was impressed by the tenacity with which many of the members of the party—including geologists of repute—adhered to the use of the term 'Yoredale' for the strata seen in the excavations of the Derwent Valley Water Board and elsewhere.

In Derbyshire and North Staffordshire there is a well-marked group, consisting of dark shales with thin limestones and sandstones, situated above the massive Mountain Limestone and below the lowest of the Millstone Grits.

I should like to ask those who still consider the name 'Yoredale' to be applicable to this group in this area to be so kind as to state the foundations of their belief. Are the palæontological or the lithological characters their guide?

From either point of view, I think it has been clearly shown that the deposits in question are sufficiently differentiated from the typical Yoredales to justify a distinctive appellation.

The name 'Yoredale' is a good one so long as it is confined to the type of deposit that exists in and about the Yorkshire Yoredale district; in addition to its historic interest it has an intrinsic value in connoting a set of conditions pre-eminent in that area; but to continue to use it for this rock in North Staffordshire and Derbyshire is to maintain a stumbling-block in the way of all workers who are not familiar with the two areas.

The name 'Pendleside Group' has been proposed by Dr. Wheelton Hind and myself, but if there are objections to this there still remains the choice of the non-committal 'Shales with limestones' and 'Shales with sandstones' of the Geological Survey.

Call them what you will; but if the name Yoredale is to stand for these beds let it be on the basis of solid palæontological evidence.

Museum of Practical Geology, London. J. Allen Howe.
May 28th, 1904.

NEOLITHIC FLINT FLAKES AT HOPE'S NOSE, TORBAY.

Sir,—On the 4th of last May I found four flakes or chips of flint about two feet deep in the earthy head or landwash capping the low cliff on the eastern side of the raised beach at Hope's Nose. The fragments were exposed on the face of the section. Sir John Evans kindly informed me that he considered two of the flints to be artificially made, and probably of Neolithic date. The soft earthy capping of the cliff is about the same height as the highest beach deposits, but is clearly much more recent. The flints did not overlie the beach, but were to the eastward of the eastern end of the raised beach.

I see that Sir Archibald Geikie mentions the fact that the 20 foot terrace on the north-east coast of Ireland has *produced* many worked flints, regarded as Neolithic (Q.J.G.S., vol. lx, p. xcvi). These Hope's Nose flints are clearly more recent than the raised beach (about equivalent to a 24 foot terrace), and it is likely enough that they were made out of the flints which occur in the beach, but are not elsewhere found in the immediate neighbourhood. I am far from wishing to trouble your readers with any remarks of my own on this rather perplexing subject, but the mere fact of the discovery of Neolithic flakes newer than the adjacent beach at Hope's Nose, Torbay, may be worth a bare record. A. R. Hunt.

Southwood, Torquay.
June 14*th*, 1904.

OBITUARY.

FRANK RUTLEY.

Born May 14, 1842. Died May 16, 1904.

The son of a medical practitioner at Dover, Frank Rutley became early in life interested in geology, and studied at the Royal School of Mines from 1862 to 1864. In 1867 he was appointed an Assistant Geologist on the Geological Survey, under Sir Roderick Murchison and Professor Ramsay. For a few years he was engaged in field-work with W. T. Aveline in the Lake District. There he gave some attention to the subject of glaciation, but, probably through the influence of his colleague, the late J. Clifton Ward, he began to undertake the special study of rocks and rock-forming minerals. The importance of the microscope in the examination of rocks was at this period becoming recognized, and Mr. Rutley was transferred to the Geological Survey Office in Jermyn Street, to undertake the determination and description of the igneous rocks that were collected in the course of the geological survey; he took charge also of the rock-collection in the Museum of Practical Geology. His first official work dealt with the volcanic rocks of East Somerset and the Bristol district (1876), and he later on wrote special memoirs on the eruptive rocks of Brent Tor (1878), and on the Felsitic Lavas of England and Wales (1885).

He was author in 1874 of a small but exceedingly useful work on Mineralogy for Murby's "Science and Art Department" series of text-books, of which a twelfth edition was issued in 1900. In 1879 he wrote an elementary text-book of Petrology, the first work of the kind published in this country, entitled "The Study of Rocks," and illustrated by many of his own excellent drawings. Of this a second edition was issued in 1881. Later on in 1888 he published a work on "Rock-forming Minerals," and in 1894 "Granites and Greenstones: A series of Tables and Notes for Students of Petrology."

In 1882 Mr. Rutley was appointed Lecturer on Mineralogy in the Royal College of Science, a post which he occupied for about ten years, when he was unfortunately forced to retire through disablement by paralysis. For several years, so far as his strength permitted, he continued to work with unabated enthusiasm at petrological subjects; and until the end he never ceased to take great interest in his favourite studies. He was a man who in early life was endowed with great vigour, but his habits were somewhat erratic; he burned the midnight oil far too much, toiling into the early morning when he should have slumbered, and finding it difficult in consequence to conform to the regulations of official life; but he was a genial companion, full of dry humour, and ever ready to assist others. His published work shows how assiduous and painstaking he was, and the accompanying list gives the best idea of the special researches which he carried on for a number of years. He was awarded the Murchison Fund by the Council of the Geological Society in 1881, and later on he served for a few years as a member of the Council:—

1865. [Letter on a Subsidence at Lexden, in Essex]: Geol. Mag., Vol. II, pp. 231–2.

1870. [Letter on] Geology of the Lake District: ibid., Vol. VII, pp. 584–5.

1871. [Letter on] Glaciation of the Lake District: ibid., Vol. VIII, p. 93.

1873. "On a New Method of Writing Crystallographic Formulæ": ibid., Vol. X, pp. 299–301, 527–8.

1875. "Notes on some peculiarities in the Microscopic Structure of Felspars": Quart. Journ. Geol. Soc., vol. xxxi, pp. 479–487.

1876. "On some Structures in Obsidian, Perlite, and Leucite": Micr. Journ., vol. xv, pp. 176–183.

1877. "On Microscopic Structures in Tachylite from Slieve-nalargy, Co. Down, Ireland": Journ. Roy. Geol. Soc. Ireland, ser. ii, vol. iv, pp. 227–232.

1879. "On Community of Structure in Rocks of Dissimilar Origin": Quart. Journ. Geol. Soc., vol. xxxv, pp. 327–340.

"On Perlitic and Spherulitic Structures in the Lavas of the Glyder Fawr, North Wales": ibid., pp. 508–9.

1880. "On the Schistose Volcanic Rocks occurring on the West of Dartmoor, with some Notes on the Structure of the Brent Tor Volcano": ibid., vol. xxxvi, pp. 285–294.

[Letter on] The term 'Schist': Geol. Mag., Dec. II, Vol. VII, pp. 239–40.

1881. "The Microscopic Characters of the Vitreous Rocks of Montana, U.S.A.": Quart. Journ. Geol. Soc., vol. xxxvii, pp. 391–399.

"On the Microscopic Structure of Devitrified Rocks from Beddgelert and Snowdon; with an Appendix on the Eruptive Rocks of Skomer Island": ibid., pp. 403–412.

"Visit to the Museum of Practical Geology [Rock Collection]": Proc. Geol. Assoc., vol. vii, pp. 114–15.

1884. "On Strain in Connexion with Crystallization and the Development of Perlitic Structure": Quart. Journ. Geol. Soc., vol. xl, pp. 340–346.

1885. "On Fulgurite from Mont Blanc; with a Note on the Bouteillenstein, or Pseudo-Chrysolite of Moldauthein, in Bohemia": ibid., vol. xli, pp. 152–156.

"On Brecciated Porfido-rosso antico": ibid., pp. 157–161.

[Letter on] The Enstatitic Lavas of Eycott Hill: Geol. Mag., Dec. III, Vol. II, p. 285.

1886. "On some Eruptive Rocks from the Neighbourhood of St. Minver, Cornwall": Quart. Journ. Geol. Soc., vol. xlii, pp. 392–400.

"The Igneous Rocks, etc., of the Neighbourhood of the Warwickshire Coal-field": Geol. Mag., Dec. III, Vol. III, pp. 557–565.

1887. "On the Rocks of the Malvern Hills": Quart. Journ. Geol. Soc., vol. xliii, pp. 481–514.

1888. "On Perlitic Felsites, probably of Archæan Age, from the Flanks of the Herefordshire Beacon; and on the possible Origin of some Epidosites": ibid., vol. xliv, pp. 740–744.

1889. "On Fulgurites from Monte Viso": ibid., vol. xlv, pp. 60–66.

"On Tachylite from Victoria Park, Whiteinch, near Glasgow": ibid., pp. 626–632.

1890. "On Composite Spherulites in Obsidian from Hot Springs near Little Lake, California": ibid., vol. xlvi, pp. 423–428.

"On a Specimen of Banded Serpentine from the Lizard, Cornwall": Trans. Roy. Geol. Soc. Cornwall, vol. xi, p. 239.

[Notes on Anglesey Rocks]: Proc. Liverpool Geol. Soc., vol. vi, p. 2.

1891. "On a Spherulitic and Perlitic Obsidian from Pilas, Jalisco, Mexico": Quart. Journ. Geol. Soc., vol. xlvii, pp. 530–532.

"On some of the Melaphyres of Caradoc, with Notes on the Associated Felsites": ibid., pp. 534–543.

"Notes on Crystallites": Min. Mag., vol. ix, p. 261.

1892. "Note on Crystals of Manganite from Harzgerode": ibid., vol. x, pp. 20–1.

1893. "On the Dwindling and Disappearance of Limestones": Quart. Journ. Geol. Soc., vol. xlix, pp. 372–382.

1894. "On the Sequence of Perlitic and Spherulitic Structures: a Rejoinder to Criticism": ibid., vol. L, pp. 10–13.

"On the Origin of certain Novaculites and Quartzites": ibid., pp. 377–391.

"Note on a Zircon from Expailly, Haute Loire": Min. Mag., vol. x, p. 278.

"On Fulgurites from Griqualand West": ibid, p. 280.

"Note on some Inclusions in Quartz": ibid., p. 285.

1895. "On a Sandy Ironstone occurring above the Chalk at Capel, near Dover": Geol. Mag., Dec. IV, Vol. II, pp. 227–229.

1896. "On the Alteration of certain Basic Eruptive Rocks from Brent Tor, Devon" (abstract): Quart. Journ. Geol. Soc., vol. lii, p. 66.

1899. "On a Small Section of Felsitic Lavas and Tuffs near Conway (Caernarvonshire)": ibid., vol. lv, pp. 170–175.

(With J. Park.) "Notes on the Rhyolites of the Hauraki Goldfields (New Zealand)": ibid., pp. 449–468.

1900. "Additional Notes on some Eruptive Rocks from New Zealand": ibid., vol. lvi, pp. 493–510.

1901. "On some Tufaceous Rhyolitic Rocks from Dufton Pike (Westmorland)": ibid., vol. lvii, pp. 31–37.

[Note] "On the Olifant Klip from Lydenburg and Ladysmith": Geol. Mag., Dec. IV, Vol. VIII, p. 555.

1902. "On an Altered Siliceous Sinter from Builth (Brecknockshire)": Quart. Journ. Geol. Soc., vol. lviii, pp. 28–34.

MISCELLANEOUS.

Bridlington Crag.—The fauna of the Bridlington Crag, described by Mr. G. W. Lamplugh in the Geological Magazine for 1881, has always been of special interest to geologists.[1] The following account by Mr. Thomas Sheppard of recent excavations at Bridlington exposing this deposit will be of special interest to our readers.

Recently an opportunity has presented itself of examining the shell patches, and a party of geologists left Hull for an examination

[1] See also his letter in May No., p. 237.

of the excavations now being carried on in connection with the new sea-wall and promenade being built at Bridlington. For the purpose of making secure foundations, large square holes of about 8 feet sides are dug into the beach at some distance from the present sea-wall, north of the promenade. These excavations are made to extend about 6½ feet into the basement clay—the dark, leaden-coloured, compact deposit containing foreign stones and occasional shell fragments. At irregular intervals in the clay occur pockets or streaks of the 'Crag,' which are not welcomed so much by the contractors as by the geologists. These pockets sometimes consist of a slightly greenish-coloured sand, crowded with shell fragments, and in other cases the sand is of a ferruginous nature, due to a quantity of iron oxide. Whilst shells usually occur in profusion in these pockets, their condition, number, and variety differ. In one the shells are found to be broken up into very small fragments; in another they occur not so plentifully, but in fairly perfect condition; another will principally contain portions of one particular species, such as *Cyprina islandica*. Another contained several large *Pectunculi.*

Mr. Matthews, the borough surveyor of Bridlington, who has interested himself in the matter, has done his best to assist the local geologists, and a fine collection which he has got together has been presented to the Hull Museum, through Mr. Stather, the Secretary of the Hull Geological Society. Amongst the material is a small heap of broken shell fragments, some far-travelled pebbles (an examination of which will doubtless yield interesting results), a few fairly perfect shells, and a single tooth of probably a small shark. These represent the careful washing of two bucketfuls of material. In addition Mr. Matthews kindly conducted the visitors round the excavations, where, fortunately, much of the shell material had recently been thrown out, and from this many fairly perfect specimens were obtained, and a large quantity of the shell-bearing sand was brought away for detailed examination. Among the shells secured the following have been identified, and many more will be added to this list after the material has been properly examined: *Anomia ephippium, Pecten islandicus, Mytilus edulis, Nucula cobboldiæ, Pectunculus glycymeris, Cardium, Cyprina islandica, Astarte compressa, Tellina balthica, Mactra, Mya, Saxicava rugosa, Pholas, Dentalium entales, Scalaria, Fusus,* and *Pleurotoma.*

The collection made by the late Judge Bedwell, together with those recently acquired, will be exhibited in a case in the Museum. [*Hull Mus. Publ., No.* 19, 1904.]

Professor E. Kinch, of Cirencester, discusses the question of "The Thames Head" (*Agricultural Students' Gazette,* April, 1904), and maintains that the true head is at Trewsbury Mead, Coates, near Cirencester.

"Notes on the Glacial Phenomena of part of Wharfedale" form the subject of an article by Mr. J. R. Dakyns (Proc. Yorksh. Geol. and Polytech. Soc., vol. xv, pt. 1). He finds no evidence of foreign ice, but all the facts indicate huge confluent glaciers, or ice-shafts (if that term is preferred) of home-made ice.

SUPPLEMENT TO THE

GEOLOGICAL MAGAZINE

FOR JULY, 1904.

ON THE ORIGIN OF THE MARINE (HALOLIMNIC) FAUNA OF LAKE TANGANYIKA.

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[*With Two Plates.*]

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NOTE.—It should be observed that the title of this paper is rather unfortunate since it starts by begging the question of a marine origin. I consented to write a paper for the *Victoria Institute* on the "Tanganyika Problem," and this I have endeavoured to do, so far as available information will allow me, but I admit at the outset that many years of observation must elapse ere the Tanganyika Problem is fully solved.

PART I.

GENERAL CONSIDERATIONS, ZOOLOGY AND PALÆONTOLOGY.

Introductory.—Fifty years ago Central Africa itself presented a problem, which as far as geographical exploration extends, was ripening for solution at the hands of the bold explorers of the latter half of the nineteenth century. By degrees the wonders of the Dark Continent were revealed to the geographer and the naturalist, and even the geology of those regions has received some share of attention, rather by way of comparison with the already known features of more accessible districts, such as the Cape, than for any detailed and systematic description of the rocks which constitute their surface. Although missionaries of German origin contributed materially to our early knowledge of East Central Africa, still the larger share of exploration has fallen to the lot of our own fellow-countrymen.*

When the geographical features became better known, it was ascertained that this once mysterious region contained numerous lakes of immense size, some of them situated in deep chasms of the earth's crust. And, more unexpected still, it was found that there were volcanoes both extinct and active, constituting lofty mountains; and furthermore that on some of these mountains glaciation had been developed on a considerable scale, and that glaciers even now exist on the higher peaks, actually under the equator.

What wonder, then, that Equatorial Africa, and particularly the eastern portion of it, should present problems, both in geology and zoology, which are difficult of solution? As for ourselves we must admit at the outset that we are entirely dependent on the descriptive portion of those numerous and excellent works, which tell us of this country; and if we venture in any case to hesitate at accepting all the inferences

* One of the greatest of whom, Sir H. M. Stanley, has just passed away; to the general regret of all from the King downwards. Sir Henry Stanley was a Hon. Corresponding Member of the Institute.—E. H. (ED.)

which their authors have drawn, it must be with bated breath and with the full consciousness ever present in our minds that they have been there and that we have not. In the light of so much that has recently been revealed, it is only natural that many controversies should arise and some of these perhaps may be ultimately settled by more extended investigations leading to further knowledge of the subject. As a case in point, I may mention the remarkable circumstance which has greatly exercised the minds of certain zoologists, viz.:—that there are some species of fishes in the waters of the Upper Nile which also occur in the hydrographic basin of the Jordan in Palestine, and yet are not found in the waters of the Lower Nile in Egypt. When zoologists are desirous of accounting for anything which seems abnormal or difficult of explanation, they are quite prepared to make the earth's surface undergo considerable modifications in order to suit their special line of argument, and indeed they can generally find a sufficient number of geologists to back them in such a course. This subject may crop up again when we proceed to consider the geological structure of eastern Equatorial Africa, and, therefore, it will be sufficient at the present moment merely to refer to the hypothesis, which connects the drainage of the Jordan system, through the Gulf of Akabah and the valley of the Red Sea, then supposed to be a fresh-water river, with a portion of the "Rift Valley" system, and ultimately with the drainage of the Upper Nile. Far be it from me to say that such an explanation is incorrect, but it certainly ignores all existing hydrographic arrangements most completely.*

The case I have just quoted is perhaps more difficult of solution than the problem which we are now called upon more especially to consider, viz. :—the origin of the halolimnic fauna of Lake Tanganyika, or in other words what Mr. Moore very aptly calls the "Tanganyika Problem." In attempting to grapple with this very curious and interesting question, besides the zoological evidence, it will be necessary to consider the geological structure of Equatorial Africa as far as the scanty details of our present knowledge permit; and if we venture in this connection to attempt to trace any portion of its physical history in times past, such reconstruction should harmonize as much as possible with known facts and existing features.

* On this subject the reader is referred to a paper "On the physical conditions of the Mediterranean Basin, which have given rise to a community of some species of fresh-water species in the Nile and in the Jordan Basins." *Trans. Vict. Inst.*, vol. xxxi, p. 3 (with map).—E. H. (Ed.)

History of the subject and statement of Mr. Moore's views.—The history of the recognition of the halolimnic fauna is important as tending to show what were men's views from time to time as each step in the progress of discovery was made. It will be remembered that Lake Tanganyika was discovered by Burton in 1857, and that his companion, Speke, picked up a few dead shells from the shores and brought them to England. The well-known conchologist, Dr. Sam. P. Woodward (*Proc. Zool. Soc.*, 1859, p. 348, Pl. XLVII) was struck with the peculiar forms of some of the gasteropods, which he considered had a certain marine look about them. Subsequently when further supplies were procured, Mr. Edgar Smith (*Proc. Zool. Soc.*, 1881, p. 276), in a paper on a collection of shells from Lakes Tanganyika and Nyassa, expressed an opinion that they might turn out to be the relics of a former sea. The subsequent discovery of medusæ in Lake Tanganyika seemed to confirm these views as far as that lake was concerned. Hence before Mr. Moore appeared upon the scene most of those who had paid attention to the subject had expressed themselves as favouring the view of the marine origin of this peculiar fauna.

Mr. Moore, as a result of his first journey in 1896, found "that in Nyassa and Shirwa there were no jelly-fishes, nor anything except purely fresh-water forms; while in Tanganyika there were not only jelly-fishes, but a whole series of molluscs, crabs, prawns, sponges, and smaller things, none of which appeared in any of the lakes he then knew, and all of which were distinctly marine in type.* Further than this, however, he found that none of these strange marine looking animals were to be compared directly with any living marine forms, yet, in their structure, some of them certainly seemed to antecede a number of marine types in the evolutionary series, and, in consequence, they appeared to hail from the marine fauna of a departed age. The most definite result of the first Tanganyika expedition, therefore, appeared to be that the sea had at some former time been connected with the lake, but when or how remained a mystery."

The above are Mr. Moore's own words in explanation of his views after the termination of his first expedition. It should be borne in mind that at this period, viz., in 1898, when his inferences were laid before the Royal Society (*Proc. Roy. Soc.*, vol. 62), there was an idea then partially and perhaps generally prevailing, that owing to the peculiar structure of the Rift-

* J. E. S. Moore, *The Tanganyika Problem* (1903), p. 3.

Valley system and its obvious physical connection with the great Red Sea depression, that the "halolimnic" fauna might have entered Lake Tanganyika from that quarter, and would consequently be found in some of the Rift-Valley lakes to the northwards, and especially in Lake Kivu, with which at the present day Tanganyika is hydrographically connected through the River Rusizi. It was therefore indeed a surprise when Mr. Moore had to announce as the result of his second expedition, commenced in the spring of 1899, that no trace of the "halolimnic" fauna had been discovered in any of the lakes, such as Kivu, the Albert Edward, or the Albert Nyanza, which lie to the northward of Tanganyika in the western arm of the Rift-Valley system. Nay, more, it would seem that no such thing as the halolimnic fauna was to be found in the great upland basin of the Victoria Nyanza, nor in the chain of lakes associated with Lake Rudolf (Basso Narok), which lie towards the northern termination of the eastern arm of the Rift-Valley system.*

To quote Mr. Moore's own conclusions on this point: "It has been shown that throughout Equatorial Africa, as in other great continents, there is a normal fresh-water fauna which has nothing peculiar about it . . . Subsequently, the fauna of L.

* There appears to be no longer any doubt as to the presence in Lake Victoria Nyanza of medusæ indistinguishable from those of Lake Tanganyika, and the fact cannot be without its effect upon the acceptance of the view put forward by Mr. J. E. S. Moore that the fauna of Lake Tanganyika differs from that of the other East African lakes in alone possessing evidences of a marine origin. On December 1, 1903, Prof. Ray Lankester exhibited at the Zoological Society some medusæ from Victoria Nyanza obtained by Mr. Hobley on August 31, 1903, and sent to London by Sir Charles Eliot. A doubt being raised by some supporters of Mr. Moore's theory as to these medusæ having really come from Lake Victoria and not from Lake Tanganyika, Sir Charles Eliot, in a letter dated Mombasa, December 20, 1903, wrote to Prof. Lankester saying that the medusæ were collected by Mr. Hobley himself, in the Kavirondo Gulf, by the side of which the railway terminus is situated, and that the water was full of them. Mr. Hobley, at the request of Sir Charles Eliot, had endeavoured to study the life-history of the medusæ, but he failed to keep them alive for more than a few days. The specimens sent to London were said by Mr. R. T. Günther to be indistinguishable from the *Limnocnida tanganyicae* of Lake Tanganyika. It is interesting in this connection to note that the Victoria medusæ were discovered quite independently in the same locality (Kavirondo, in the Kisuma district), and apparently at about the same time of year. According to *Globus* (January 28, p. 84), M. Ch. Alluaud, on the day of his arrival at Lake Victoria, discovered a marine medusa similar to that of Lake Tanganyika, and communicated an account of his discovery to the Paris Geographical Society on September 19, 1903.—*Nature.*

Tanganyika has been examined in detail, and it has been shown that this lake, like all other great lakes of Central Africa, contains the ordinary fresh-water fauna of the continent; but that in Tanganyika, and in Tanganyika alone, there are a number of organisms possessing definitely marine and somewhat archaic characters. Along with these, the halolimnic members of the Tanganyika fauna, there are others, such as the prawns, sponges and protozoa which, although not like the previous types, unique in being found in Tanganyika for the first time as fresh-water forms, are notwithstanding probably portions of the same group, for they are peculiar to Tanganyika, and are not characteristic of the general fresh-water fauna of the African continent." He further suggests that the African ganoids and certain other members of the African fish fauna may be portions of the "halolimnic" fauna. Lastly, he points to the significance of the similarity which subsists between the shells of the halolimnic gasteropods and "the remains of those found in the deposits of the old Jurassic seas."

Thus far Mr. Moore. When we ourselves attempt to face the Tanganyika Problem, it is obvious that it will have to be considered both from a zoological and a geological point of view, and the question is which shall we consider first, the zoology or the geology? We are dealing with an exceptional fauna, occurring under peculiar conditions and in what was, until quite recently, a most out-of-the-way place. Perhaps the first question we should ask ourselves is this: Do we consider that there is sufficient evidence of the marine origin of the halolimnic fauna? This fauna is placed by Mr. Moore himself under two different categories. (1) The halolimnic gasteropods, which are thought to be homæomorphic with certain shells from beds of the Inferior Oolite formation in Western Europe, and are thus inferentially regarded as descendants of those forms. (2) A fauna, not so thoroughly exceptional as the halolimnic gasteropods, made up of prawns, sponges, protozoa, etc., which are archaic in type and may be portions of the same group of marine derivatives. The presence of *Medusa* also is held greatly to strengthen this view. As regards the portion of the argument relating to the fishes it has been stated by a competent authority that the fishes described by Mr. Boulenger in Mr. Moore's beautiful book are all essentially present day types, and do not in any way represent survivors from the seas of the Mesozoic period.*

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* *Geological Magazine*, September, 1903, p. 418.

The argument limited to the halolimnic gasteropods.—Although, therefore, the subsidiary fauna of exceptional character may help to strengthen the argument in favour of the marine origin of the entire halolimnic group, yet the most important link in this chain of evidence is to be sought in the *halolimnic gasteropods*, which are considered so greatly to resemble Inferior Oolite forms, and which on the strength of this resemblance are held to be derived from a well known gasteropod fauna of Jurassic age. The malacological evidence, as regards the Tanganyika species, has been well worked out by Mr. Moore, and the conclusions as to the peculiar mixed and to a certain extent archaic structure of their anatomy must undoubtedly have great weight. But at this point the argument fails us, for when we are disposed to institute a comparison between living and fossil species we must in the main fall back on conchology alone. One point of importance must be noted here, viz., that, since the connection between the halolimnic fauna of Tanganyika and the old Jurassic marine fauna is confined to univalves, one might almost have expected that some lamellibranchs, and particularly *Trigonia*, if only in a modified form, might have accompanied their molluscan relatives. For it can hardly be contended that *Trigonia* would suffer more from translation to fresh-water conditions than the numerous species of gasteropods which are correlated with Jurassic forms. Moreover, if conchology is to be our guide in this matter, it is to be regretted that the author of the "Tanganyika Problem" should have endeavoured to minimize the value of a branch of science on which his conclusions with reference to the Jurassic origin of these Tanganyika shells must in the main be based.*

The above considerations apart, it must be admitted that there are some genera of Tanganyika gasteropods which have a striking external resemblance of form and ornamentation to certain well-known genera which more especially characterize the Inferior Oolite of the Anglo-Norman basin; and if such resemblance is not fortuitous there seems a fair reason for regarding them as the possible descendants of such genera or their allies. Consequently, some portions of Mr. Moore's latest work are devoted to a detailed comparison between the Tanganyika shells and their presumed Jurassic analogues. The text is accompanied by excellent illustrations, the shell and the fossil being drawn side by side. As a detailed criticism of these comparisons might be somewhat tedious to the members

* *Geographical Journal* for 1903, p. 682 *et seq.*

of this Society, it will be sufficient to relegate this portion of my paper to an appendix, and briefly to state the impressions which a careful examination of both sets of shells, the fossil and the modern, have left upon my mind.*

As a result of this detailed examination I find on conchological grounds, that the evidence of an ancestral connection between certain fossils of the Inferior Oolite of the Anglo-Norman basin and the following halolimnic genera, viz., *Typhobia*, *Bathanalia*, *Limnotrochus*, *Chytra*, *Paramelania*, *Bythoceras*, *Tanganyicia*, *Spekia*, and *Nassopsis*, is not nearly so strong as I had anticipated from the inferences already drawn and from what I had read in several publications. There are two Jurassic genera, chiefly developed in the Lower Oolites, viz., *Amberleya* and *Purpurina*, which have their conchological analogues in Lake Tanganyika, and in some cases the resemblance is very striking. But this is scarcely sufficient to justify the assumption that the oceanic character of these Tanganyika molluscs will more or less necessitate that the Tanganyika region of to-day must have approximated in character to an arm of the deep and open sea in ancient times,† and the inference is in Jurassic times. Indeed some people, I believe, have gone so far as to describe Tanganyika as an arm of the Jurassic sea. On biological grounds alone this is not at all probable; because under any circumstances this would have been a different zoological province from that occupied by the Anglo-Norman basin in Jurassic times.

It is further pointed out in the appendix, that, besides the resemblance between Jurassic and Tanganyikan gasteropods noted by Mr. Moore, there are other cases of what I have regarded as mere mock resemblances; but in order to appreciate such cases it will be necessary to study the appendix closely, which the majority of the members probably will not be inclined to do.

On the whole, taking the evidence of the *Medusa*, and the other semi-marine forms, as well as that of the halolimnic gasteropods themselves, a fairly good *primâ facie* case for the originally marine origin of these exceptional organisms has been made out, nor do these curious gasteropods appear to be in any degree of close relationship with their ordinary fresh-water companions, although most of them undoubtedly bear traces of a long probationary experience of life in fresh-water. This may

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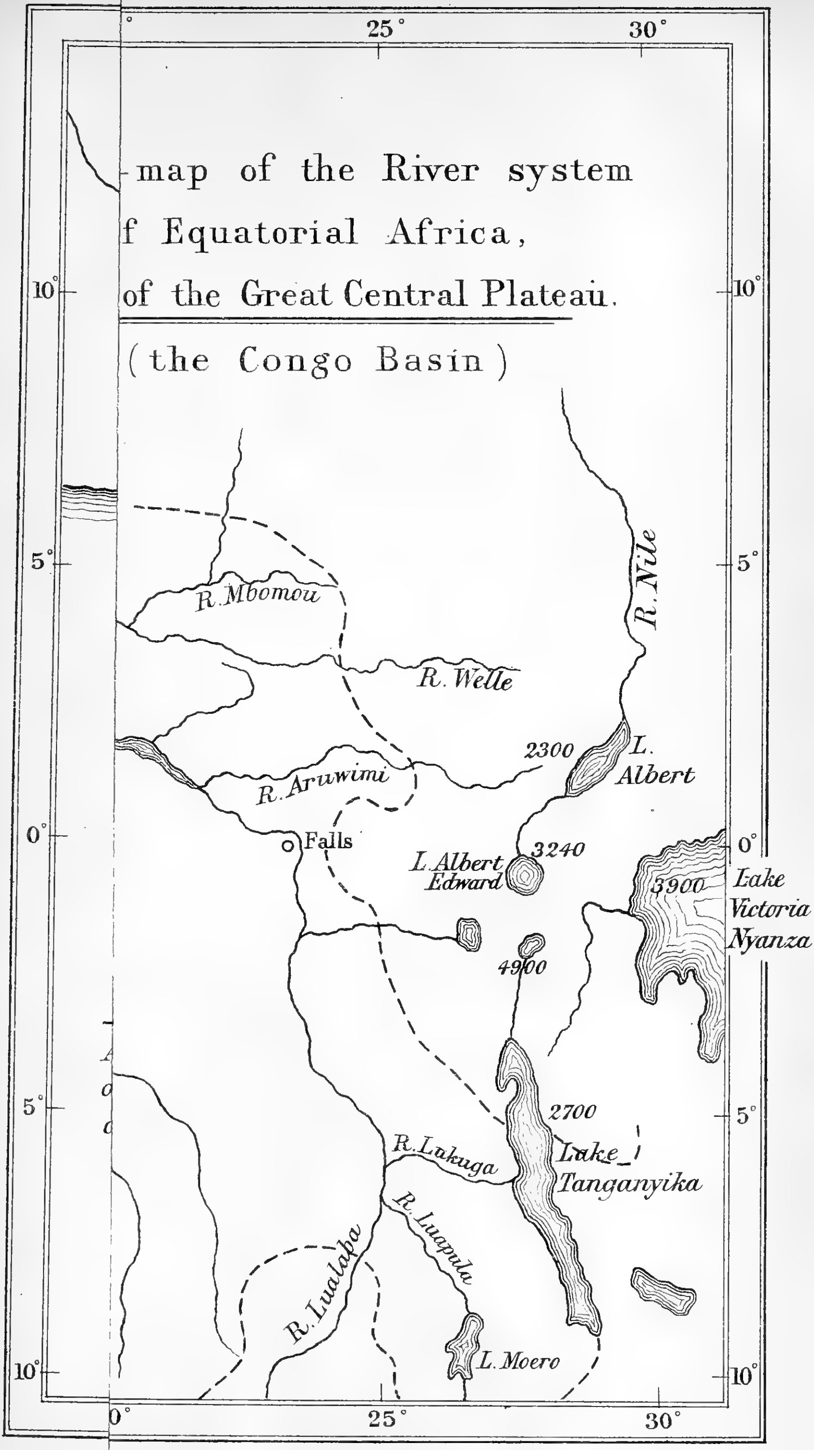
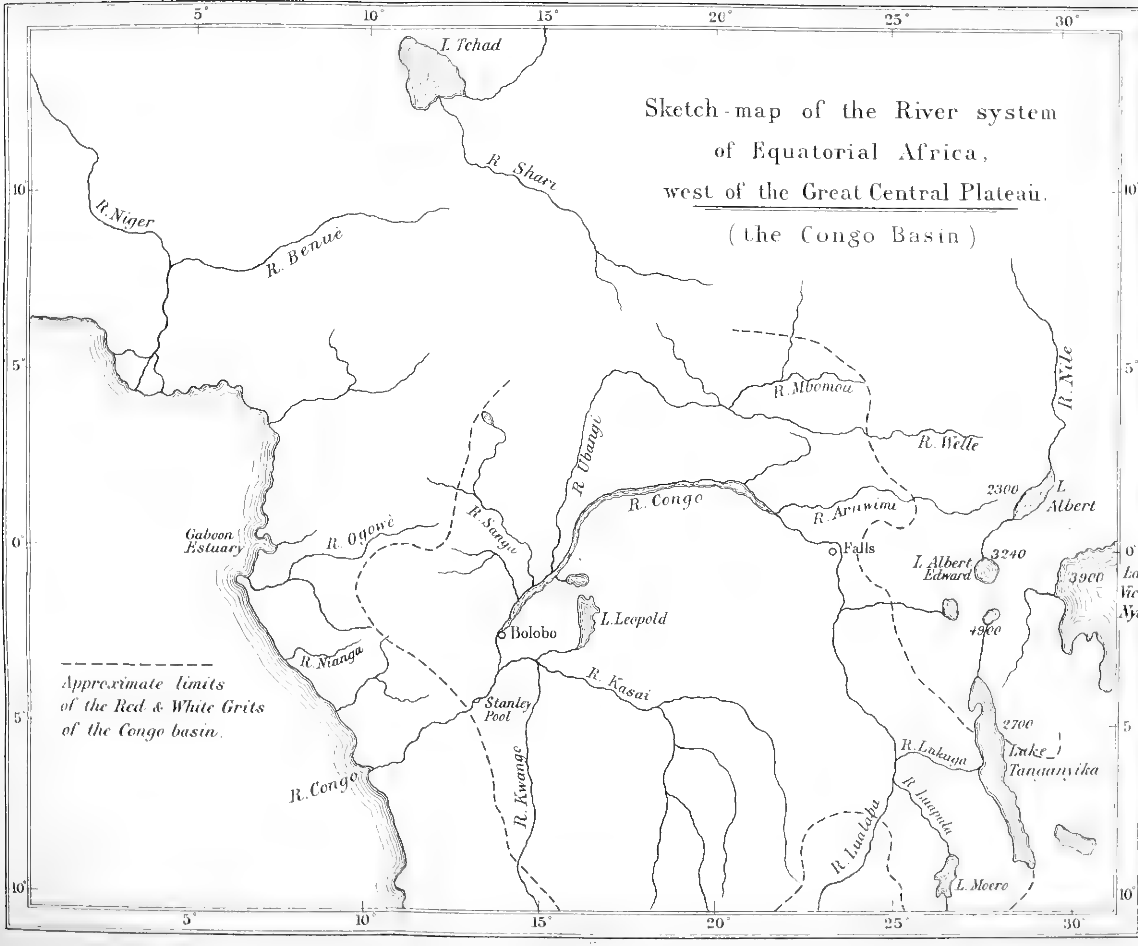
* Appendix to Part I.

† *Proceedings Royal Society*, 1898, p. 455.


map of the River system
f Equatorial Africa,
of the Great Central Plateau.
(the Congo Basin)
25°
30°
10°
5°
0°
R. Mbomou
R. Welle
R. Nile
2300
L. Albert
R. Aruwimi
Falls
3240
L. Albert Edward
3900
Lake Victoria Nyanza
4900
2700
R. Lukuga
Lake Tanganyika
R. Luapula
R. Lualaba
L. Moero


Sketch-map of the River system
of Equatorial Africa,
west of the Great Central Plateau.
(the Congo Basin)
L. Tchad
R. Shari
R. Niger
R. Benuè
R. Mbomou
R. Welle
R. Nile
R. Ubangi
R. Congo
R. Aruwimi
L. Albert
2300
Falls
3240
L. Albert Edward
3900
Lake Victoria Nyanza
4900
Gaboon Estuary
R. Ogowè
R. Sanga
L. Leopold
Bolobo
R. Nianga
R. Kasai
Stanley Pool
R. Kwango
R. Congo
Approximate limits
of the Red & White Grits
of the Congo basin.
2700
R. Lukuga
Lake Tanganyika
R. Luapula
R. Lualaba
L. Moero
5°
10°
15°
20°
25°
30°
0°

be seen in the texture of the shells, the colouring, the condition of the epidermis, etc., which may be noted in some of, but not in all, the genera.

The strongest argument of all in favour of an exceptional original is the fact that, so far as is known at present, the halolimnic gasteropods are confined entirely to Lake Tanganyika, and this circumstance will incline us to look to the Congo basin, as being the place where the mystery may some day be solved.*

Before attempting to grapple with this part of the subject which will involve the study of the geological structure of large portions of Equatorial Africa, there are two independent considerations on which I might say a word.

Distribution of Jurassic faunas in intermediate areas.—The first of these considerations relates to the distribution of *known* Jurassic faunas in areas intermediate between the Anglo-Norman basin and Lake Tanganyika, so far as such an investigation can be made, and thus endeavour to ascertain if this will throw any light upon the possible Jurassic origin of the halolimnic gasteropods themselves. From the quarries of Dorset to the depths of Tanganyika is a far cry and there should be some half-way houses, some stepping stones, as it were, to bridge over the vast distance that lies between them. Mere zoological conjecture, as I have already pointed out, is not sufficient. We must have some palæontological evidence in corroboration of the intimate relationship claimed to exist between the two gasteropod faunas, *i.e.*, between the real fossils and those molluscs which are only archaic in their internal development. In the first place, then, I may say that in this country the peculiar gasteropod fauna which characterises the Inferior Oolite of the Anglo-Norman basin can hardly be traced above the Lower Oolites, though a stray form may linger in the Callovian or even the Corallian of Yorkshire. In middle France a repetition of this peculiar fauna is seen in the Callovian of Montreuil-Bellay. When we trace the Jurassic faunas into the south-west of France, although there is much in common with parts of the Inferior Oolite of our own country, yet the analogy, as far as gasteropods are concerned, is mainly confined to such genera as *Nerinæa*.

* The fact that a species of jelly-fish identical with the one in Tanganyika has recently been discovered in the Victoria Nyanza, but slightly affects the argument as regards the halolimnic gasteropods. We can scarcely doubt that the more mobile organisms have had opportunities of establishing themselves from the great centres of distribution in a way which is denied to the more sedentary molluscs.

Out of about thirty genera of gasteropods quoted in Dr. Glangeaud's list from the Lower Oolites of the south-west of France the genus *Purpurina* does not appear at all, whilst the genus *Amberleya* is restricted to a single unnamed species. On the other hand the genus *Purpuroidea* is recognised.* Going further south again, we look to Choffat for information as to the Jurassic faunas of the Iberian peninsula. Hitherto, I have been unable to come across any systematic list of the gasteropod fauna of the Jurassic beds, though I note in the *Faune Cretacique du Portugal*,† a species of *Purpuroidea* described by that author. There are, however, throughout Choffat's numerous publications many lists of Jurassic fossils, yet I can find nothing which might lead one to suppose that the peculiar Anglo-Norman facies of Inferior Oolite gasteropods can be traced in the peninsula.

There is one very rich gasteropod fauna of Lias-Oolite age in Sicily which inspired the famous monograph of Gemmellaro: "Sui fossili del calcare cristallino della Montagna del Casale e di Bellampo, nella provincia di Palermo." The gasteropod facies of these beds possesses some forms which appear specifically identical with those of the Anglo-Norman Inferior Oolite. However, there is no *Purpurina* and only one species of *Amberleya*.

On a higher Jurassic horizon in the same island, we recognise an *Amberleya*-like form in *Eucyclus alpinus*. On the whole, however, there is nothing in this assemblage which would help us to connect this gasteropod fauna specially with the halo-limnic gasteropods of Tanganyika.

The above enumerations may be regarded in the light of a search after the stepping stones between the Anglo-Norman basin and Lake Tanganyika; and if there has ever existed, either in Jurassic, Cretaceous, or Tertiary times, any such connection, direct or second hand, between the region in which Lake Tanganyika is situated and the sea, as is claimed by Mr. Moore, such connection has most probably been from the northwards and ultimately by way of the Congo basin. At any rate the physical configuration of Africa seems to point in this direction; and since this is the case, any discovery of Jurassic faunas, such as those of Madagascar, though very interesting in themselves, and in reality much nearer Tanganyika, is of less

* *Bulletin des services de la Carte Géologique de France* (No. 50) vol. viii. (1896–7) p. 118.

† Vol. i (1886), p. 6, Plate I, fig. 1.

importance in considering the origin of the halolimnic fauna, being outside any possible connection with the Congo basin.

African Jurassics (*Madagascar and Abyssinia*).—Briefly referring to a valuable paper by Messrs. Baron and Newton on fossils from Madagascar,* we may note that the Jurassic fossils of that region are fairly numerous, the following horizons having been determined by means of the ammonites: viz., Oxfordian, Callovian, Bathonian, Bajocian and Lias. Amongst the Gasteropoda were two species of *Cerithium* from the Oxfordian. The remainder of the gasteropods were mostly from the equivalents of the Great Oolite (Bathonian), and included *Nerita Buvignieri*, M. and L. together with species of *Nerinæa* and *Natica* described by Morris and Lycett; also *Solarium* and *Trochus*, and likewise a new species of Opisthobranch of large size referred by Mr. Newton to *Trochactæonina*. Along with this limited assemblage of gasteropods occur a very considerable number of lamellibranchs. A peep at Jurassic times almost under the equator is interesting in this connection, but there is nothing in the Madagascar fauna which particularly reminds us of the halolimnic gasteropods of Tanganyika.

The very important development of Jurassic limestones in Abyssinia described by Dr. Blanford, is extremely interesting from the fact that undoubted marine beds of Jurassic age have been raised, in a district situated about 10° N. of the equator, to plateau elevations of 8,000 feet. Nevertheless, owing to their apparent poverty in gasteropods, these beds throw no light upon the question with which we are at present concerned.†

Character of Fresh-water Faunas.—The second independent consideration of which I propose to treat relates to the character of fresh-water faunas, and more especially of the mollusca, and this, though a large subject, must be treated briefly. Without going back into the very remote past, we possess a considerable number of fresh-water forms, interlarded as it were with those of marine origin, in the Coal-measures. This subject has received much attention from Dr. Wheelton Hind, and it is interesting to note that most of these forms are lamellibranchs, hence they are, to a certain extent, outside the subject more especially under consideration. Gasteropoda in the really fresh-water beds of the Coal-measures are rare.

The earliest appearance of *Paludina* (*Vivipara*) in this

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* *Quarterly Journal, Geological Society*, vol. 51, pp. 57–92.
† Blanford, *Geology and Zoology of Abyssinia*, 1870.

country occurs towards the top of the Inferior Oolite, where it is extremely local; and as a proof of the conservative character of some fresh-water organisms, always supposing them to have lived in fresh-water, this form is almost identical with the *Paludina vivipara* of the present day. I mention this genus as being very characteristic of fresh-water; and on the higher horizon of the Purbeck beds the genus is represented by two other species in great abundance, together with many other fresh-water genera. Nevertheless in the Purbecks, as in the Coal-measures, there are estuarine intercalations when a different set of fossils are found, and in the case of *Paludina langtonensis* from the Lower Oolites of Oxfordshire marine gasteropods occur in the same bed. The above statements supply a few facts as to the appearance in time of certain fresh-water organisms; but the question of their origin seems scarcely to have got beyond the range of conjecture. However, it is in the Coal-measures and in some members of the Jurassic system that the question of the origin of fresh-water molluscs can best be studied at present. The remarkable uniformity in general character of these organisms over very wide spaces is itself a problem as yet by no means solved.

Before proceeding to study the geology of Equatorial Africa as in any way affording a possible clue to the origin of the halolimnic fauna and especially the gasteropods, which present such a contrast to the average fresh-water molluscs of Tanganyika or of any other African lake, we might consider a possible explanation, which has already been put forward, viz., that some of the halolimnic genera, such as *Paramelania*, for instance, might be related to such a stock as *Pyrgulifera*,* a fossil from fresh-water beds of the Upper Chalk in southern Europe. As far as external appearances go, the halolimnic *Paramelania* resembles the Cretaceous fresh-water *Pyrgulifera* quite as much as it does the Jurassic *Purpurina*, and since *Pyrgulifera* was nearer in time and moreover a fresh-water shell, it might with more probability be regarded as an ancestral form. Too much stress should not be placed on the resemblance of a single genus, but it is a fact of some importance that a fresh-water genus of the Cretaceous period is conchologically as like the old *Purpurina* as any of the Tanganyika shells.

On the possible transference from marine to fresh-water con-

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* Figured on p. 343 of the *Tanganyika Problem*, and referred to on p. 335.

ditions.—If we accept, merely for the sake of the argument, the marine origin of the Tanganyika halolimnic gasteropods, and still further if we suppose that they are derived from certain indicated Jurassic forms, it becomes a question when and where the transference from marine to fresh-water conditions was effected; in other words, when and where did their ancestors cease to be marine molluscs and become fresh-water ones. I have already said that it is to the immense Congo basin that we must look for any indications on the subject; but before making any attempt in this direction it may be as well to point out the difficulty in supposing that this transference was effected anywhere in the Tanganyika region itself. If such a transference ever took place we should seek for it rather in some region where Jurassic beds are known to occur, or at least in their neighbourhood, unless we leave everything to mere conjecture. Again the question when, *i.e.* to say, at what geological period, did the transference take place is equally important. The original Jurassic stock of our hypothesis must have existed as Cretaceous molluscs during the Cretaceous period and as Tertiary molluscs during the Tertiary period. It may be argued that these considerations are in favour of an early separation from a marine area, since fresh-water conditions are held to be conservative of form, and consequently the more remote in time the transference took place the less likelihood of change in the morphology of the shells.

Undoubtedly, in the long run, these questions of when and where, which I have put before the members of the Institute, must be determined by geological and above all by palæontological considerations. The nearest known Jurassic fauna of any importance which has hitherto been described is that of northwest Madagascar distant in an air-line from the south end of Lake Tanganyika about 1,400 miles, and almost on the same parallel of south latitude. The improbability that the halolimnic stock was derived from this source has already been indicated, owing to the physical structure of East Equatorial Africa, which we shall presently proceed to study. It is on the whole a fortunate circumstance for the hypothesis of a Jurassic origin for the Tanganyika stock that this is the case, for in these Jurassic deposits, which would have the advantage of being under the same conditions with respect to latitude and presumably in the same zoological province as the area of Tanganyika in Jurassic times, *there is not a single genus of gasteropods which has any especial resemblance to the halolimnic gasteropods of Tanganyika.* See ante, p. 347.

Jurassic fossils of the Mediterranean basin.—Hence, if we still cling to the notion of a Jurassic origin, we must go further afield and direct our attention to other Jurassic deposits and especially to those of the Mediterranean basin, as being more likely to give us some inkling of a possible derivation in this direction. I have already referred to the very rich deposits of the Lias-Oolite in Sicily, but we may come to Africa itself, where, in the extreme north, marine Jurassic and Cretaceous beds have been fairly well exploited, both in Algeria and Tunisia. Now, as a proof of the apparent poverty of the Jurassic beds in Gasteropoda, I would observe that Coquand* was only able to enumerate one species, although the Cretaceous and Tertiary beds of this region account for over fifty species of Gasteropoda. It may be noted that *Voluta*, *Strombus*, *Fusus* and *Buccinum*, are quoted from beds of Cretaceous age in Algeria, but this Gasteropod fauna in its entirety has nothing in common with the Tanganyika halolimnics beyond a doubtful shell referred to *Trochus*. In Tunisia† the most ancient formations are those of Jurassic age, forming some of the mountain cores such as Zaghouan. In that country the ammonite fauna is characteristic of certain stages of the Jurassic system, but no gasteropods are mentioned. Still following the Mediterranean coast, when we come to Egypt the Jurassics fail us entirely, and beds of Cretaceous age rest directly on the Archæan.‡

It is not necessary to pursue this line of investigation further beyond observing that if there are any stepping stones between the Anglo-Norman basin and Central Africa *quâ* Gasteropods, they remain to be discovered. I will now direct attention to another aspect of the Tanganyika problem, viz., the Geology of Equatorial Africa, more especially in connection with the physical history of the Congo basin.

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* *Géologie et Paléontologie de la region sud de la Province de Constantine*, *Marseilles*, 1862.

† *Expl. de Carte Geol. Provisoire*, par Aubert, *circa* 1890.

‡ By this name I propose, without prejudice, to indicate the Crystalline complex which is the foundation-stone of the African continent.

Part II.

Outlines of African Geology with Especial Reference to the Central Regions in which Lake Tanganyika is Situated.

It need hardly be observed that Africa is an extensive though well-defined continent, and from its size it might be expected to exhibit considerable variety of rock formation. Yet this is by no means the case, since the proportion of crystalline rocks and barren sandstones is so great that its life history has been, for the most part, but obscurely written. If the medals of creation were ever struck here in any considerable quantity they have since been in a great measure destroyed. The absence of fossil evidence is especially noteworthy in the equatorial regions, which form the special ground of our inquiry.

Roughly speaking for geological purposes the whole of Africa might be divided into three divisions of very unequal size.

(1) *The Northern Division.*—This may be considered as part of the Mediterranean basin, and indeed, almost as European for geological and orogenic purposes, always regarding the Atlas range and its dependencies as being under the same tectonic system as the Alps. Although the precise boundaries of this division can scarcely be defined, it is a limited area and by no means deficient in marine fossiliferous rocks. In Part I, under the heading of Algeria and Tunisia, some of the palæontological features of this division have already been indicated. Marine beds of Mesozoic and Tertiary age constitute the bulk of these rocks. Morocco may be included in this category.

(2) *The Region of the Great Deserts* constitutes the principal part of the second division. Prof. Cornet* tells us that this is characterized by the horizontality of the palæozoic beds, as though the area had not been one of disturbance for a long period. He also says that there is a great hiatus in the formations of this region, extending in time from the Carboniferous to the Cretaceous.

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* "Formations postprimaires du bassin du Congo," *Ann. Soc. Géol. Belge*, vol. 21 (1893–4).

Egypt might be included in this district, where, as in the case of the Nubian sandstone, beds of Cretaceous age rest on the Archæan. Altogether the Cretaceous and Tertiary beds of this region are analogous to those of Syria and of countries still further to the eastward. The southern extension of the great Cretaceous overlap in this area is not exactly known; but De Lapparent* has recently announced the discovery of Eocene fossils on the frontier of Sokoto due west of Lake Tchad. He also announces the discovery of an upper Cretaceous echinoid, believed to be from Belina, which is 300 miles north of the same lake.

The full significance of these discoveries can only be realised by the aid of a map; but among the results thus obtained we find that marine deposits of Mesozoic and Tertiary age, as proved by their fossils, are now known to exist within 14° north of the Equator. Indeed there is no reason why a considerable portion of the basin of Lake Tchad should not be underlain by Cretaceo-Eocene formations, which in all probability extend from the Atlantic coast of Senegal to the crystalline rocks of the Ethiopian Highlands. The effect of this would be that a much larger portion of Northern Africa than hitherto supposed must be included in our second division, though the limits between this and the third, or peninsular division, cannot yet be defined. There is, however, one marked difference between our second and third divisions, which cannot be too soon realised, viz., that in the second division fossiliferous marine beds of Mesozoic and Tertiary age penetrate into the heart of the continent, whereas in the third division such beds occupy but a narrow fringe between the sea and the peninsular massif. Thus, the physical history of the two regions is entirely different.

(3) *Peninsular Africa.*—Constitutes the third division, and this may be divided as follows:—

Section a. The Cape Beds, which have now been studied for a long time, and which it is necessary in some measure to refer to, if we would endeavour to understand the geology of Equatorial Africa. There is a useful summary of these beds in a recent issue of the *Geological Magazine,*† which I condense as follows:—

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* *Bull. Soc. Géol. France* (4) III, No. 3, p. 299 (1903).

† December, 1903, p. 569. See also Seward, *op. cit.* November, 1903, who deduces the age from plant evidence.

	Beds.		*Age.*
	Superficial Deposits	....	Recent, etc.
Coastal	Pondoland Series	....	Cretaceous.
	Uitenhage Series	....	Wealden.
Karoo	Stormberg Series	....	Rhætic.
	Beaufort Series	....	Triassic.
	Ecca Series	}	Permo-Carboniferous.
	Dwyka Series		
	Cape System	....	? Old Palæozoic.
	Pre-Cape Rocks	....	Archæan.

The beds above referred to the Cretaceous and Wealden are simply strips along the coast, and it may be said generally of the principal system, viz., the Karoo, that its fauna and flora are entirely fresh-water or terrestrial. The older beds on which the great Karoo system unconformably rests contain no marine fossils. It is probable that the beds marked as Rhætic were formerly regarded as Triassic.

Section b.—We now come to consider the geological structure of *Equatorial Africa* adjoining the Cape Beds, which lie to the south. With certain exceptions presently to be described, the beds of this region coincide geographically with the Congo basin. Cornet says of this region that it is constituted by depressed massifs, formed of Archæan and Palæozoic beds much folded; these are covered by beds almost horizontal extending over immense distances, consisting of conglomerates, sandstones and clay schists, all utterly unfossiliferous. This is the unpromising region which we have to study with some degree of detail, but before doing so it will be necessary to glance at the history and structure of the peculiar mountain chain, which though it hangs to the eastern side of the continent, is called by Mr. Moore the great Central Range.

The mountain-chain or plateau-range of East Africa.—In the above geological disquisition we must not lose sight of our main object, which is to account, if we can, for the presence of the peculiar halolimnic fauna of Lake Tanganyika. Now this lake, which has a length from north to south of 400 miles, lies at the junction of the Great Central Range with the enormous Congo basin. We shall consider the structure of the Congo basin in some detail presently, but a few words as to the peculiar mountain system with which the lake is connected ought to be useful. If we want to account for anything, we must understand the position on all sides.

This mountain chain is largely volcanic in its composition, and it will be sufficient for our purpose if we take our start from the great volcanic mountain mass of Abyssinia, whose geological features, to a certain extent, resemble those of the peculiar mountain plateau-region which is characteristic of Equatorial East Africa. Isolated volcanoes, now extinct, such as Elgon, Kenya and Kilima-Njaro rise to heights, in the two latter cases, of over 18,000 feet, but the most characteristic feature is the double chain of depressions which contain the numerous longitudinal lakes of Equatorial Africa. This system, which may be said to commence with Lake Rudolf, just south of Abyssinia, bifurcates, the eastern and smaller arm containing such lakes as Baringo (3,200 feet), and Navaisha (6,200 feet), whilst the western, or more important arm, includes the uppermost Nile-valley and such lakes as the Albert Nyanza (2,300 feet), the Albert Edward (3,240 feet), and Kivu (4,900 feet). This latter lake, as Mr. Moore has shown, formerly belonged to the Nile-valley system, but owing to volcanic extravasations the drainage has been reversed and its waters now find their way into Lake Tanganyika (2,700 feet). The two arms of this double series of longitudinal depressions are regarded as to a certain extent coalescing in the great lake of Nyassa (1,500 feet), where the system of these peculiar longitudinal depressions may be said to terminate. The mountain system of East Africa, in another form, is renewed in the Drakensberg, where the surveyors have lately found numerous indications of volcanic action. A sketch-map of the East African Lake-Chain (after Suess), modified from Gregory's *The Great Rift Valley*, is appended. (Fig. 1.)

Between the two arms of the system of longitudinal depressions (" Graben " of Suess) is situated, the wide basin of the Victoria Nyanza (3,900 feet) which has an area in miles of 270 × 225—a veritable inland sea. This constitutes a sort of broad and shallow depression in complete contrast to the Graben with their vertical walls and succession of trough faults.

Our brief sketch of the Great Central East African Range would not be complete without allusion to two very remarkable features in connection therewith, which characterize the uppermost Nile-valley system in the neighbourhood of the Lake Albert Edward. The first of these is the still active volcanic range of Mount M'fumbiro which crosses the great western arm of the Graben system at a right angle, and rises to a height of 14,000 feet in Karisimbi (extinct), whilst the rim of the crater of the still active Kirungo-cha-Gongo Mr. Moore found to be 11,350 feet. As he observes, this mass acts like a dam to the original drainage of the Graben. The chief points to note

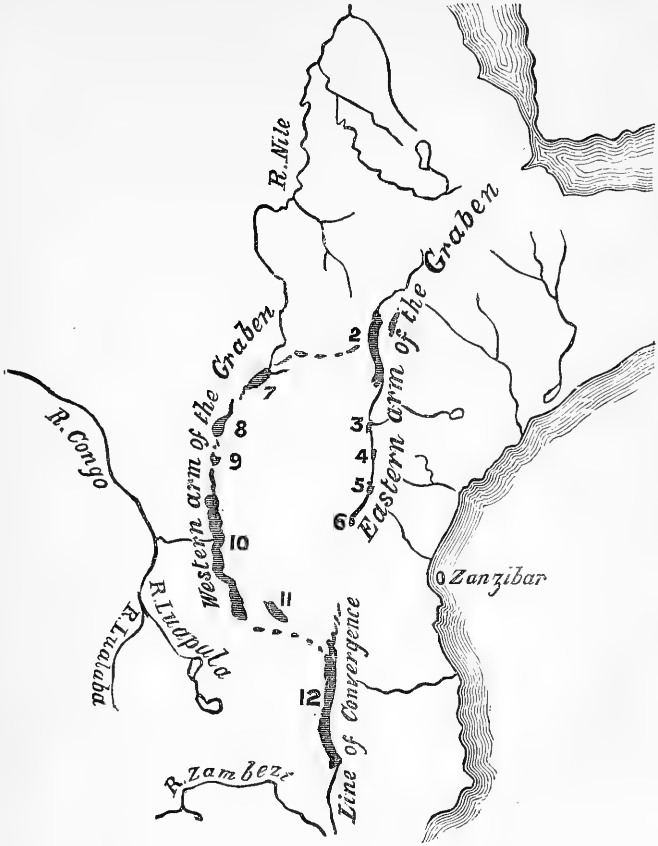


FIG. 1.—PLAN OF THE GRABEN SYSTEM AND ITS RELATION TO THE CONGO BASIN.

Eastern Arm.	*Western Arm.*
1. Lake Stefanie.	7. Lake Albert.
2. ,, Rudolf.	8. ,, Albert Edward.
3. ,, Baringo.	9. ,, Kivu.
4. ,, Navaisha.	10. ,, Tanganyika.
5. ,, Natron.	11. ,, Rukwa.
6. ,, Manyora.	

12. Lake Nyassa.

in this case are: (1) The existence of volcanic action within the containing walls of the great western Graben. (2) The fact that volcanic action is not extinct in this region, though it is probably fast dying out. There are yet some traces of volcanic activity in the eastern arm of the Graben, where the mountain, Longonot (9,350 feet), still shows a fresh looking crater and emits steam. The facts in regard to the existence of modern volcanic action in the Graben system is of importance in connection with any attempt to estimate the age of this mountain plateau-system, in which the Graben themselves are situated.

The second feature in connection with the equatorial portion of the Great Central chain is the existence of the short, but lofty Ruwenzori Range, whose southern extremity lies actually on the equator. Whilst the axis of the volcanic chain of Mount M'fumbiro lies at right angles to the northerly trend of the great western Graben, that of the crystalline system of Ruwenzori is approximately parallel to it. "These ranges, which rival the Alps in magnitude and in the sublimity of their scenery, lie along the eastern edge of the depression, and appear, in fact, to stand out into it beyond what was originally its eastern face."* We recognise the importance of the above observation, as it tends to show that this portion of the Graben is older than the Ruwenzori Range itself. The adjacent Victoria Nyanza plateau is mainly composed of schists and gneiss, and this class of rock usually terminates abruptly at the eastern edge of the Graben where the depression ensues. But opposite Ruwenzori, instead of being broken off at the edge of the depression the gneiss and schists are bent and piled upon the steep flanks of the mountains themselves, which in their more central portions are found to consists of massive old amphibolites. These latter are, most probably, the base of the Archæan, as developed throughout the greater part of Equatorial Africa, and these amphibolites seem to have been thrust up through the overlying gneissic and schistose layer.†

Geology of British East Africa.—Having paid some attention to the physical structure of the Central Range with its associated Lake Chains, it would not be amiss just to glance at the geology of the equatorial region of East Africa and its relations to the remarkable system of Graben already partly described. In this respect we cannot do better than follow Gregory in his description of the region between the Indian Ocean and the Victoria Nyanza, which includes the eastern arm of the Graben system. The subjoined section, which lies

* Moore, *The Tanganyika Problem*, p. 94. He gives the altitude of the highest peaks at about 16,500 feet.

† *Amphibolites* are igneous rocks in which hornblende is a chief constituent ; diorite is a common variety.—E. H. (Ed.)

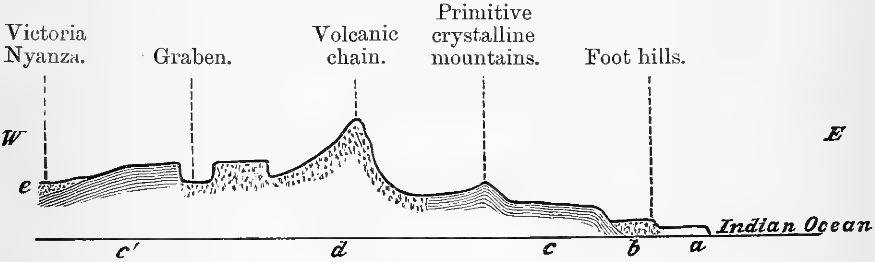
almost on the Equator, will serve not only as a description of the immediate region, but may in many respects be regarded as typical of Peninsular Africa, both east, south and west.

In particular the section shows:

(1) That fossiliferous deposits are a mere coastal fringe, or at least get no further inland than the Foot Hills, and,

(2) The enormous development of old crystalline and more recent volcanic rocks.

FIG. 2.—SECTION ACROSS BRITISH EAST AFRICA (AFTER GREGORY: "RIFT VALLEY," p. 222.)



GEOLOGICAL SIGNS.

(*a*) Coastal deposits: raised coral-reefs and old sea beaches with much wind-borne sand.

(*b*) The foot plateau. The seaward portion consists of shales, etc., of middle Jurassic age as proved by their ammonites; the middle portion of bright coloured sandstones, probably of Triassic age, but without marine fossils; the western portion of shales of probably Permo-Carboniferous age, with land plants and fresh-water mollusca (*Palaeanodonta*).

(*c*) The portion of the Archæan rocks to the eastward of the volcanic region.

(*d*) Volcanic region, consisting of plateaux, mountains (Kenya, Kilima Njaro, etc.), and Graben.

(*c′*) Archæan rocks west of the volcanic region. N.B.—The Archæan system is said to cover something like two-thirds of British East Africa, and there can be little doubt that it underlies the greater part of the rest.

(*e*) Lower Palæozoic rocks without fossils on the horizon of the Karagwe series—here and there on the shores of the Victoria Nyanza.

An old crystalline axis is well shown in the above generalized section, and, as we perceive, these crystalline rocks are stated to cover two-thirds of this part of the country. Indeed it has always been an idea of mine that the immense extent of old crystallines in Peninsular Africa helps us to understand the sandy and unfossiliferous nature of the bulk of its sedimentary rocks. What we now see are merely the eroded stumps of crystalline masses which once towered in the air, but which have been riven for ages by equatorial storms and rains, and their material distributed by torrents, rivers, and backwaters, so as to help to level up the surface. In this particular case the crystalline system has been invaded by an enormous extent of volcanic extravasations, and if we wish to discover the age of the Great East African Central Chain, as it now exists, we must endeavour to ascertain the period during which these phenomena have been in operation. The origin of Lake Tanganyika itself depends upon these considerations. That this period is post-Jurassic, there can be little doubt, for the strip of Jurassic rock near Mombasa is traversed by dykes, which seem to be connected with the general mass of extravasated matter on the central plateau. It is probable, however, that a much later date may be assigned. In this connection I would refer to Dr. Gregory,* who places the first plateau-eruptions in the Cretaceous, probably towards the close of that period, as is the case with the great basaltic outpourings of Western India. From this time up to the Pleistocene there have been, according to this author, a succession of eruptions and coast-movements, and he places the first series of Rift-Valley faults (Graben) in the Upper Eocene and the second series in the Pliocene. These statements are made, principally with reference to the eastern arm of the Graben system, but it would probably apply also to the western arm in which Lake Tanganyika is situated. It is pretty clear, however, that volcanic eruptions have taken place, as we now know, down to the present time, and that earth movements have continued, for some of the fault scarps, Dr. Gregory observes, are so bare and sharp that they must be of very recent date.

Enough has now been said with regard to the anomalous history and condition of the Great East African Central Chain and its double string of lakes of depression. Tanganyika is the largest and most peculiar of all these, and its origin is intimately connected with the above considerations. We may believe that its initiation may have taken place in early Tertiary times, but that both its drainage area and also the great Rift in which it occurs have undergone some modification owing to the instability of the earth's crust in that region.

* *The Great Rift Valley*, p. 235.

Geological structure of the Congo basin.—The above considerations present to us only one phase of Tanganyika's history. If we desire even to try to account for its peculiar fauna we must now turn to another factor in the case, viz., the geological structure of the Congo basin, with which it seems, almost by accident, as it were, to be connected. This is a very large subject, and the region under consideration is quite the converse of the one previously described; for we are about to deal with an immense circular area having only an elevation of from 1,000 to 2,000 feet above sea level, and which, for the most part, seems to have been free from tectonic disturbance. It might be thought there would be immense variety of formations in this region, but if the Belgian and French geologists, whom I shall presently quote, are correct, we have the old story over again:—a rim of crystalline and, possibly, palæozoic rocks, with absolutely unfossiliferous sedimentaries, largely consisting of sandstones, dumped down in the centre.

The best evidence we obtain of the general structure of the Congo basin is derived from the writings of Professor Cornet, of Mons, supplemented for the French Congo by those of Mons. Barrat, a mining engineer, and inspector of public works.* The first mentioned author is a geologist of great experience, and his earliest work in this region (Katanga) relates to the geology of the Uppermost Congo in the basin of the Lualaba, which is almost in touch with Tanganyika itself. Before venturing, however, to deal with this ground, I will bring to your notice Professor Cornet's experiences on the Lower Congo. The railway from Boma to Stanley Pool has materially helped the engineer to obtain a fairly accurate idea of this piece of country. It is true that this railway is only 350 kilomètres (216·35 miles) in length, and that the distance from the outlet of the Lukuga on Lake Tanganyika, measured in a straight line along the sixth parallel of south latitude, is nearly 1,300 miles, yet the section traversed by the railway and prolonged to about the neighbourhood of Bolobo, appears to be the key to

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* *Cornet.* "Terrains anciens du Katanga (expédition de 1891–93)," Liège (1897).

Cornet. "Observations sur la géologie du Congo occidental." *Bull. Soc. Géol. Belg.*, vol. x (1896).

Cornet. "Études sur la géologie du Congo occidental." *Op. cit.*, vol. xi (1897).

Cornet. "Les formations post-primaires du bassin du Congo," *Ann. Soc. Géol. Belg.*, vol. 21 (1893–4).

Barrat. "La géologie du Congo Français." *Ann. des Mines*, Livraison d'avril (1895).

the structure of nearly the whole basin of the Congo. I may be pardoned, therefore, if I dwell upon this section on the Lower Congo in some detail.

The western Congo may, from a geological point of view, be divided into four zones from west to east as follows (see Fig. 3, page 361.)

I. The Maritime Zone.
II. The Crystalline Zone.
III. The Calcareo-schistose Zone.
IV. Zone of the Sandstones.

I. The Maritime Zone. — This consists of old estuarine deposits, and more particularly of fragments of Tertiary beds, Cretaceous beds, and of continental pre-Cretaceous sandstones. It is interesting to note that the only fossiliferous beds whose age may be known from their contents, constitute a narrow and insignificant fringe on the borders of the Atlantic, just as we have seen to be the case on the east coast of equatorial Africa (see Fig. 2, p. 357). All the other zones are without any definite traces of organisms.

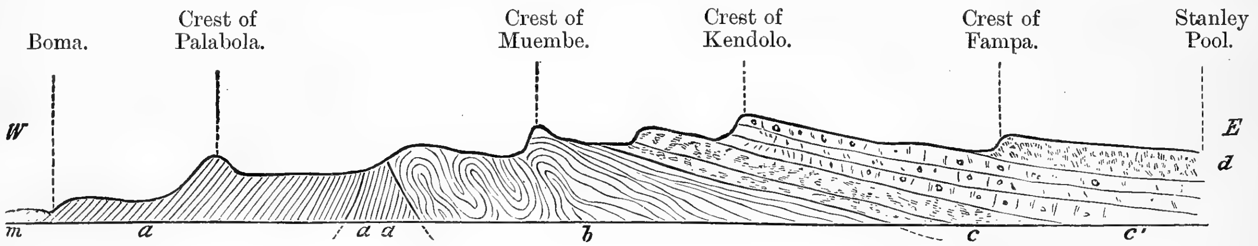
II. The Archæan and metamorphic beds.—The Archæan is well represented on the Lower Congo from the granitoid gneisses of Boma, in the west, to the chlorite and sericite schists of the higher portions. The dip is generally towards the west at variable angles, which are sometimes low. Both north and south of the Congo this zone can be traced for some distance. The so-called metamorphic beds are less crystalline, and in some cases calcareous.

III. The calcareous-schist system.—There is a massive conglomerate at the base, and this is succeeded by schistose argillaceous limestones. The middle member consists largely of marbles, whilst the highest beds are calcareous schists with silicious concretions. The beds of this system exist in a series of synclinal basins indicative of a thrust towards the west, and with a diminution of folding as one advances eastwards, until the beds pass under the felspathic grits of the fourth zone with a slight dip to the eastwards. The age of these beds is uncertain, but it is thought that part of them may represent in time the Devonian of other countries.

Zones II and III represent the rim of the basin in which the nearly horizontal sandstones of the fourth zone were deposited.

Zone IV. Zone of the Sandstones, or beds of the Congo basin proper. These are the beds to which Professor Cornet more

FIG. 3.—DIAGRAMMATIC SECTION ON THE LOWER CONGO BETWEEN THE ATLANTIC COAST (W.) AND STANLEY POOL, ABOUT 1,000 FEET ABOVE THE SEA (E.) (AFTER CORNET).



m.	Coastal deposits	Zone I.
a.	Archæan	Zone II.
aa.	Metamorphic	
b.	Calcareous schist system	Zone III.
c. & *c'*	Red Felspathic Grit system	Zone IV.
d.	White Friable Sandstone system	

N.B.—The beds of Zone IV are in complete discordance on the underlying rocks, and constitute the "formations post-primaires" of Prof. Cornet.

particularly alludes in his paper on the "Formations post-primaires." The lowest, or *Red Felspathic Grits,* is divided into two sections by a slight unconformity. It reposes in complete discordance upon the flanks of Zone III. There is a great variety of detrital matter in this formation, including conglomerates, fine grained sandstones and argillaceous schists, but one of its characteristics consists of thick beds of grit largely charged with big grains of altered felspar causing a reddish or brownish tinge. These beds correspond to the "couches de Kundalungu" of the highest Congo (Lualaba), and form part of the margin of Lake Tanganyika, as we shall see presently. On the Lower Congo the Red Felspathic Grit series extended to the westward of its present outcrop, as shown by outliers, possibly as far as the crystalline zone.

The upper portion of Zone IV, *d* of the section, which is strongly in evidence near Stanley Pool, extends up the river as far as Bolobo. It consists of white or yellowish silicious sandstones, very pure, soft and friable under the fingers, forming beds several hundred mètres in thickness and having a wavy and current-bedded stratification. Enormous sarsens attest the former presence of these beds in areas where the softer material has been removed by denudation. The beds of this system, in this region, are nearly flat, or with a slight dip to the eastward. They correspond to the "couches de Lubilache" of the Lualaba district, and may be known as the *White Friable Sandstones.*

It will not be necessary to carry the geological *résumé* of the Lower Congo any further, beyond pointing out one or two matters which may have a bearing in future discussion relative to the fauna of the Middle Congo, and, in consequence, of Lake Tanganyika. In the first place it must be borne in mind that from Stanley Pool to Boma the present river Congo has cut for itself a passage through what may be regarded as the western coastal range in a series of falls and rapids which precludes any present connection with marine conditions. We cannot doubt that during the initiatory stages of this escape from the interior, the waters of the Congo basin selected the most depressed portion of the coastal range, which thus presents an appearance, in section, of less importance than would be the case either to the north or the south of the river's course; also denudation has been active in lowering the rim of the original basin. It may be mentioned in this connection that the coastal range in the north of the French Congo (province) attains elevations of 1,500 mètres in the "Monts de Cristal," which are of granite. Secondly, it must be remembered, that, as far as what we may term the solid geology is concerned, the White Friable Sandstone series is the highest in the sequence of the beds which form the vast interior. These are often concealed by horizontal beds of clayey and sandy alluvium (silt), dating from a period when the mean level of the river was higher; also by spreads of what the French geologists call "Laterite." Even these alluvial beds seem devoid of organic remains, except that in one case shells of *Ætheria* are mentioned.*

Having thus briefly considered in some detail the material of which the Congo basin, in a geological sense, is constituted, we are now in a position to glance at the structure and physical history of that immense area, including some attempt to fix the chronology and parallelism of the two great sandstone systems, which probably cover more ground than any other sedimentary beds throughout Africa. Cornet, in speaking of the physiography of the Congo basin, describes it as an immense "vat," whose peripheral margins are always higher than the central region.

The periphery of the Congo basin (Plate I).—The western portion we have already studied in the traverse from Boma to Stanley Pool. Although the topography varies throughout this immense circle, the geological sequence is pretty much what we have seen. Thus, on the southern margin, the watershed between the Congo and the Zambesi, towards the sources of the Lualaba, runs from elevations of 4,000 feet to 5,000 feet. On the south-east the headwaters of the Congo-Luapula proceed from a region of gneiss, mica schists and argillaceous schists with granitic massifs, which extend between lakes Nyassa and Tanganyika. The "ancient rocks" of Katanga, so well described by Cornet, of course form a part of the general periphery in these regions. It would be well to mention here that, although such ancient rocks are, in the flatter parts of the basin, covered

* There is an article by Stainier (*Trans. Inst. Mining Engineers*, vol. 15 (1898) p. 491), in which the author, besides summarizing the results of Cornet and others on the solid geology of the Congo basin, gives a very useful abstract of the *superficial formations* of this immense area. These include (1) Products of the alteration *in situ* of subsoil rocks; (2) Products of decomposition on slopes under the influence of rainfall; (3) Alluvial deposits in watercourses; and (4) Ancient alluvial deposits. It can readily be understood that the solid geology of the Congo basin is largely masked by some one or other of the above conditions, to say nothing of vast districts under water and swamps.

by one or other of the sandstone systems (formations post-primaires), yet the latter have been cut clean through by streams in many places so that the framework and bones of the skeleton are occasionally displayed throughout the vast region under description.

The eastern margin of the periphery calls for especial notice, as Professor Cornet considers Tanganyika to be within the limits of the original basin, since the Red Felspathic Grits extend to the east as well as to the west of the lake. Its eastern affluents descend from a granitic or metamorphic district stretching towards the east and also bordering the lake for a considerable distance. When we come to deal more especially with the geology of the shores of Lake Tanganyika it will be seen that these Red Felspathic Grits, almost horizontal in many places, are occasionally tilted in this region, showing that Tanganyika is within the influence of the disturbances in connection with the Great Central or East African Range, whereas the Congo basin, as a whole, is outside these influences. The south end of the lake is bordered with red and variegated grits belonging to the Red Felspathic series which are horizontal and have been transformed by metamorphism into a kind of quartzite with intercalation of eruptive rocks. At the outflow of the Lukuga are seen grits and red schists (of the Red Felspathic group) which continue for a distance of 120 kilometres westward from Tanganyika. At this point (Wabenza) they are covered by the white friable schists (White Friable Sandstone) of the centre of the basin. This formation also prevails at Nyangwe, but the Red Felspathic Grits reappear at Stanley Falls.

The limits on the north-east of the periphery are constituted by the western lip of the western arm of the Graben, which contains the lakes belonging to the Upper Nile. The region of the sources of the Aruwimi consists of crystalline rocks. On the north gneiss occurs at several points between the basin of the Uellé and the White Nile.

On the north-west there is a sandstone plateau of an altitude of 2,000 to 2,800 feet, which occupies the meeting ground of the Shari, Congo and Nile basins, and falls to the north in a plain some 400 feet lower, watered by the Auk, an eastern branch of the Shari, the principal feeder of Lake Tchad.*

* Chevalier, quoted in the *Journal of the Royal Geographical Society*, vol. 22, p. 569 (November, 1903).

This completes the periphery of the Congo basin as at present constituted.

Suggested correlation of the beds composing the interior of the basin.—Having completed the circuit of the Congo basin, we must next endeavour to ascertain something of the geological history of this vast tract and its constituent elements. The first question we ask ourselves must be, what is the approximate age of these two great interior sandstone formations? Without fossils, terrestrial, fresh-water or marine, to guide us, this can only be done by way of inference and analogy.* Cornet calls them post-primary, *i.e.*, to say, they rest in almost horizontal layers, for the most part, either on crystalline rocks or on old palæozoic rocks inclined at high angles. This is very much the case with the Karoo beds at the Cape, which are in position analogous to the two sandstone series of the Congo. The Karoo beds fortunately contain a fairly abundant fauna and flora, which is wholly terrestrial and fresh-water. The geological position of the Karoo beds is pretty well known, and I must refer to a previous statement on this subject (see page 353). We are not altogether without links in the chain of evidence.

A paper appeared lately in the *Quarterly Journal of the Geological Society* by Mr. Molyneux† on "The Sedimentary Deposits of Southern Rhodesia," where a provisional classification of the several formations, down to the Zambesi, was suggested. Beneath a series of sandstones and grits, capped by volcanic rocks, occur some 800 feet of beds containing workable and impure coal and also some recognizable fossils (Matobola beds). The interest of these consists in the fact that scales of the fish *Acrolepis* were recognized, the genus also occurring in the Lower Karoo, and likewise in the so-called "Drummond's beds" on Lake Nyassa. A very few lamellibranchs were obtained from the Sengwe coal-field and were described by Dr. Hind. These are small, oval, gibbose bivalves belonging to the genus *Palaeomutela*, similar to species from the Permian of the Volga. A few plant remains were collected, and amongst others fronds of the fern-like plant *Glossopteris Browniana*, Brongn, and of some of its varieties. There can be very little doubt, therefore, that the Matobola-beds of Southern Rhodesia may be referred to the terrestrial and fresh-water Lower Gondwana system of Permo-Carboniferous age. The

* This was Prof. Cornet's view at the time he wrote.
† Vol. 59 (May, 1903) p. 266.

"Drummond's beds" towards the northern end of Lake Nyassa present similar traces of this fauna in association with a series of conglomerates, red grits and shales, and as they are not far from the south-east rim of the Congo basin their evidence is all the more valuable.*

There is good reason, on the whole, for supposing that the Red Felspathic Grits of the Congo basin are the equivalents in time, and to a certain extent in composition, of part of the Karoo system of the Cape. If this view be accepted we might roughly correlate the White Friable Sandstone series with the Upper Karoo which may possibly extend upwards as high as the Rhætic period. It should be distinctly borne in mind that no marine organisms occur in any of these beds referred to the Karoo. Mons. Barrat, in his map of the Congo basin, boldly correlates the whole of the post-primary sandstone systems of that basin with the Karoo, and in a general sense he is probably not far wrong. Cornet himself considers that the "Bassin primitif du Congo," at the period of the horizontal deposits, was separated by a chain of mountains from a region lying towards the south, south-east and east, where the beds of the real Karoo were being deposited.†

It is difficult to conceive the precise physical conditions under which these lifeless masses were accumulated during a period which may be regarded as very early mesozoic (including the Permo-Carboniferous). That the mountainous periphery already described was being ground down by atmospheric causes and its products distributed by some sort of water action thoughout the central depressed area seems certain, and it is also highly probable that during the greater part of the time there was no drainage outlet, so that this part of Equatorial Africa became the dumping ground of a mass of mechanical sediments, which had no means of escape by the usual method of rivers flowing towards the ocean. But a time came, perhaps towards the middle of the mesozoic epoch, when deposit ceased to be the order of the day and these interminable sandstones themselves became subject to the laws of

* The Drummond's beds of Nyassa are described as a small system of grits, schists and limestones with fish (*Acrolepis*), molluscs (*Mutela oblonga*) and plant remains. Other localities are quoted where the Red Felspathic Grits contain remains of vegetation, according to the traveller, Thompson.

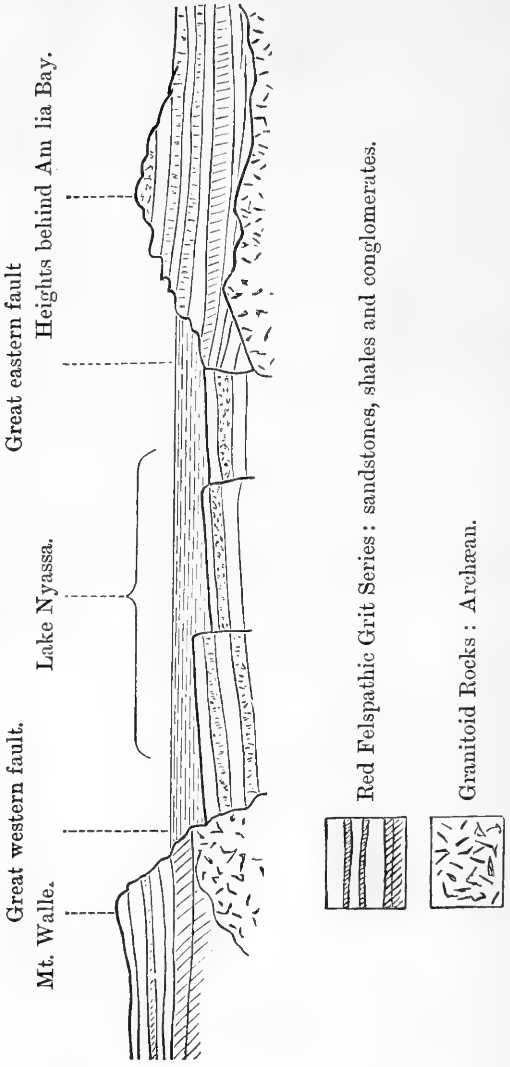
† It is admitted that the Karoo beds of the Cape constitute a somewhat indefinite system, yet within certain limits their horizon may be accepted as fairly well understood.

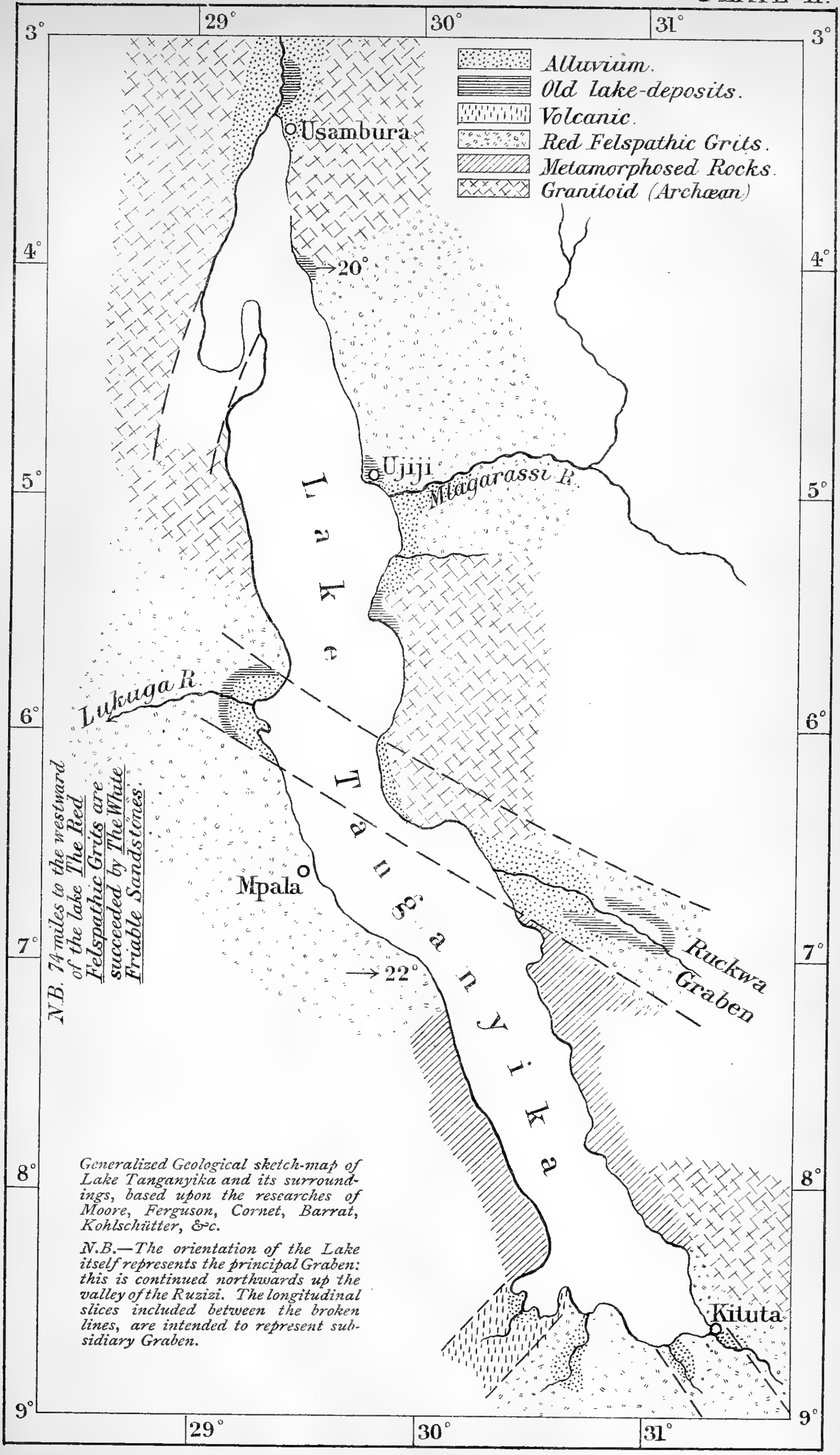
denudation. A new era had arrived, and some faint shadow of modern conditions was inaugurated. Unfortunately, there is no evidence, as far as I can make out at present, of what took place between the close of the White Friable Sandstone period and that of sub-recent and recent deposits. This interval doubtless was, during part of the time, a period of great inland waters, where the basins of the Congo, Shari and White Nile inosculated and where the fauna now exisiting in Equatorial Africa was to a considerable extent evolved, and the rivers themselves partly marked out. But enough perhaps has been said on this subject, and I must now conclude this geological disquisition with a brief description of the more immediate surroundings of Lake Tanganyika itself, inasmuch as a proper understanding of the peculiar physical features of this lake may help us to consider, if not to explain, the origin of its still more remarkable molluscan fauna.

Structure of a Graben.—Before proceeding to consider the geological features of Lake Tanganyika, I would draw the attention of members to the structure of a Graben as depicted by Mr. Moore, in the case of Lake Nyassa. This traverse which is taken through Mount Waller towards the north end of the lake, shows the relation of the Red Felspathic Grits to the underlying granitoid rocks (Archæan); and it also exhibits the system of trough-faulting which may be taken as one form of the structural arrangement of a Graben.

Geology of Lake Tanganyika.—As regards Tanganyika itself the lake occupies the principal depression in the western arm of the Graben-system of Equatorial Africa, running due north and south for 400 miles, and the present elevation of the surface of the water is stated to be 2,700 feet. There are several affluents, the principal one being the Ruzizi at the head of the lake, whilst there is only one effluent, viz., the Lukuga, which escapes through a chasm in the western walls (? *vide* Gregory, *The Great Rift Valley*, p. 3), and ultimately joins the Congo drainage system, to which at present it belongs. The discharge of the Lukuga seems to be a precarious one, and it is clear that there have been times when the water does not escape, in which case one would expect an increase in its salinity. Great depths are reached in this lake, and Mr. Moore considers that it is not all of one age, the central portion between Karema and Ujiji being regarded as the oldest. This circumstance is also true of Lake Nyassa, where in some places the bottom is so bare of recent deposit as to suggest that such portions may have been added to that lake

FIG. 4.—STRUCTURE OF A GRABEN.





Generalized Geological sketch-map of Lake Tanganyika and its surroundings, based upon the researches of Moore, Ferguson, Cornet, Barrat, Kohlschütter, &c.

N.B.—The orientation of the Lake itself represents the principal Graben: this is continued northwards up the valley of the Ruzizi. The longitudinal slices included between the broken lines, are intended to represent subsidiary Graben.

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at a comparatively recent period. Oscillation of the floor and containing walls of both these great Graben lakes is noticeable in places.

In attempting to construct a geological map of Tanganyika I must be guided by Mr. Moore to a certain extent, not forgetting, however, to consult the works of Cornet, Bornhardt, Kohlschütter and other distinguished scientists. If there is obscurity, in the geology of Equatorial Africa, still there is a certain degree of simplicity as far as the composition of the several formations with which we have to deal. Around Tanganyika, though not to the same extent as around Nyassa, the basement granitoid rocks (Archæan) are strongly in evidence. Upon these at the south and south-east end of the lake in complete unconformability reposes the great sandstone and shale formation, which, we have seen, Cornet in his numerous writings on the Congo basin calls the *Red Felspathic Grits,* or "couches de Kundelungu" of the Lualaba district, and which constitute the lower division of his "formations post-primaires." Beds of this character also extend to the east as well as the west of the lake, and this part of the area now occupied by Tanganyika must have been within the limits of the original basin of deposition (see *ante*, p. 364). These Red Felspathic Grits, so horizontal for the most part throughout the basin of the Congo, are tilted in portions of the western wall and notably at Mount M'rubi, where they are said to have an inclination to the eastward. As previously observed, this shows that Lake Tanganyika is within the influence of the movements connected with the East African Plateau Range, whereas the bulk of the Congo basin is without the sphere of those influences. At the south end of the lake the Red Felspathic Grits are shown for the most part as horizontal, although, according to Mr. Moore's mapping, much cut up by subsidiary Graben which carry on the principal Graben of Tanganyika in a southerly direction. In one of these subsidiary Graben, towards the south-west, is situated both the true and the salt lake Mwero of the higher Congo, and that perhaps is about as far west as the Graben-system can be traced. In the neighbourhood of Cameron Bay there are considerable indications of volcanic eruptive matter, and, according to Cornet, much of the Red Felspathic Grits have been transformed into quartzites with intercalation of this eruptive material. These most probably are the "metamorphic" beds of Mr. Moore, which seem to occupy both sides of the southern third of the lake.

Towards the northern termination of the series which has been subject to this kind of metamorphism, the great Rukwa Graben strikes the Tanganyika fissure at an acute angle, and it is extremely probable that this longitudinal depression, as pointed out by Mr. Moore, extends across the lake and reappears as the great gap in the western wall through which the drainage of Tanganyika has been effected. Possibly subsequent erosion may have had something to do with the deepening of the primary fissure, which thus becomes a "rift-valley" in the true sense of the term. After passing over modern lake deposits, the Red Felspathic Grits are encountered on the Lukuga as previously stated (p. 364), and extend for a distance of 120 kilometres from Tanganyika, and beyond this point are covered by the *White Friable Sandstones* which constitute the upper member of Cornet's "formations postprimaires."

It seems doubtful whether any fossils occur in connection with the Red Felspathic Grits of Lake Tanganyika. There can be no doubt whatever that the Red Felspathic Grit series of Cornet is the same as the sandstone series of Mt. Waller and Amelia Bay on Lake Nyassa, which is identified by Bornhardt with the Karoo formation, and with which are associated the so-called "Drummond's beds" with their *Glossopteris* flora and fresh-water fauna (see pp. 365 and 366). At more than one spot in the vicinity of the northern end of Lake Nyassa indisputable evidence of coal, fossil plants, shells and fish scales of fresh-water origin have been found. It seems unfortunate that the corresponding beds (*i.e.*, the Red Felspathic Grits) of Tanganyika and the Congo basin seem to be barren in this respect. At least such appears to have been Cornet's opinion, and he accounts, as we have seen, for the barrenness of these beds on the supposition that they were laid down in a basin on the west side of the primary mountain range of what is now East Central Africa.*

* Reymond (*Bull. Soc. Géol. France*, 1885) speaks of certain "schistes fossiliferes," collected by Giraud in 1881, at some distance from Mpala on Lake Tanganyika, which were said to contain a *Cyrena* and fish remains (*Lepidosteus*). This alleged discovery on Tanganyika may be the same as that mentioned by Drummond (*Tropical Africa*), where he observed that three days north of Nyassa Giraud found in the schists certain fossils which Bertrand referred to *Lepidosteus* and *Cyrena*. Moreover, Moore considers that "Drummond's beds" occur at two or three localities on or near Tanganyika, but as he mixes these up with modern lake deposits, it is not very easy to get at his meaning, the more so, since no organic remains are mentioned, other than those of the lake itself. On the whole, I conclude with Cornet, that no good evidence of fossils belonging to the Red Felspathic Grit series has hitherto been found in the Congo basin, of which L. Tanganyika at present forms a part.

The next formation in order of time is the volcanic series to which allusion has already been made towards the south-west corner of the lake, and with this may be associated the metamorphosed sandstones, etc., which appear, in fact, to be portions of the Red Felspathic Grits and not "primary metamorphics," such as those described by Cornet in Katanga. These volcanics most probably belong to the graben-system, and must be approximately of the same date as similar volcanics towards the north end of the great Nyassa-graben and elsewhere.

The latest formations in point of time are deposits derived from the lake itself, and these are of especial interest as containing the remains of the existing halolimnic molluscs. It is probable that they may be met with at many places along the shore. Mr. Moore refers especially to the line of coast between Ujiji and Usambora, where layers of modern lake-deposit, somewhat shattered, are found dipping 20° to the east conformably to the sheets of Old Sandstone on which they repose. According to the same author the flat floor of the Ruzizi valley (at the head of the lake) is composed chiefly of modern sandstones and alluvium. Higher up the valley, to about 200 feet above the present surface of the lake, his party kept passing over older and older ground, and the plains thus traversed were found to be intersected by water-courses in some cases to a depth of 90 feet, so that the older stratified materials were exposed. These strata were found to consist of brown and yellow sandstones, having a slight dip to the south, and contained many shell fragments and also some fossilised shells which could be identified as *Neothauma*, *Nassopsis* and *Paramelania*. The age of the deposit is probably Pleistocene, and not only has the water level of the lake fallen, but he thinks that the valley-flat north of Tanganyika has undergone elevation also since those days. It should not be forgotten that Mr. Moore (*Tanganyika Problem*, p. 90) states that the water of the lake is somewhat salt. He observes that it seems to be fresher now than when Livingstone and Stanley examined it. Moreover, as both these explorers aver, there are traditions among the Arabs that, within the recollection of living men, it was a lake which never flowed out at all.

Part III.—Conclusions.

1. The zoological aspect.
2. The palæontological evidence.
3. The argument from geology.

To a certain extent the probable conclusions have already been indicated in Parts I and II, of this communication, but a brief summary at the final stage may be of use. On the whole we have three main factors to guide us in the investigation, and these we will take in the order above indicated.

The zoological aspect of the question.—This is mainly studied by means of conchological comparison, and it will be seen on referring to Part I, and more particularly to the Appendix, that, in my opinion, the resemblance between the Tanganyika shells and those of our British Inferior Oolite is not sufficiently close to warrant any theory as to the derivation of the former from the latter. But, on the other hand, there is the malacological evidence derived from the study of the anatomy of the existing mollusc, which reveals a peculiar archaic character, and also a singular blending of attributes usually held to be distinct. Such peculiarities, whilst pointing to the exceptional character of this assemblage of gasteropods, fail altogether to establish any connection with the Inferior Oolite of the Anglo-Norman basin. Yet the very existence of a group of halolimnic gasteropods limited to Tanganyika, is in itself a proof that there is something remarkable about these molluscs and such a view is further confirmed by anatomical investigation. Hence these gasteropods may, in some way, have had a remote marine origin, although that need not have been Jurassic.

It has always seemed to me that the most hopeful line of research is to be sought in the waters of the Congo basin, and particularly in Lakes Bangweolo and Mwero. If the halolimnic gasteropods had their origin in the vast inland seas of this immense system, as they existed formerly, there should be some trace of them in the lakes of the Upper Congo. This, Mr. Moore informs us, is unfortunately not the case, although in Lake Mwero a genus closely approaching the *Neothauma* of Lake Tanganyika has been found. I am rather inclined to consider that the zoological evidence points to a local and restricted origin for these Tanganyika shells, and if we accept the theory of their special marine derivation, whether Jurassic or more recent, it must always be with a certain degree of doubt.

The palæontological evidence.—Since the hypothesis of a

Jurassic origin for the Tanganyika shells has been mooted, the Palæontological evidence brought forward in Part I may now be briefly recapitulated. I must confess that the possibility of tracing a connection between the Inferior Oolite fauna of the Anglo-Norman basin and the fauna of Lake Tanganyika had a considerable fascination for me, and I rather hoped that as we approached the Mediterranean basin there might have been some evidence in favour of these views. On the contrary, except in Sicily, no really important gasteropod fauna has been discovered in the intermediate areas, and even in the case of the Sicilian fossils the prevailing assemblage of gasteropods lends but little countenance to any theory of a Jurassic origin for our halolimnic shells.

These considerations were originally based upon a hope that there might be some evidence of a Jurassic derivation by way of the Congo basin, but the more I studied this part of the question the less faith I had in my original expectations. Supposing, as is by no means improbable, that there may have been a communication with Tertiary and even with Mesozoic seas on the northern side of the Congo basin at some period of its history, the misfortune is that we obtain no palæontological evidence in the direction required. If we take North Africa, the Iberian Peninsula, or even the south-west of France, where-ever Jurassic deposits are known, they have never yielded a fauna approaching that of the Anglo-Norman basin, and therefore do not help us in the least towards covering the immense distance in space which exists between that classical region and the centre of Equatorial Africa. As regards Jurassic deposits within the limits of the African tropics, such as those of Abyssinia and Madagascar, we have already seen that their fauna, so far as known, has no analogy with the Tanganyika gasteropods. This, however, is a fact of minor importance, since the Madagascar deposits especially occupy a region which there is good reason for believing on geological grounds, has never had any connection with the Congo basin, in which Lake Tanganyika is situated.

The argument from geology.—Since neither the zoological nor the palæontological evidence favours the notion of an Inferior Oolite origin for the halolimnic gasteropods, we must endeavour to ascertain how far the geological history of this part of Equatorial Africa tends to throw any light upon the subject.

In Part II, I have endeavoured to sketch a brief outline of this history, dwelling more especially on the geological structure of the Congo basin, and of that portion of the East

African Plateau-chain which flanks it on the east. The importance of Lake Tanganyika in a physiographic sense is based largely upon the fact that it lies at the junction of these two very different regions, the latter a disturbed, and the former a quiescent one. As constituting a part of the western arm of the Graben-system I am inclined to the belief that it is by no means an ancient feature of the earth's crust. Much depends upon the date assigned to the East African volcanic plateau, which was probably initiated towards the close of the Cretaceous period. The Graben-system is of necessity more recent, and if this system has any connection, as regards time, with the Jordan-valley fissure it must be post-Eocene in date. I think that we may provisionally accept this date for the initiation of the Graben-system, though I should be disposed on other grounds to make it more recent still, bearing in mind that its activities are not yet extinct.

Lake Tanganyika, as Mr. Moore points out, was formed at different times, but since its existence could not precede that of the Graben-system, the oldest date that we can assign to any portion of it is Middle Tertiary. It is not contended, however, that there were no large lacustrine sheets of a different character at the time of its formation in the neighbourhood, and notably in the area now occupied by the eastern portion of the Congo basin. The geological history of this vast territory is unfortunately a blank since the deposition of the "White Friable Sandstones." All we can say is that nothing which could indicate the presence of a Jurassic Sea or even of a Cretaceous Sea has been discovered therein. There can be little doubt that the "Red Felspathic Grits" of Cornet, which underlie the "White Friable Sandstones," may be comprehended under the very wide term of Karoo, which gives us an approximate date. The overlying "White Friable Sandstones" will, therefore, be Mesozoic in age, and probably like the Karoo beds non-marine in origin.

We now come to the consideration of a very interesting question, viz., the connection between Lake Tanganyika, which is a fissure lake, with the wide and quiescent area of the Congo basin. For several years, as you are aware, geographers were in doubt as to whether Lake Tanganyika had an outlet, and when the outflow of the Lukuga was at last established it was thought that the outflow was intermittent. The conditions vary even now, I believe, according to the supply of water in the lake. But what I especially wish to point out is the peculiarity of the Lukuga outlet in a fissure lake surrounded for the most part by lofty enclosing walls. Was this outflow caused by a cross-fissure (Graben) such as might be produced by the prolongation of the great Rukwa-Graben in the way indicated by Mr. Moore? At any rate these drainage facilities may not always have existed, and in that case Tanganyika during part of its history would be a closed water, and consequently more or less saline. Whether such conditions as these had anything to do either with the origin or conservation of the halolimnic gasteropods I do not venture to say. My endeavour has been to find any geological evidence in favour of the view that they were derived either primarily or secondarily from a Jurassic stock of Inferior Oolite age. It must be confessed that thus far my efforts have been without success. At the same time mere negative evidence must not be accepted as final.

In conclusion, then, since neither the zoological, the palæontological nor the geological evidence affords much support to Mr. Moore's theory, we must regard the Tanganyika problem in its main features as unsolved. In the present state of our knowledge we are not bound to submit an alternative hypothesis. Yet, if we still cling to the notion of a specially marine origin for the halolimnic gasteropods, the most promising quarter for a solution of the riddle is to be sought along the northern margin of the Congo basin, where it adjoins that of the Shari. This opens up the notion of a possible communication through the depression in which Lake Tchad is situated with the undoubted marine deposits of the second geological division of Africa. That the so-called "post-primary" deposits of Equatorial Africa, like their equivalents at the Cape, are, with the exception of coastal strips, mainly of terrestrial and fresh-water origin, I entertain no doubt. The only exception to this rule appears to be a Jurassic formation in Abyssinia known as the Antalo limestone.

It should be distinctly understood that I have not taken up this investigation in a controversial spirit; nor indeed, in the first instance, with a view to controverting the theory of a Jurassic origin for the Tanganyika gasteropods. If, during the course of the inquiry, I have been unable to find evidence in favour of that hypothesis, it has at least been a source of gratification to follow Mr. Moore's lead in his character of explorer and naturalist. In this way both myself and those members of the Victoria Institute who have taken the trouble to follow me must feel indebted to him for having awakened a more than passing interest in one of the many problems of Equatorial Africa.

APPENDIX TO PART I.

NOTES ON THE COMPARISONS BETWEEN THE HALOLIMNIC GASTEROPODS AND CERTAIN FOSSILS FROM THE INFERIOR OOLITE—TOGETHER WITH AN ABSTRACT OF MR. MOORE'S STATEMENTS REGARDING THE MOLLUSCA OF TANGANYIKA GENERALLY.

* Forty-six species of mollusca are enumerated (*The Tanganyika Problem*, p. 138), consisting entirely of Gasteropods and Lamellibranchs, the former preponderating. Of the latter are a number of distinct specific forms supposed to be related to *Unio*. Many of the Gasteropods belong to normal genera, such as *Limnæa* (four species), *Isidora* (two), *Phyopsis* (one), *Planorbis* (three), *Ampullaria* (two), *Vivipara* (one), *Cleopatra* (one), *Melania* (three). There is also the very fine *Vivipara*-like genus, *Neothauma*, Smith, which cannot in any sense be regarded as halolimnic. Mr. Moore further observes that the normal fresh-water molluscs found in Tanganyika are specifically distinct from the representatives of the same genera occurring in the neighbouring lakes. Excluding *Neothauma* there are fourteen Gasteropodean types (p. 218) judged by their conchological characters, generically distinct, as follows, viz. :—

Typhobia.	*Spekia.*
Bathanalia.	*Nassopsis.*
Limnotrocus.	*Syrnolopsis.*
Chytra.	*Stanleya.*
Paramelania.	*Reymondia.*
Bythoceras.	*Horea.*
Tanganyicia.	*Ponsonbya.*

Out of these the following are regarded as specially representing the halolimnic molluscs, and are classified in six groups, viz. :—

Typhobia and *Bathanalia*, *Tanganyicia*, *Limnotrochus* and *Chytra*, *Spekia*, *Paramelania* and *Bythoceras*, *Nassopsis*.

It is more especially the above forms which are regarded as homæomorphic with certain fossils, chiefly of the Inferior Oolite, and this resemblance has impressed Mr. Moore so strongly, that he is disposed to consider these groups as the partially modified descendants of the old Jurassic molluscs.

As most of these comparisons were made with fossils in my own collection, I have endeavoured, in those cases where it has been possible to procure the particular Tanganyika shells, to check the resulting determinations, of course on conchological lines solely.

1. *Melania admirabilis, Smith, with Cerithium subscalariforme, D'Orbigny.*

N.B.—These shells are not referred to in the above list. On pp. 219 and 353 of the *Tanganyika Problem* are back and front views of the

* It is probable that this is not an absolutely full list.

Melania admirabilis of Lake Tanganyika—at least, I suppose that both of these cuts are intended for the Tanganyika shell, and not for the Jurassic fossil. The likeness is by implication only, for on referring to page 273 for the affinities of *Melania admirabilis* I find no recognizable account of that species. It is true that on page 269, the author makes a general attack upon the genus *Melania*; but this is rather with a view of criticising the suggested relationship of *Typhobia* to *Melanopsis.*

The shape and ornamentation of *Melania admirabilis* (judging from the figures) and *Cerithium subscalariforme* are singularly identical. There is some difference in the apertures, for in *C. subscalariforme* there is a well-formed anterior spout slightly reflexed. Not having any specimen of *M. admirabilis* in my possession, I cannot pursue the comparison any further.

2. *Typhobia horei, Smith, with the genus Purpuroidea, Morris and Lycett.*

Mr. Moore in this case does not institute any close comparison, but rather suggests (p. 350) that *Typhobia* is matched by the Oolitic fossil genus, *Purpuroidea*, "from which it is difficult, if not impossible, on conchological grounds, to distinguish it." I select *Purpuroidea Morrisii*, Buvignier, a characteristic Great Oolite fossil, to exemplify the genus.

Here the ornamentation and general strombiform character of the shell in each case is strikingly apparent. On comparing the apertures we find that, instead of the short notch of *Purpuroidea*, the inner lip of *Typhobia* is produced anteally into a narrow and reflexed spout. In other respects both the outer and inner lip in *Typhobia* and *Purpuroidea* greatly resemble each other and equally differ from *Strombus*. Whilst recognising a considerable degree of homæomorphy between the two shells from Tanganyika and Minchinhampton respectively, a comparison of the shell substance seems to suggest important differences. So far as we are able to judge from the usual calcite replacement of the fossil shell, one would say that *Purpuroidea* had a thick and heavy shell. On the other hand *Typhobia* has a very thin and fragile shell, and, despite its identification as a halolimnic shell, has all the appearances of a fresh-water genus—so much so, indeed, that its affinities with *Melania* have been suspected by some, though this would seem to be negatived by internal characters. As regards the history and distribution of *Purpuroidea*, the genus makes a doubtful appearance in the Inferior Oolite of the east of England; it is fairly abundant in limited districts of the Great Oolite and is last seen, so far as England is concerned, in the Corallian of Yorkshire. It would seem also to be fairly abundant in the Corallian beds described by Buvignier. It does not occur on a higher horizon in this part of Europe.

3. *Bathanalia howesi, Smith, with Amberleya orbignyana, Hudl.*

Bathanalia is figured on pp. 227 and 348. Of this peculiar genus Moore says (p. 228) that it is an inhabitant of deep water throughout the southern third of the lake, and he considers that, in conchological characters, it is identical with several marine Jurassic fossils, described under *Amberleya*. He further remarks that except for its widely different shell, *Bathanalia* is structurally identical with *Typhobia*. Referring to the diagnosis of *Amberleya*, quoted in p. 346, Moore says that this would absolutely answer for *Bathanalia*. According to his view the thin shell, the absence of all trace of epidermis, and the character of the whorls, as well as the sculpture and character of the mouth, are all essentially the same in *Bathanalia* as they are in *Amberleya*.

Judging from figures only, this is the most striking of all the resemblances. I gather, however, that there are some differences in the aperture.

On p. 348, Moore has figured the back only of my specimen of *Amberleya orbignyana*. The right hand upper figure on this page is intended for an *Amberleya*, which I do not quite recognise. The two lower figures represent *Bathanalia*, back and front. It is unfortunate that no good front aspect of *Amberleya* is presented to the reader, for if the aperture in *Bathanalia* is correctly drawn, it does not possess the straight pillar lip, coming forwards almost to a point, which is so characteristic of *Amberleya*. In all other respects the resemblance is most striking, even to the angular outline of the outer lip, which in *Bathanalia* is prolonged into a short process. It should be observed, however, that there is somewhat of an umbilical opening in *Bathanalia*, whereas the shell of *Amberleya* is entirely closed.

Amberleya (including *Eucyclus*, which latter, if not a synonym, has a close relationship) is eminently characteristic of the Lias. It comes up from the Lower Lias, and culminates in the Inferior Oolite, especially in beds having a Cephalopod facies, as in the Anglo-Norman basin. Occurs also in the Great Oolite, and seems to have left this country with bed of Corallian age.*

4. *Limnotrochus thompsoni, Smith, with Littorina sulcata, Hebert and Deslongchamps.*

See pp. 233 and 349. It is also compared with *L. dorsetensis*, Hudl. In the possession of a black epidermis and in its general aspect *Limnotrochus thompsoni* has a certain fresh-water character. The aperture, however, is more like that of *Littorina* than of *Trochus*. The trochiform outline of the shell and the ornamentation, especially the

* Since writing the above, I have had an opportunity of inspecting a specimen of *Bathanalia* through the courtesy of Mr. Da Costa. I am more than ever impressed with the extraordinary resemblance of the spire to that of *Amberleya pagoda*, but the character of the mouth is so very different, that I conclude the resemblance of the spire to be fortuitous.

strongly bicarinate body whorl, have a singular resemblance to *L. sulcata*, H. and D. The aperture, however, presents considerable differences, and in this respect *Limnotrochus thompsoni* more nearly approaches some of the many varieties of "*Littorina*" *dorsetensis*, the chief difference being that in the latter, the umbilicus is closed and the aperture is not free as in the former case. Nevertheless, the general resemblance is sufficiently striking.

5. *Chytra* (*Limnotrochus*) *kirkii, Smith, with Onustus ornatissimus D'Orbigny.*

See pp. 229 and 350. Originally the empty shell had been described and figured by Mr. Smith (*Proc. Zool. Soc.* 1881), who classed it under *Limnotrochus.* Mr. Moore has founded for this species the genus, *Chytra*, and further observes that the shell of *Chytra kirkii* is remarkably solid, resembling both that of *Solarium* and *Zenophora* (*Onustus*).

The resemblance of *Chytra* to the Jurassic species referred to *Onustus* is very slight indeed, beyond the general pyramidal shape of the shell. One of the leading characteristics of the Jurassic *Onustus* is the imbricate overlapping of one whorl over the next one, and this feature is equally seen in the *Onustus pyramidatus*, Phillips, as in *Onustus ornatissimus* D'Orbigny. There is no trace of this kind of overlapping in *Chytra*, which, to my notion, has more the character of *Solarium.* The basal characters in *Chytra* are also different to those in the Jurassic species of *Onustus.*

Hence I fail to trace any marked resemblance between *Chytra* and *Onustus.* Nevertheless *Chytra* is perhaps the most thoroughly marine in aspect of all the halolimnic series, the shell being thick and more or less free from epidermis. Indeed, most conchologists, if they did not know its habitat, would hardly suspect that it was anything more than a somewhat aberrant *Solarium.*

6. *Paramelania damoni, Smith, with Purpurina bellona, D'Orbigny.*

See pp. 245 and 345, for figures. There are three species of *Paramelania* mentioned by Moore (index, p. 366) viz., *P. crassigranulata*, Smith, *P. crassilabris*, von Martens, and *P. damoni.* Other species also have been described by Bourguignat, some of which possibly belong to *Nassopsis.* The species of *Paramelania* selected by Moore for comparison with the Jurassic *Purpurina* is *Paramelania damoni*, of which unfortunately I do not possess a specimen, and must therefore rely solely on Moore's figures, pp. 245 and 345. The comparative figures are to be found on p. 345. The particular *Purpurina* there drawn is *P. aspera, Hudl.* from the *Concavus*-beds of Bradford-Abbas. This is a very rugose form of *Purpurina*, and its resemblance to *Paramelania damoni* (judging from the figure) is very striking; only that in *P. aspera* and indeed in *Purpurina* generally, the anterior notch or channel is more in evidence, and also more reflexed than in the majority of specimens of

Paramelania. In this respect the regulation *Purpurina bellona* (which occurs on a higher horizon than *P. aspera*) more resembles the average Paramelanias of Tanganyika. It should be remarked also that most species of *Paramelania* have a considerable amount of brown scaly or epidermal matter, and are generally thick and nassoid or purpuroid in the texture of the shell. Reference is made to the conchological similarity of *Pyrgulifera*, a genus of fresh-water shells (p. 343) of the Upper Chalk, to *Paramelania*, and this casual identification opens up several interesting questions.

7. *Nassopsis nassa*, *Smith*,* *with Purpurina inflata* (*? auctor*).

See pp. 250 and 347. During life this mollusc, we are told, inhabits the surface rocks of Tanganyika and its shells are always richly encrusted with the green algæ which clothe the rocks for a considerable depth. It is sluggish and appears to browse within a very limited area, like the Patellas of the Ocean beach.

As regards the Jurassic fossil figured for comparison (upper figures, p. 347) under the name of *Purpurina inflata*, I should point out that this specimen is not *Purpurina inflata*, Tawney, but a peculiar unnamed form which was figured in Plate I of the "Jurassic Gasteropoda." The true *P. inflata* has a very different figure and ornamentation, but possesses a rounded and almost unchannelled aperture, having in fact the least indented mouth of all the *Purpurinæ*.

The real value of these comparisons is an unknown quantity, but the conchological resemblance of both *Paramelania* and *Nassopsis* to certain named and unnamed forms of *Purpurina* is clearly pointed out by Mr. Moore, and admitted, as I understand, by Mr. Edgar Smith. Such resemblances are interesting, but if *Paramelania* and *Nassopsis* are really different genera, as their internal structure would imply, one learns two things from this fact: (1) that the outward form of the shell is not always indicative of the character of the animal within, and (2) that two different genera of existing molluscs are compared with the one Jurassic genus, *Purpurina*.

It may be mentioned here that the genus *Purpurina* was somewhat loosely constituted by D'Orbigny, and was more carefully reconstituted by Piette and Deslongchamps, who regarded it as having relations on the one side with *Turbo* and on the other with *Cerithium* and *Purpura*. Fischer places *Purpurina* among the Littorinidæ, but its real family relationship is by no means clear. In the Jurassics of this country *Purpurina* first makes its appearance in the Marlstone (Middle Lias), culminates in the Inferior Oolite, is rare in the Great Oolite, and dies out

* I possess a specimen supplied by Sowerby and Fulton, marked "*Paramelania coronata*," Bourguignat; which greatly resembles the figures of *Nassopsis nassa*.

in the Callovian of Yorkshire. It is also represented in the Callovian of Montreuil Bellay, where a gasteropod fauna, greatly resembling that of the Inferior Oolite of the Anglo-Norman basin, is found to occur.

8. *Bythoceras*, *Moore.*

See pp. 238 and 242. There are two species figured, but, so far as I know, no special comparison with Jurassic forms is invited.

9. *Tanganyicia*, *Cross.*

See p. 246, *T. rufofilosa.* In this case also, no special comparison with Jurassic forms is instituted, but its general resemblance to *Natica* is pointed out. The fine spiral coloured lines are characteristic of this very pretty little shell, which though naticoid in its outline is certainly different as regards shell-substance to the regulation *Natica.* It is said to be a littoral form and occurs in abundance.

10. *Spekia zonata, Cross or Smith, with the Jurassic genus, Neridomus M. and L.*

See pp. 256 and 351. On p. 257, Moore remarks on its *naticoid* appearance, and considers it so "completely similar to that of numerous fossil naticoid forms that, had it appeared fossilized instead of having been found living in a great fresh-water lake, there is not the slightest doubt that it would have been placed in one of the numerous fossil genera which are supposed to group themselves about the living Naticas." Yet on p. 349 (the figures are on p. 351) he says: "Again we find that the shells of the Tanganyika genus, *Spekia*, are practically indistinguishable from the fossil remains of the marine Jurassic genus, *Neridomus.*"

In this latter conclusion he is partly correct, for there is no doubt that the affinities of *Spekia* are with the Nerites rather than with the Naticas. *Spekia* is *neritoid*, not *naticoid*, but I fail to trace any especial resemblance to *Neridomus.* If the reader turns to the illustrations on p. 351, he will perceive that the two representations of *Spekia* are back views, whereas the two intended to represent *Neridomus* are front views, nor does the author assist the comparison in the text. But if we take a typical Jurassic *Neridomus* such as *N. Hemispherica* from the Great Oolite of Minchinhampton, which may be regarded as the type on which *Neridomus* was founded, we at once find that the columellar region is convex and the shell imperforate, whereas in *Spekia zonata* the columellar region is extremely concave, and in some specimens a peculiar umbilical slit is noticeable. Hence, beyond the fact that both *Spekia* and *Neridomus* belong to the Neritidæ there is very little resemblance so far as the anterior aspect is concerned. It may be remarked, in conclusion, that *Spekia zonata* is related to *Neritina* rather than to *Nerita.* There is nothing naticoid about it, and moreover its thick epidermis and general aspect are highly suggestive of fresh-water conditions, although its shape may be somewhat unusual.

Of the remaining genera of Gasteropods enumerated, none are especially correlated with Jurassic forms, although they are regarded as belonging to the halolimnic group. *Syrnolopsis* is a genus of small elongate shells represented by two species, and there is stated to be an almost exact conchological identity (p. 219) between these shells and the marine genus *Syrnola*. It is not necessary here to comment on all the remaining halolimnic genera, consisting mostly of small forms, but I would point out certain conclusions with reference to some of them, *e.g.*, *Reymondia*, Smith. There are several species, mostly small, but *R. horei*, Smith, is the most conspicuous form, and may be taken as the type. I mention the circumstance because of the very considerable conchological resemblance between this very smooth shell and some of the Jurassic species such as "*Phasianella*" *elegans*, M. and L., and other sub-elongate forms. This identification seems to have escaped Mr. Moore. I don't attach any importance to it, since neither *Reymondia horei* nor "*Phasianella*" *elegans* have any special features of ornamentation like *Amberleya* and *Purpurina*. There is also another case of mock resemblance, where *Horea ponsonbyi*, Smith, presumably a Prosobranch, bears a strong likeness to some of the striated *Actaeoninæ* of Jurassic age; whilst the remarkably straight columellar lip of *Horea* reminds one of *Orthostoma*, which is, I believe, a synonym of D'Orbigny's genus, *Actaeonina*.

Not the least interesting of the Tanganyika molluscs is the handsome viviparoid shell, *Neothauma*, whose varieties are figured on p. 261. This of course is a thoroughly fresh-water genus, and has no connection with the halolimnic fauna beyond sharing the hospitality of the same lake. One of the most remarkable characteristics of *Neothauma* is the extraordinary difference, judging from the figures, between shells from the south of the lake, and those from the middle and the north. If the internal structure is the same in all three, we have again an instance of the difficulty of recognizing an animal by means of its shell even in living creatures. Here again is a singular instance of mock resemblance to a Jurassic species, since the strap-like or bicarinate variety of *Neothauma* would also do for the figure of *Cloughtonia cincta*, Phillips, a well known fossil of the Inferior Oolite of Yorkshire and the East Midlands.

Postscript. This appendix was written before I had the advantage of hearing Mr. Edgar Smith's presidential address to the Malacological Society, delivered in February last. It was highly satisfactory to find that the chief conchological authority in this country had arrived at pretty much the same conclusions as myself, with regard to the presumed connection between the halolimnic gasteropods of Tanganyika and certain shells of the Inferior Oolite.

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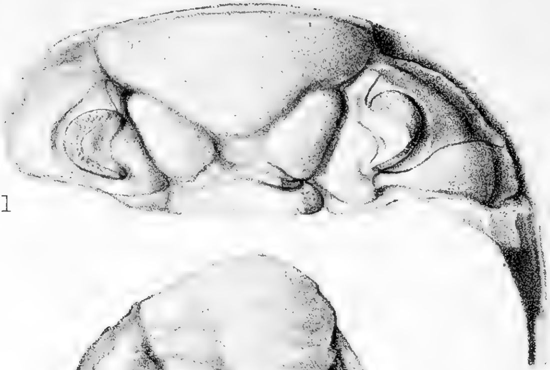

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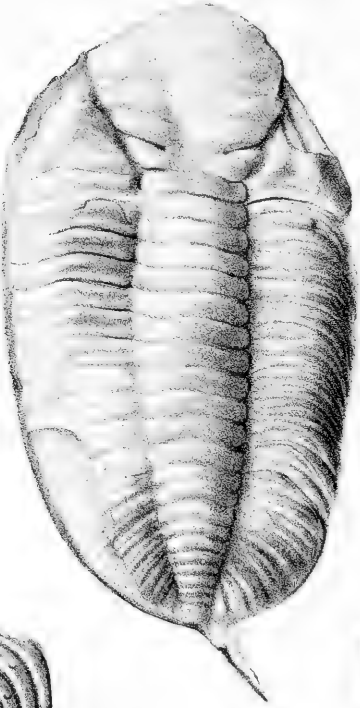

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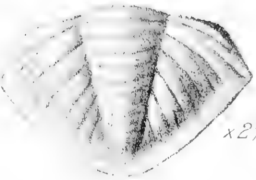

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Phacops and Encrinurus.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. VIII.—AUGUST, 1904.

ORIGINAL ARTICLES.

I.—Sedgwick Museum Notes.
New Fossils from the Haverfordwest District. II.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XII.)

Phacops (Dalmanites) socialis, Barrande, var. (Pl. XII, Fig. 2.)

THERE is one complete individual of a species of *Phacops* from the *Orthis-argentea* zone of Prendergast Lane, Haverfordwest, showing certain interesting characters which make it worthy of notice. The head is somewhat crushed and imperfect, but the glabella is seen to be large and broad and to expand regularly towards the front; the frontal lobe is transversely rhomboidal and nearly half the total length of the glabella; there are three pairs of lateral lobes, of which the anterior pair is the largest; the second pair is narrower, and the third pair is subequal to the second in size. The first pair of lateral furrows is oblique; the second pair is horizontal and slightly arched forwards; the third pair is slightly oblique and the most strongly marked of all; the occipital furrow is strong and curved forwards in the middle. There is only a narrow median strip of the glabella not crossed by the lateral furrows, for they are rather long and all reach inwards to about the same extent.

The thorax has a prominent axis about three-fourths the width of the pleuræ, which are bent downwards and backwards beyond the fulcrum, which is situated at about half their length. Their extremities are slightly bent forwards and apparently rounded or bluntly pointed; a deep diagonal furrow traverses the whole length of each pleura.

The pygidium is nearly semicircular, with a regular rounded margin, except behind the axis, where there is developed a long, pointed, straight posterior spine, about two-thirds the length of the pygidium. (In this specimen it is bent to one side, owing to subsequent crushing.) The axis is about one-fourth the width of the pygidium at its anterior end, and tapers rather rapidly to its middle, and then scarcely at all to end with a blunt (?) extremity just within the margin; it is completely annulated to its tip and shows 11–12 strong rings. The lateral lobes consist of 8 pairs of pleuræ, of which the first seven are prominent, gently curved, and separated by deep interpleural furrows, and each is marked by a weak pleural furrow. The pleuræ and furrows die out before reaching the rounded margin, but there is no independent border or marginal furrow to the pygidium. The whole surface of the head, thorax, and pygidium is ornamented with granulations, and there are also a few large tubercles on the frontal lobe of the glabella.

Dimensions.

		mm.
Length of whole trilobite		82·0
Length of head		27·0
Width of head	(about)	56·0
Length of thorax		33·0
Length of pygidium (without spine)		22·0
Width of pygidium	(about)	33·0

Affinities.—This species clearly belongs to the early group of *Dalmanites* of Barrande, of which *D. socialis* is the type. Our specimen is closely comparable with the variety of this species termed *proæva.*[1] In the characters of the head, so far as it is preserved, there seems to be no difference; the pygidium, except in the shape of the axis, is identical, and the ornamentation is quite similar. The species recently described by the author as *Ph.* (*Dalmanites*) *Robertsi*[2] differs by the narrower and more elongate glabella, by the shape and fewer segments of the pygidial axis, and especially by the absence of the terminal spine of the pygidium.

Ph. (*Dalm.*) *appendiculatus*, Salter,[3] has a somewhat similar glabella, but the pygidium is more elongate and tapers to the mucronate extremity; the axis tapers regularly, and has fewer rings and an appendix; the ribs on the lateral lobes are falcate and undulate the margin.

Phacops (Dalmanites) aff. incertus, Deslongchamps.
(Pl. XII, Fig. 4.)

There are several pygidia from the Slade Beds of the quarry at Upper Slade, Haverfordwest, which seem to indicate a new species of *Phacops*, the description of which may be given as follows:—Pygidium broadly subtriangular, bluntly pointed behind; surrounded by narrow, depressed, concave, smooth border, not mucronate, but slightly elevated and upturned behind axis. Axis conical, tapering rather rapidly at first and then more slowly to blunt apex, not reaching posterior margin; extending about four-fifths the length of the pygidium, and with a width at front end a little more than a quarter that of pygidium; gently convex, annulated for whole length with about 12 or more rings, but only the first 9 or 10 are distinct. Lateral lobes gently convex, each consisting of a half pleura at front end followed by six simple,

[1] Barrande: Syst. Silur. Bohême, vol. i, p. 552, pl. xxi, fig. 32.
[2] Reed: Geol. Mag., Dec. V, Vol. I, p. 106, Pl. V.
[3] Salter: Mon. Brit. Trilob., p. 46, pl. iv, figs. 11, 12.

slightly curved pleuræ, ending abruptly at concave border, and not corresponding to the axial segments. Each pleura has a short oblique furrow on its outer half. Interpleural furrows distinct and of uniform strength for their whole length. Axial furrows moderately strong.

Dimensions.

	mm.
Length of pygidium	9·0
Width	15·0
Width of axis at front end	4·5

Affinities.—This species in its shape and number of axial rings and pleuræ recalls *Ph. appendiculatus*, Salter,[1] but the pleuræ in the latter are deeply furrowed along their whole length and undulate the margin. In *Ph. Weaveri*, Salter,[2] the segments are more numerous, though the contour and proportions of the pygidium are not dissimilar. *Ph. incertus*, Deslongchamps, as recorded by Salter[3] from the Budleigh Salterton pebbles, has a pygidium almost identical, and apparently it differs only in the possession of a more produced and mucronate posterior end. The Slade form is undoubtedly more closely allied to it than to any other. Salter (*op. cit.*) correctly recognised that *Ph. incertus* belonged to the group characterised by *D. socialis* in Bohemia, and it is difficult therefore to see why he ascribed it in the same work to the subgenus *Acaste.*

Phacops (Chasmops) conicophthalmus, Boeck. (Pl. XII, Fig. 1.)

No member of the subgenus *Chasmops* appears to have been so far described or recorded from the Haverfordwest district. Mr. Turnbull's collection, however, contains two examples, one consisting of a fine head from the Slade Beds of Upper Slade, which may be confidently referred to the British form termed *Chasmops con[ic]ophthalmus* (Boeck) by Salter and others, though it is doubtful if it is really identical with Boeck's species. The Slade specimen consists of a cast and external impression, the latter of which shows the surface-characters fairly well. In the shape and proportions of the glabella and of the frontal lobe, 'cat's ear' lateral lobes, and third lateral lobes, it is identical with Salter's figured specimen (*op. cit.*, pl. iv, fig. 25) in the Sedgwick Museum; there is likewise to be noticed the practical absence of the second lateral lobes, which are in most species represented by small nodules; the convexity of the cheeks, position and size of the eyes, and deep furrow round their base also agree, but in our Slade specimen the eye is well preserved and shows the lenses, which are arranged in about 25 rows, with a total number of about 150 lenses in all. The eye-lobe is elevated, prominent, and almost angulated, as Angelin's[4] figure shows, and the genal angles are similarly produced into long, broad, flattened spines, steeply inclined to the general plane of the head-shield and extending

[1] Salter: Mon. Brit. Trilob., p. 46, pl. iv, fig. 12.
[2] Ibid., p. 57, pl. iv, fig. 7.
[3] Ibid., p. 30, pl. i, figs. 27, 28.
[4] Angelin: Pal. Scand., p. 9, pl. vii, figs. 5, 6.

backwards for a distance at least equal to its length. The points of the spines are broken off. Salter (*op. cit.*) described the genal angles as "short-spinous," but his figured specimens have the angles of the head-shield broken off short, so that their true character could not be determined.

The whole surface of the head-shield in our specimen is minutely granulated, but the glabella and neck-ring possess also numerous minute inconspicuous tubercles, regularly distributed over the surface. Salter's figures show the head-shield as coarsely tuberculated, though he expressly states that it is "granular and not tubercular." His figured specimen (*op. cit.*, pl. iv, figs. 5, 6) and other specimens named by him show numerous small low tubercles; so that the description is misleading.

Of other species resembling this British form the one named *Ch. maxima*, Schmidt,[1] may be mentioned; the shape of the glabella and first lateral lobes agrees closely in some specimens, and the proportions as given by Schmidt are similar; but the presence of distinct second lateral lobes, the more numerous lenses in the eye, and the absence of a tubercular ornamentation mark it off.

DIMENSIONS.

	mm.
Length of head-shield	19·0
Width of head-shield...	50·0
Length of glabella	15·0
Width of glabella (anterior end)	25·5
Width of glabella (at base)	12·0
Length of frontal lobe	11·0

PHACOPS (CHASMOPS) MACROURA (Sjögren)? (Pl. XII, Fig. 3.)

The second example of the subgenus *Chasmops* is a specimen of an imperfect pygidium from the Sholeshook Limestone of the Sholeshook Railway cutting. It shows the typical characters of the form attributed by Salter[2] to *Ch. macroura*, Sjögren, but which is believed by Schmidt[3] to belong to *Ch. Eichwaldi*, Schmidt. It appears to me highly probable that the English form is distinct from both these species, and perhaps more than one species has been included by Salter and others under this name. But the species of this subgenus are so closely allied to each other that when dealing with imperfect and fragmentary specimens it is almost impossible to separate them with certainty.

In this Sholeshook specimen there is a faint row of pits visible along each pleural furrow on the lateral lobes, such as was described by McCoy[4] in the pygidium of *Ch. macroura*, but this feature was not mentioned by Salter in his specific description and is not observable in the majority of British specimens, though perhaps

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 112, pl. iii, fig. 11; pl. iv, figs. 1–3 (especially fig. 2), etc.

[2] Salter: Mon. Brit. Trilob., p. 37, pl. iv, figs. 18–23.

[3] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 117, pl. iv, fig. 4; pl. v, figs. 8–10, 16; pl. x, fig. 21.

[4] McCoy: Syn. Brit. Pal. Foss., p. 162, pl. i G, fig. 20 (*Odontochile truncato-caudata*).

this may be due to their state of preservation. It is present in *Ch. amphora*, Salter,[1] but in other respects this species is distinct.

ENCRINURUS MULTISEGMENTATUS (Portlock). (Pl. XII, Fig. 5.)

This species was not recorded by Messrs. Marr and Roberts from the Haverfordwest area, but in the Turnbull Collection there are several well-preserved pygidia and one cranidium from the Slade Beds of Cuckoo Grove Lane.

The cranidium of this species, which was described by Portlock[2] as *Ampyx* (?) *baccatus*, has a characteristic circlet of about ten large projecting tubercles in front of the pear-shaped convex glabella, which in our specimen (a cast) shows distinct traces of two pairs of lateral lobes. The tumid fixed cheek is about half the length of the glabella, and is ornamented, like it, with large tubercles. The pygidium, upon the characters of which Portlock[3] based his species *Amphion* [*E.*] *multisegmentatus*, is of an elongated triangular shape, with a long tapering axis annulated to its tip with 24–30 rings, which are quite continuous across the axis, though between the posterior ones the intervening furrows are less deep in the middle. No tubercles are present on the axis. The lateral lobes consist of 12 simple pleuræ (8–10 only show in our specimens, which are imperfect posteriorly); the anterior ones are curved gently backwards, while the posterior ones are successively more strongly directed backwards till the last few lie almost parallel to the axis. The whole surface of the pygidium is finely granulated, and there are 1–3 large tubercles on each pleura.

DIMENSIONS.

	mm.
Length of cranidium	8·5
Length of pygidium	14·0
Width of pygidium (at front end)	12·5

REMARKS.—A form under the same specific name, comparable or identical with Portlock's species, has been described by Schmidt[4] from the Lyckholm Beds of the Russian Baltic provinces, and by Törnquist[5] from the Leptæna Limestone. The species has also recently been recognised in the Whitehouse and Drummuck groups of the Girvan district. It is closely allied to *E. Seebachi*, Schmidt,[6] from the Wesenberg Beds.

The points of difference between *E. multisegmentatus* and the allied *E. multiplicatus* have been previously given by the present author[7] in describing the latter. The type of Portlock's *E. multisegmentatus* is in the Jermyn Street Museum, where I have had the privilege of examining it.

[1] Salter: op. cit., p. 42, pl. iv, fig. 16.
[2] Portlock: Geol. Rep. Londonderry, p. 262, pl. iii, fig. 11.
[3] Ibid., p. 291, pl. iii, fig. 6.
[4] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 227, pl. xiv, figs. 14, 15; pl. xv, figs. 19, 20.
[5] Törnquist: Undersökn. Siljansom. Trilobitf. (Sver. Geol. Undersökn., ser. C, No. 66), 1884, p. 24, pl. i, figs. 18, 19.
[6] Schmidt: op. cit., p. 229, pl. xiv, figs. 16–26; pl. xiv, figs. 21–23.
[7] Reed: GEOL. MAG., Dec. IV, Vol. VIII (1901), p. 107, Pl. VII, Fig. 3.

EXPLANATION OF PLATE XII.

Fig. 1.—*Phacops* (*Chasmops*) *conicophthalmus*, Boeck. Head-shield. Slade Beds, Upper Slade, Haverfordwest. × 1½.
,, 2.—*Phacops* (*Dalmanites*) *socialis*, Barr. Var. Nearly complete individual. *Orthis argentea* zone, Prendergast Lane, Haverfordwest. Nat. size.
,, 3.—*Phacops* (*Chasmops*) *macroura*, Sjögr.? Portion of pygidium. Sholeshook Limestone, Sholeshook Railway Cutting, Haverfordwest. Nat. size.
,, 4.—*Phacops* (*Dalmanites*) aff. *incertus*, Desl. Pygidium. Slade Beds, Upper Slade, Haverfordwest. × 2½.
,, 5.—*Encrinurus multisegmentatus*, Portl. Pygidium. Slade Beds, Cuckoo Grove Lane, Haverfordwest. × 2½.

II.—Some Eroded Rocks in Corsica.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(PLATE XIII.)

As I have recently seen certain cases of the curious hollowing out of rocks in Corsica, described by Mr. F. F. Tuckett (with a note from myself) in the January number of this Magazine, for which Mr. Lake suggested an explanation in the following number, I will add something to that note and intimate why I did not refer to desert regions for an explanation. The case which Mr. Lake mentions ("Das Gesetz der Wüstenbildung," fig. 7) undoubtedly much resembles Mr. Tuckett's photographs, and so, to some extent, do figs. 16 and 17, more especially the latter. With these I was not then acquainted, perhaps having overlooked the book, because I wrote a notice of "Die Denudation in der Wüste," when it appeared in 1891, and had formed the opinion that the author was disposed to work his hypothesis for rather more than it would stand. As, however, I knew there would shortly be a chance of my getting a glimpse of the Egyptian desert, I postponed stating why I had not suggested that kind of atmospheric erosion. In this region, however, I saw no more than I already knew, but on our return, owing to an unexpected change of plans, we spent an afternoon and part of the next day in harbour at Ajaccio, when, by a lucky chance, I hit upon some curious instances of erosion, which I think may be worth a brief description.

After strolling through the town, I walked from the Place Bonaparte to a quarry which has been opened at the foot of the hills. These rise rather steeply from the town, and must be sloping just at this point roughly to the south-east. The rock was a fairly coarse porphyritic granite, grey with a tinge of pink, with the surface but slightly decomposed.[1] I rambled up the slope, on which outcrops of granite are often frequent, attracted by the beauty of the wild-flowers, until I reached a road running along the hillside,

[1] A thin slice shows the rock to be, for a granite, in good preservation. Enough to say that it consists (apart from minor details) of quartz, biotite, and felspars, some of which (probably orthoclase), by enclosing smaller crystals of another species (usually a plagioclase), and by a peculiar mottling and streaking (perhaps a result of strain), recall the felspars of one or two Alpine granites, such as the protogine of the Mont Blanc range or that on the upper part of the St. Gotthard Pass.

perhaps 400 feet above the sea.[1] Along this I strolled for a short distance to enjoy a yet wider view; the slope rising rather steeply on one hand, occupied partly with tillage, partly with trees, but showing here and there a small knoll or boulder of granite, and descending on the other hand, being overgrown, in the immediate neighbourhood, with herbage and trees.[2] On this slope, and a short distance below the road, my eye was attracted by a block of granite, apparently a boulder several cubic yards in volume, on the lower part of which was a curious excavation.

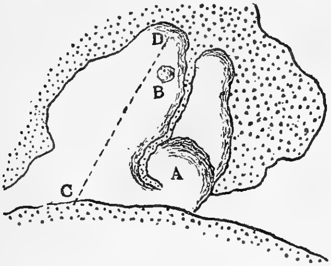

Fig. 1.—Hollow in Granitic block, outer surface dotted. A, mouth of inner hollow; B, hole into it.

Fig. 2.—Section along the line C–D in Fig. 1.

The annexed sketches (Figs. 1 and 2), though very rough, for the subject was difficult to draw, will save a long description. The hollow (as the section in Fig. 2 shows) was on rather the under side of the boulder, against which a smaller one was lying. From C to D (Fig. 1) was about 30 inches (estimate), and the deepest part (at A) perhaps 16 inches. From this, however, a funnel-like cavity went upwards with a circular opening into it at B, about 2 inches in diameter. Holding the head of my hammer, I thrust the handle up the funnel till its end passed this opening. How much higher it may go I cannot say, for when I have a defective knowledge of the aggressive fauna of a country I am not over curious in exploring dark hollows. The part drawn looked roughly west, and on the opposite side of the block was a smaller hollow.

A few yards lower down the slope a block of granite, measuring rather more than a yard one way and a little less the other, is built into a low wall. On its surface are no less than eleven basin-like hollows, most of them about 4 inches in diameter; two being from 8 to 10 inches deep, and others 4 or 5 inches. As I scrambled downwards through the wood I saw many more hollows, either in boulders or in outcrops of granite, sometimes one, sometimes several on a block. Some were mere 'potholes' like those made by water, others short channels, rudely resembling the cast of a slug, which not seldom deepen in one part to a kind of basin;

[1] Perhaps it was part of the Salario Road. I had no map of Ajaccio.
[2] The majority were wild olives, as Sir W. T. Thiselton-Dyer, after examining a specimen, has kindly informed me.

others again sink deep into the stone, certain of them running either upwards or sideways; occasionally they reminded one, though of course they were much larger, of the borings made in limestone by snails.[1] One resembled those photographed by Mr. Tuckett (except that the eroded hollow was higher up the side of the block), and I think a big lad might have curled himself up inside. The surface of the blocks was in fair preservation, for though the felspar was rather dulled and whitened it was not at all rotten;[2] that of the hollows was smoothed, occasionally almost glazed, but the porphyritic felspar-crystals were often just prominent enough to catch the eye and be felt by the finger. The majority of the hollows looked towards the west; the remainder faced to the other points of the compass, sometimes more than one way on the same block, and they were at various heights from the ground. The group represented in Pl. XIII, though not one of those which I saw, gives an excellent idea of some of the hollows. I am indebted for it to Sir C. W. Wilson, K.C.B., F.R.S., to whom I had mentioned the discovery, and from whom I received it after this paper was in type. He tells me that it was on the slope, a few yards from a wall boundary and pathway, and, as far as he can remember, within a hundred yards of the garden wall of the Hôtel Continental (in the Boulevard Grandval). The dimensions are, at a rough estimate, 5 × 6 feet.

I saw from the vessel some granite blocks on the northern slopes of a valley which comes down to the sea a little to the north of Ajaccio, so I walked there next morning. They are not far from the Pénitencier de Castelluccio. Here, however, the blocks were not so numerous or accessible, and I found but one good example of these hollows, of which a diagram is annexed (Fig. 3); this occurs

Fig. 3.

on the front face of a rudely quadrangular block, defined by rough joints, which rises to a height of 9 or 10 feet above the ground, being perhaps 5 feet wide near the top. In form the hollow slightly resembles the outstretched head of a duck with a rather

[1] See Geol. Mag., 1869, Pl. XVII, and the Fig. on p. 486.

[2] In a specimen obtained from a block on a more exposed part of the hillside, in which was one hollow, the cleavage-planes of the larger felspars still reflect light fairly well.

Eroded Granite Boulder, near Ajaccio. Corsica.

From a photograph by Sir C. W. Wilson, K.C.B., etc.

pointed bill; it was about a yard long, 16 inches in greatest breadth, and 14 inches in greatest depth, the lowest point being about $7\frac{1}{2}$ feet from the ground. All the figures are estimates, the hollow being inaccessible. In it were two basins, one in the head (the deeper, I think), the other at the end of the 'neck.' This face of the rock looked a little south of east.

Since my return to England I have ascertained that an account of these curious hollows was published in 1882 by Prof. H. H. Reusch (Bull. Soc. Géol. France, sér. III, t. xi, p. 53).[1] He states that they occur in both granite and schists, the smaller being called *tafoni*, the larger *grottes*, and thinks they indicate soft places in the mass, thus being the converse of the weathered out blocks which simulate erratics. He remarks that he has seen some approach to the structure in the old sea caves of Norway. They are also mentioned, with other cases of peculiar erosion, in Professor Penck's "Morphologie der Erdoberfläche" (1894, pt. i, pp. 214–216), and by him attributed to local decomposition, but these in several cases appear to be only basins of the 'sacrificial' type. Signor Paul Choffat, however, gives an excellent description of some examples in Portugal ("Communicações da Direcção dos Trabalhos Geologicos de Portugal," t. iii, p. 17) with four good illustrations. They occur in a porphyritic granite at two localities very different in situation. One, in the Gerez, is nearly 15 leagues inland on barren hills, almost 3,000 feet above sea-level; the other, at Faro d'Anha, at heights of from 500 to 550 feet in a thick wood of tall pines. There are three types: simple basins, basins with a linear arrangement and more or less in communication by destruction of the intervening walls, and, thirdly (only at Faro d'Anha), varied forms, such as I have described above, one of them being undercut, though to a less extent than that figured by Mr. Tuckett; the sides, not in this case only, exhibit a slight, rudely horizontal ridging, with an approach to a glaze. Signor Choffat attributes these hollows to local decomposition, though, if I rightly understand him, he would not exclude the possibility of some having been 'touched up' by prehistoric man. He states that the basins (of the Dartmoor type) are not unfrequently surrounded by a slight rim, as if the adjacent rock were slightly harder than the rest, mentioning a suggestion by Professor Heim that this might be due to percolation of silica liberated by decomposition of the felspar—an ingenious idea, worth careful consideration, for it would also explain the occasional approach to a glazing of the surface, but not quite free from difficulty, for this percolation would have sometimes to extend almost against gravitation, and one would expect the hardening of the silica to check the enlargement of the cavity.

Decomposition seems the natural explanation, but in some of the cases described this must have acted in a singularly selective way; the granite also, as I have said, shows no sign of anything

[1] I was set on the track of this and other references by Sir A. Geikie's valuable "Text Book" (p. 456). Professor Reusch also published in a Christiania scientific periodical (1878), but I have not been able to consult the paper.

like rottenness, and the schist, as implied on p. 12, is in good condition close to the very outside. The state of the surface suggests that mechanical forces may have co-operated with chemical, for it is not unlike that produced by blown sand; yet to gouge out some of these, for instance that first described, the winds would have to eddy in a very queer fashion, for the holes occasionally run deep into the rock both sideways and upwards. Nor does the action of dew or of moisture in any form seem a promising explanation, for they occur on both sheltered and exposed sides of the blocks and look to all points of the compass, though more commonly westwards.

This brings me to the difficulty, which, owing to my general knowledge of Corsica and Mr. Tuckett's descriptions, had prevented me from seeking an explanation in Indian or any other desert regions. Its scenery, so far as I know it, is at least as luxuriant as that around the subalpine Italian lakes. There was not a trace of grit or sand about the Ajaccio blocks, and to reduce an island in this part of the Mediterranean to the conditions of a desert or steppe would demand changes of geography or climate which are almost startling, and we must also suppose that since the arid epoch ended the surfaces of the hollows have undergone little or no alteration. Neither atmospheric corrosion nor any form of wind abrasion seems to satisfy all the conditions of the problem, and until I can spend some time in Corsica to study other examples I prefer to restrict myself to this statement, negative though it be.

III.—On the Homotaxial Equivalents of the Lower Culm of North Devonshire.

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

In the paper on the Pendleside group at Pendle Hill, Q.J.G.S., vol. lvii, p. 377, I said, "The further facts of the distribution of *Glyphioceras spirale* and *Posidonomya Becheri* set forth in the foregoing pages open up the wide question of the age of the Culm beds of Devon and Germany." Since then I have had the great advantage of examining suites of fossils from the Lower Culm of Devonshire, collected by Mr. Hamling, of Barnstaple, and Mr. Coomáraswámy, from the Coddon Hill Beds and other localities in North Devon. I was so interested in the fossils that I found it necessary to go down and examine the beds in which they occurred, and Mr. Hamling gave me the inestimable advantage of his guidance. In this way we examined the Lower Culm and the underlying Pilton Beds in detail from West Leigh to Fremington, and the so-called Middle Culm of Bideford and other places. I was able to see the Hall collection of fossils at Barnstaple, and again to renew my acquaintance with Mr. Hamling's collection. This visit to Devonshire, it seems to me, was fortunately planned after a visit last Summer to the Devono-Carboniferous succession in the south-west of Ireland, and a study of the fauna in the collection of the Geological Survey at Dublin and in the Museum of Queen's College, Cork.

If palæontology is of any value, and the distribution of fossils does indicate homotaxis, then we are particularly fortunate in the Culm, which, though it is not richly fossiliferous, yet contains peculiar and well-marked species, which do indicate well-marked horizons in the Carboniferous series further north.

There are certain stratigraphical facts which are well known, such as the general succession of the Devonian series and its relation to the Culm. It is agreed that the geological structure of Devonshire is a synclinal, and that in the north the rocks are all very highly tilted and dip steadily south at high angles; that the dip is not simple, but that in each member of the series there are many secondary folds, owing to which it is impossible to estimate the thickness of each division. There appears to be no unconformity between the Upper Devonian or Pilton Beds and the Lower Culm.

The Lower Culm consists of two very distinct series of rocks: the Coddon Hill Beds, which are composed of thin-bedded, hard, siliceous, or cherty, light-grey or fawn-coloured rocks, full of radiolarian remains, and containing a small but distinctive fauna, and the Venn or Black limestones, of hard, splintery, black, semi-crystalline limestone and calcareous shales with *Posidonomya Becheri* and *Glyphioceras crenistria.*

The first and important point to settle is the true succession in the Lower Culm, that is to say, what is the relation between the peculiar thin siliceous beds of Coddon Hill and the Black limestones yielding *Posidonomya Becheri* of Venn, Bampton, and West Leigh?

Sedgwick (Trans. Geol. Soc., ser. VI, vol. v, p. 670) thought that the Coddon Hill Beds were below the *Posidonomya* beds. Phillips and many others thought the reverse; but Mr. Ussher ("Culm-measure Types of Great Britain," Trans. Inst. Min. Engineers, vol. xx, 1901, p. 362), in his table of the classification of strata, favours the view that the Coddon Hill cherts are below the *Posidonomya* beds. This Mr. Hamling tells me has been his opinion, and together we examined the ground carefully with a view to ascertain the evidence for this succession.

Mr. Hamling writes me as follows:—"I see at the reading of Hinde & Fox's paper on 'A well-marked horizon of Radiolarian Rocks in the Lower Culm of Devon, etc.,' I expressed agreement with their conclusions, which suggest that Venn beds are below Coddon Hill (Q.J.G.S., vol. li, 1895, p. 609). I have worked these beds very closely since then, and now believe the Coddon beds are below Venn. Perhaps you can explain this change of opinion since 1895."

Standing on Coddon Hill and looking north and east, it is to be noted that the Coddon Hill range runs east to beyond the village of Swimbridge, and that it meets east of that village a ridge which runs into it from the west, forming a Y; i.e., there is a synclinal of Coddon Hill Beds which west of Swimbridge has the beds contained in the syncline gradually pinched out in succession, so that the two limbs of the synclinal come together. The contour of the surface of the synclinal trough is important. Tracing the rocks from north to south, Coddon Hill beds form an east to west line of elevation, succeeded by a hollow trough. In this hollow the Venn limestones,

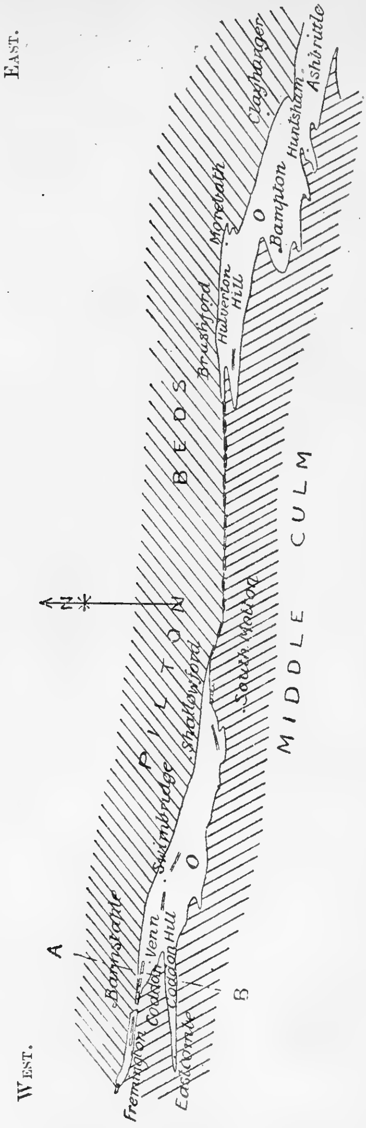

Fig. 1.—Country near Barnstaple, from Fremington and Eastcombe on the West to Clayhanger and Ashbrittle on the East. O, O = the Coddon Hill Beds, with *Posidonomya* Limestone; A–B, line of section given in Fig. 2.

Scale, 6 miles to an inch.

with *Posidonomya Becheri*, have been worked. In the centre of the synclinal is an east to west line of elevation, sections of which show grits and rocks of a Middle Culm type. South there is a hollow parallel with the strike between these grits, the main Coddon Hill range, which I think indicates the Black limestone of Venn, and immediately south is the Coddon Hill range. This would make the succession—

Middle Culm grits.
Posidonomya beds.
Coddon Hill beds.

Unfortunately no limestones have been worked in the hollow south of the Middle Culm, although the depression which exists parallel to and between the Coddon Hill Beds and Middle Culm grits seems to indicate calcareous beds.

There is no doubt that the dips taken in various quarries show that the beds on the north are dipping south, and those of the main Coddon Hill range dip north. Also the Venn limestones are dipping south at a very high angle, conformable to the Coddon Hill Beds of Venn Cross quarry on the north side of the synclinal. So that in the valley between Venn Cross, where the beds dip south, and Coddon Hill, where the beds dip north, is situated the Venn limestone with *Posidonomya Becheri* and the Middle Culm grits. Traced east, in the gradually vanishing synclinal, first of all the feature formed by the Middle Culm grits disappears near Hannaford, and in the hollow between this terminating feature and the junction of the two limbs of the Coddon Beds, the *Posidonomya* limestones crop out rich in fossils and occupying a hollow with beds of Coddon Hill type to the north and south of it.

East of Swimbridge, from Filleigh to Marsh, are a line of old workings in the Black limestones, but the Coddon Hill Beds become faulted out, so that apparently in turn, first *Posidonomya* beds and then the Middle Culm beds rest on the Pilton series or Upper Devonian. At Headon, quarries of well-marked Coddon Hill Beds, here associated with much wavellite, are dipping south and are north of the line of the Filleigh limestones, but a little east of North Aller Farm they have disappeared and the limestones are faulted against Pilton Beds. For the next 17 miles eastward Lower Culm beds have been cut off by faults, but near Dulverton Station beds of Coddon Hill type are to be seen having the same strike as at Coddon Hill east and west, dipping almost vertically but with a southerly trend.

Close to Dulverton Station, near Brushford village, is a quarry in Pilton Beds whence Phillips obtained many of the fossils which he described, and south of this village is Kent's Hill quarry with thin siliceous beds of the Coddon Hill type. About half a mile further east is the Hulverton Hill quarry. This hill has the curious contour which seems to be typical of Coddon Hill Beds elsewhere, and the beds themselves are characteristic. Nowhere are beds of *Posidonomya* limestone seen between Pilton and Coddon Hill Beds. Still further east, at Ashbrittle, are Coddon Hill Beds, and these are apparently lying on Pilton Beds.

If the geological map made by Mr. Ussher and published in his paper in the Transactions of the Institute of Mining Engineers (op. supra cit.) be examined, it will be seen that from south to north the Lower Culm beds tend to form a succession of small evanescent synclinals due to folding. Tongues of Middle Culm measures invade the Lower Culm, lying in small troughs which become lost as they pass east. One of these troughs runs up between Hulverton Hill and Westbrook, but in this trough I think I am right in saying no limestones have been found. But at Westbrook Farm and near the road from Brushford to Bampton, beds of Coddon Hill type are to be seen dipping south, to pass beneath the *Posidonomya* limestones so fully exposed in the many Bampton quarries. In the railway cutting north of Bampton Station the beds are distinctly thin and cherty, and approach closely to the Coddon Hill type.

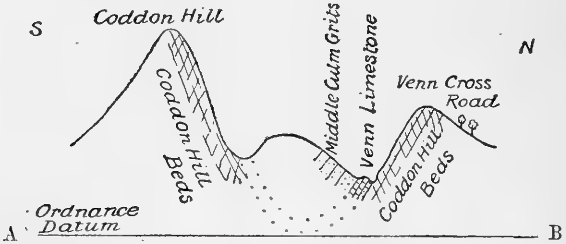

Fig. 2.—Section through Coddon Hill Beds, Barnstaple, on the line A–B in Fig. 1. Scale: horizontal, 4 inches = 3 miles, or 2 inches = $1\frac{1}{2}$ miles; vertical, $\frac{1}{4}$ inch = 150 feet.

At Holcombe-rogus and Westleigh the well-developed limestones all crop out south of the general strike of the Coddon Hill Beds, but the time was too short, in this immediate neighbourhood, to examine the ground in sufficient detail.

West of Barnstaple an examination of the succession at Fremington seems to point to similar conclusions. The river bank at Fremington shows a series of fossiliferous shales with numerous Brachiopods and corals of a Carboniferous type, but containing no fossils which could be used as an index of horizon. These beds evidently are either at the top of the Pilton series or immediately overlie that series, but for our present purpose it is important to note the relation of the strike of these beds to that of the Pilton series, for they afford a base-line for the determination of the beds immediately above them. These are seen at Pen Hill quarry, immediately south of the railway line, where there are thin platy beds with cherts in bands and siliceous beds, but also there is here a development of calcareous beds of some few feet in thickness. The limestones and shales, however, have not been found to contain *Posidonomya Becheri*, and the whole section bears a close lithological resemblance to the Coddon Hill Beds. The beds are dipping south at an angle of 28°. At Fremington Pill, near Gaydon's Cottage, thin-bedded siliceous rocks of light fawn colour, with numerous chert bands, here decomposed, strongly recall Coddon Hill Beds. These lie above the beds seen in Pen Hill quarry, and in the upper portion of them, 90 yards from the wall of Gaydon's Cottage, occurs *Posidonomya Becheri* in abundance. A short distance further south the Black *Posidonomya* limestones have been worked.

On the foreshore west of Fremington Station are beds dipping 50° S. which have a Coddon Hill character; they are apparently on the top of the limestone band in Pen Hill quarry, which crops out on the shore at low water. This would make the succession at Fremington as follows:—

Posidonomya Becheri Limestones	Venn Limestones.
Dark shales with *P. Becheri*.	
Lighter-coloured shales with cherts	Coddon Hill Beds.
Band of limestone	
Shales	
Fossiliferous shales	Passage beds.
Pilton series	Upper Devonian.

Following the beds along the strike westward, no beds of Coddon Hill type are to be seen between the Fremington limestones and the Middle Culm beds at Instow.

The beds at Instow are of great importance; they consist of a series of sandstones, shales, and clays, including calcareous nodules crammed with fossils. I was fortunate enough to find two species which had not previously been recorded from these beds.

Pterinopecten papyraceus, Sow., sp.
Posidoniella lævis, Brown, sp.
Gastrioceras Listeri, Martin, sp.
Gastrioceras carbonarium, V. Buch., sp.
Dimorphoceras Gilbertsoni, Phill., sp.
Cœlacanthus elegans.
Elonichthys Aitkeni.

These beds seem to succeed the sandstones and shales at the base of the Middle Culm, and the fauna indicates unmistakably the Lower Coal-measures of the horizon of the Bullion Mine of Lancashire.

Quarries between Instow and Bideford show indurated clays, shales, and grits, which have a very familiar aspect to anyone well acquainted with the Coal-measures of the Midlands.

Roberts' Quarry, east of Bideford, is an important horizon, because here in indurated clay and fawn-coloured shales abundant plant-remains occur, which are identical with ferns and plants found in the Coal-measures of the Midlands. Immediately above the plant-bed is an indurated light-coloured clay, with iron stains in its joints, in which the typical Coal-measure shell *Carbonicola acuta* is not uncommon. Unfortunately, time did not allow further work in the beds above the Lower Culm, but the fauna and flora bear out Sedgwick's view (op. supra cit., p. 682), "The Upper Culm strata of Devon are the geological equivalents of the ordinary Bristol coalfields."

Palæontology. — The fossils of the Lower Culm are, with the exception of some new species of Trilobites described by Dr. Henry Woodward, not confined to Devonshire, but are known to have a fairly definite and constant distribution in other Carboniferous areas.

In that area of England between Cracoe in Craven and Leicestershire where the Pendleside series is developed, it is found that immediately on the top of the massif of Carboniferous Limestone at Warsoe, at the foot of Pendle Hill, in the River Hodder, near Stoneyhurst, and at Astbury limestone quarry at the foot of Congleton Edge, Cheshire, are beds containing *Prolecanites compressus* and Trilobites of various species. Higher up in the series are beds with *Posidonomya Becheri.* Then at Congleton Edge and Pendle Hill some 300 feet below the Millstone Grit beds are marine shales with *Glyphioceras spirale.* Such a succession has been found to occur in many localities, and I take it to be a normal one, and that the fossils mentioned above indicate definite zones in the Pendleside series. Seeing that these fossils occur in the Lower Culm series, it is important to ascertain whether there is any stratigraphical reason for supposing a different succession of these fossil zones; if not, the known relation of the fossil zones in other areas may be used as an argument for a similar succession in the Culm area.

In the Lower Culm series there are two distinct faunas, one contained in the Coddon Hill Beds, the other characterising the Venn limestones.

Beds of Coddon Hill type.

In the Coddon Hill Beds the following important fossils have been obtained :—

Trilobites.

Phillipsia Leei.
,, *minor.*
,, *Cliffordi.*
? **Phillipsia Polleni.*
Griffithides acanthiceps.
,, *longispinus.*
Proetus, sp.

Corals.

**Palæacis humilis*, Hinde.
**Pleurodictyum Dechenianum*, Kayser.
**Petraia* cf. *pauciradialis*, Phill.

Cephalopoda.

Prolecanites mixolobus, Phill., sp.
* ,, *compressus*, Sow., sp.
**Nomismoceras spirorbis*, Phill., sp.
**Pericyclus*, sp.

Lamellibranchs.

**Chænocardiola Footii*, Baily, sp.

Brachiopoda.

**Chonetes Laguessiana*, and shells either crushed or varieties alluded to by Von Koenen as *C. deflexa* and *C. rectispina.* **Productus plicatus*, Sarres.

*Several Radiolaria.

The species marked * are all found at the base of the Pendleside series in the Bolland district of Yorkshire. The exact locality where Phillips obtained *P. mixolobus* is unknown, as he only gives Bolland, which is a large district in which are beds belonging to the Carboniferous Limestone, Pendleside series, and Millstone Grit.

Palæacis humilis, says Dr. G. J. Hinde, is "fairly common in shale or mudstone, associated with limestones and chert exposed on the banks of the river Hodder, below Stoneyhurst College, Lancashire; according to Mr. R. H. Tiddeman the rocks . . . . come in between the Clitheroe limestones and the Pendleside limestones."

This is so, the beds forming the base of the Pendleside series. It occurs in the Lower Culm only in beds of the Coddon Hill type.

Chænocardiola Footii is a shell always associated with a lower Pendleside fauna in the Midlands and Ireland; its occurrence in the Lower Culm of Hannaford quarry is important. Mr. J. G. Hamling has some fragments in his collection, but I was particularly fortunate to find two valves in the trilobite beds of Hannaford quarry. In my monograph on British Carboniferous Lamellibranchs, vol. i, p. 476, I quoted Coal-measures as the horizon for this species. I think Roscliff, co. Clare, is below that horizon, and should be Pendleside series.

Prolecanites compressus.—Although I feel strongly the value of this species as a zonal form, there is no doubt that it is not absolutely confined to the base of the Pendleside series, for it occurs in the Carboniferous Limestone of Little Island, co. Cork, and in the lower limestones of Scarlett Quarry, Isle of Man. Still, there is a definite and well-defined series of rocks, of no very great thickness, immediately at the base of the Pendleside series, which is characterised by this shell, and it does occur below shales and black limestones with *Posidonomya Becheri.*

Nomismoceras spirorbis.—The type of this species was obtained from the Black limestone of Black Hall, Bolland, Pendleside series; and it is of great interest to note that the strike of the beds and their relation to the Millstone Grits at Black Hall would make these beds below a series quarried at Cold Coates which contain *P. Becheri* in abundance.

Pericyclus, sp.—I have obtained similar examples from the Pendleside series of Yorkshire and the Lower Culm.

Trilobites.—Dr. H. Woodward described two Trilobites from the base of the Pendleside series (R. Hodder, Geol. Mag., 1894, Dec. IV, Vol. I, pp. 481–489), *Phillipsia Polleni* and *P. Van-der-Grachtii.* Subsequently I found the latter associated with *Prolecanites compressus* at Ashbury quarry, Cheshire, and Dr. H. Woodward recognises *P. Polleni,* though with some hesitation, in the cherty beds of Coddon Hill (Geol. Mag., 1902, Dec. IV, Vol. IX, p. 482). It is important, however, to note the occurrence of species of Trilobites at the horizon of the base of the Pendleside series and Lower Culm, the majority of which do not occur in the Carboniferous Limestone.

Brachiopoda.—There is no very important evidence afforded by the Brachiopoda found in the Lower Culm and Pendleside series. I have always regarded the varieties of *Chonetes* occurring in the Culm of Germany and described under different names to show no greater difference from each other than is found to obtain amongst a number of individuals collected from the same bed and horizon. Certain species of *Productus* may be peculiar, but unfortunately the specimens are not well enough preserved to say whether the differences are due to dwarfing and crushing or to specific characters. All the other Brachiopods, *Discina nitida, Leptæna analoga, Orthotetes crenistria, Athyris ambigua,* occur at many horizons in the whole Carboniferous series.

Radiolarian rocks also are found in the Pendleside series. There is, therefore, a very remarkable and close resemblance in the faunas of the Coddon Hill Beds of the Lower Culm and the Pendleside series: so practically identical, indeed, are they, that there can be little or no doubt that they are the homotaxial equivalents of each other.

The Venn, or *Posidonomya Becheri* Limestone.

The fauna contained in the black limestones of North Devon is not so rich in species as that of the Coddon Hill Beds, but the following species are abundant:—

Posidonomya Becheri.
Pseudamusium fibrillosum.
Glyphioceras spirale.
,, *crenistria.*
Glyphioceras striatum.
,, *sphæricum.*
Orthoceras cylindraceum.

Plant Remains: *Cordaites*, sp.

Posidonomya Becheri.—I only recognise one species. The examination of a large number of specimens has convinced me that the forms *P. tuberculata* and *P. lateralis* are accidental, due to conditions of preservation and degree of flattening by compression.

I regard *P. Becheri* as an important zonal form, indicating a horizon somewhat above that of *P. compressus.* I have found this zone constant in position from Old Head of Kinsale in the south of Ireland to Clavier and Visé in Belgium. The zone has no great vertical depth, and I am unable to indicate the precise thickness, but in the Midlands, beds characterised by *G. spirale* extend some hundreds of feet above *P. Becheri.*

I have, as in the case of *Prolecanites compressus*, found specimens of *P. Becheri* at a lower horizon. It occurs in the Yoredale series of Wensleydale above the Great Scar Limestone, and I have found it actually in the top beds of the Carboniferous Limestone at Castleton, but in these places it has, with it, a typically Carboniferous Limestone fauna.

At Poolvash, Isle of Man, *P. Becheri* occurs in black limestone and shales, which succeed the shelly white upper beds of the Carboniferous Limestone. With it is the following fauna:—

Solenomya costellata.
Orthoceras Morrisianum.
,, *sulcatum.*
Glyphioceras crenistria, and a crushed Cephalopod which Mr. Crick identifies as *Stroboceras sulcatum.*

I have not been able to get at the beds at the base of the series, where I should expect to find *Prolecanites compressus* and Trilobites.

Some curious beds containing *P. Becheri* occur at Budle, Northumberland, the real horizon of which is very doubtful and vague.

Ireland.

In co. Dublin the Pendleside series succeeds the Carboniferous Limestone near Sherries; at the former horizon *P. Becheri* is found in abundance. At Old Head of Kinsale, south-west of Cork, *P. Becheri* occurs in hard shaly beds in a curious sequence of shales and thin indurated calcareous beds. In South-West Cork, as in Devonshire, the Carboniferous Limestone is absent, and there is a passage from Devonian rocks into Carboniferous without a stratigraphical break. Curiously enough, beds with a Devonian fauna, *Cucullæa unilateralis* and *Ptychopteria Damnoniensis*, which in Devonshire are recognised as the *Cucullæa* beds and occur below the Pilton Beds, are classed as Carboniferous in Ireland. It appears to me that a similar sequence occurs in both South-West Cork and Kerry and Devonshire. The Coomhola grits with *Cucullæa unilateralis* and *Ptychopteria Damnoniensis*, are the equivalents of the Pickwell Down and Baggy Point Beds, and the beds with *P. Becheri*, the equivalents of the Venn Limestone series of the Lower Culm. It would be well if stratigraphical lines, based on palæontology, were identical in the two countries. The fauna of the Coomhola grits is typically Devonian, and not Carboniferous. The absence of Carboniferous Limestone in North Devonshire and further west along the line of strike, at Old Head of Kinsale and the part of Ireland west of that point, shows that this absence in both localities is due to the same conditions of deposit. The succession in both countries is the same.

Devonshire.	South-West Ireland.	
Lower Culm	*Posidonomya* beds, Pendleside series.	
Pilton Beds	Coomhola grits	Upper Devonian.
Baggy Beds	*Cucullæa* zone	

The absence of Carboniferous Limestone in both areas is very definite, and the recognition that the sequence in North Devon and South-West Ireland is identically the same not only broadens the question, but at the same time demonstrates that the Culm of Devonshire is not merely a local condition, and that the absence of Carboniferous Limestone in South-West Cork and in the Carboniferous series of Devonshire is due to the same series of causes.

Pseudamusium fibrillosum.—This species is, as far as I know, never found below the Pendleside series, but it passes up into Coal-measures. This is an important species, because it has been obtained from the Culm of Herborn and Magdeburg. For the synonymy of this species *vide* my monograph on British Carboniferous Lamellibranchs, vol. ii, p. 106.

Glyphioceras spirale.—This species is very plentiful, occurring in thousands, in a blackish shale about 500 feet below the third grit at Congleton Edge, Cheshire. I have found it at various other localities in Yorkshire, but I always consider that it denotes a zone higher up in the series than that of *P. Becheri.* The species appears to be more common in South Devonshire than in the north of the country, and I can say nothing definitely about its actual position in the series there, but it is stated that it occurs with *Posidonomya*, Ussher, "British Culm Measures," Somerset Arch. and Nat. Hist. Soc., vol. xxxviii (1892), p. 132; he says, "The *Posidonomya* in these beds are, as a rule, smaller than those occurring in the beds which in the Chudleigh and Bovey Tracey districts carry on the calcareous horizon." In Cheshire *G. spirale* occurs with *Posidoniella lævis.* The other Goniatites found in the *Becheri* beds are not typical of the horizon, for they occur at various horizons in the Carboniferous

Limestone series, but are specially plentiful in the upper shelly limestone of Derbyshire, Staffordshire, and Yorkshire.

Palæontological evidence is therefore decidedly strong in favour of the *Posidonomya Becheri* beds overlying the Coddon Hill Beds, especially when such a sequence of fossil zones is found to obtain over large areas at a distance.

The occurrence of flinty deposits at a definite horizon in the Carboniferous beds may be adduced for what it is worth. In Wensleydale the chert beds come on immediately on the top of the Yoredale series. In Derbyshire and Yorkshire the chert horizon is found at the base of the Pendleside series. At Bishopton, near Gower, a series of white cherty beds, containing Trilobites and Brachiopoda, occur on the top of the upper beds of the Carboniferous Limestone, the Oystermouth Beds. The cherty beds are here overlain by black shales, with *Posidoniella lævis* and *Glyphioceras bilingue*, fossils which occur low down in the Pendleside series. These cherty beds are, I believe, homotaxial with the Coddon Hill Beds. Similar cherty beds, but much less well developed, are to be seen at Clavier, near Dinant, in Belgium, where a typical lower Pendleside fauna, *Prolecanites compressus* and *Chænocardiola Footii*, etc., is obtained. The beds at Clavier rest in hollows in the Carboniferous Limestone, and are therefore on the horizon of the Pendleside series, a fact which cannot be doubted if the collection of fossils made by the Geological Survey of Belgium, and now placed in the Musée Royale at Brussels, is examined. I was enabled by the kindness of Professor Dupont, Director of that Museum, to study all the fossils collected from Clavier, and I identified the following. It was, however, impossible for me to determine in what position they occurred *in sitû*, but it is doubtless on record.

Phillipsii, sp., with long cheek spines.
Pseudamusium fibrillosum.
Posidoniella lævis.
Posidonomya membranacea.
Pteronites angustatus.
Chænocardiola Footii.
Athyris ambigua.
Chonetes Laguessiana.
Productus scabriculus.
Productus semireticulatus.
Orthoceras, sp.
Prolecanites compressus.
Glyphioceras bilingue.
Glyphioceras spirale.
? *G. diadema.*
Cœlonautilus sulcatus.
Lestracanthus Beyrichii.
Crinoid joints.
Plant remains.

And from shales at Visé I determined

Posidonomya Becheri.
Pterinopecten papyraceus.
Posidoniella lævis.

Whether or not the Coddon Hill Beds are below the *Posidonomya* limestones, it cannot be denied that the palæontological evidence shows that the Lower Culm is the homotaxial equivalent of the Pendleside series, and that the Instow Beds indicate Lower Coal-measures, and the *Carbonicola acuta* and plant beds near Bideford represent Coal-measures of a higher horizon. The Culm series, then, represents the whole Upper Carboniferous series of the Midlands, and in this case the idea of workable coal being found in Devonshire is very improbable. It seems to me that the beds of Culm represent the total result of the attempt to form coal, and nothing more is to be hoped for. The views expressed in this paper are the result of a profound belief in the value of certain Carboniferous fossils as zonal indices, based on careful observation in the Midlands. The zones are not quite so well defined as those which obtain in older and newer formations, a result probably due to conditions of deposit, but nevertheless I find these life zones to be of economic importance to the mining engineer.

A paper in the Geological Magazine for June by Dr. J. H. Parkinson, pp. 272–276, on "The Zoning of the Culm in South Germany," is of interest, because from an examination of the fauna of the Culm of Königsberg he arrives at the conclusion that this Culm with a Visé Limestone fauna lies above the *Posidonomya* shales of Herborn.

This is very improbable. The Herborn fauna is identical with that which is found in the Pendleside series of England, which is definitely known to succeed beds with a Visé limestone or a *Productus giganteus* fauna. At Visé also shales with *P. Becheri* succeed the Visé Limestone, and lastly the Tournai Limestone, to which Dr. Parkinson refers the *Posidonomya* beds of Herborn, does not contain the fauna characteristic of the Lower Culm, but has an altogether different assemblage of fossils. Judging from the fauna of Königsberg Culm, I think he is quite correct in referring the beds to the Visé horizon, but beyond that I beg to join issue with his conclusions.

Through the kindness of Dr. H. Woodward I have been favoured with the précis of Mr. Newell Arber's paper on "The Fossil Flora of the Culm Measures of North-West Devon," read before the Royal Society on June 9th. This paper conclusively proves from the evidence of the flora that "the horizon in the Upper Carboniferous represented by that portion of the Upper Culm Measures in which the Coal or Culm occurs in the Bideford district is equivalent to the Middle Coal-measures in other British coalfields." That this is so I have also attempted to demonstrate by the known presence of *Carbonicola acuta* at Bideford, and a Gannister or Lower Coal-measure fauna at Instow.

I greet this work of Mr. Newell Arber with delight, because it tends to prove the subject-matter of this paper from an entirely different point of view.

IV.—Note on the Correlation of some Cornish Beds with the Gedinnian of Continental Europe.

By Upfield Green, F.G.S.

The group of beds which I propose to identify and correlate with those known in France, Germany, and Belgium by the name of 'Gedinnien,' forming the lowest member of the Devonian system, extends in its full development from the Lizard peninsula in the west to Gorran and St. Austell on the east, and thence to near Newquay on the north. The upper beds, at least, may be traced through Fowey and Looe along the coast, and across the Start peninsula as far as Babbacombe, south of Dartmouth in Devonshire. They are referred to by Ussher[1] as 'Dartmouth Slates.' They exist also on the north of the Devonian basin, and are mentioned by Etheridge[2] as underlying the Lower Devonian.

Reference has of course been made to them by various English authors, but few have attempted to assign to them a definite stratigraphical position, and fewer still have studied them in detail or made any investigation of the Continental equivalents occupying a similar position in the Devonian series.

Literature.

The earliest reference I can find is by Berger[3] in 1811, the next by Sedgwick[4] in 1821–2, who was followed by Conybeare[5] in 1823. In 1832 Boase[6] published an exhaustive petrological description of the district (according to the light of that time), founded on no less than 1,085 specimens deposited in the Museum of the Royal Geological Society of Cornwall, with a series of sections. He also attempted an extension of the hitherto accepted nomenclature of the components of the rocks (pp. 369–425 of his paper), which he termed 'Ocrynian.'

In 1838–40 Sedgwick and Murchison,[7] De la Beche,[8] and the Rev. D. Williams[9] made the first serious attempts at unravelling the structure of the county, while T. Weaver[10] commenced a comparison with Continental areas. Since then no comprehensive description has appeared, but isolated papers may be found in the Proc. Roy. Geol. Soc. Cornwall, Roy. Inst. Cornwall, and the Quart. Journ. Geol. Soc. London, by J. H. Collins, 1872–1903, Howard Fox, 1885–1903, and others.

Collins[11] considered the whole of the beds at the extreme south-west of the county, from Penhale to Breage, as pre-Silurian; a small strip, extending from Penhale to the Van and St. Austell, and the area south of Porthmellin and Gwennap to Mullion and Porthalla, as Lower Silurian; Newquay and Ladock and a small extent of ground on the coast to the north of Porthalla as 'Ladock beds' = Upper Silurian. For a comparison of the northern exposures in Devonshire with other areas, Sharp, Quart. Journ. Geol. Soc., ix (1853); Jukes, Quart. Journ. Geol. Soc., xxii (1866), and Additional

[1] Summary Progress Geol. Survey, 1902, pp. 160–165.
[2] Quart. Journ. Geol. Soc., xxiii (1867), p. 585.
[3] Trans. Geol. Soc., i, p. 93.
[4] Trans. Cambridge Phil. Soc., i, pp. 89, 291.
[5] Annals Phil., ser. II, v, p. 184, and vi, p. 35.
[6] Trans. Geol. Soc. Cornwall, iv, pp. 234–264.
[7] Trans. Geol. Soc., ser. II, v, p. 633.
[8] Geol. Survey.
[9] Proc. Geol. Soc., iii, pp. 115 and 158; and Phil. Mag., ser. III, xvi, pp. 59–64.
[10] Phil. Mag., ser. III, xvi, pp. 59–64.
[11] Journ. Roy. Inst. Cornwall, vii (1881), p. 37, and Trans. Roy. Geol. Soc. Cornwall, x (2), 1880, p. 51.

Notes (Dublin, 1867); Etheridge, Quart. Journ. Geol. Soc., xxiii (1867); and Hull, Geol. Mag., Dec. II, V, may be consulted.

'Gedinnien' of the Continent.

These beds have been described by many eminent geologists in their respective countries. Among them may be mentioned Gosselet and Barrois in France; Dumont, Dewalque, and Malaise in Belgium; Von Dechen, Koch, Kayser, Holzapfel, Rothpletz, and Lossen in Germany. To Professors Gosselet, Barrois, Kayser, and Holzapfel I am gratefully indebted for personal guidance and much information.

Speaking generally, the beds comprised in the Continental Gedinnien in descending order are as follows:—

1. Slates, mostly variegated and phyllitic, underlying the 'Taunusian,' with fish remains either in the base of the latter or in the slates themselves.
2. Arkose or Felspathic Grits, locally, and more especially on the south border (Taunus, etc.), sericitic and metamorphous.
3. Conglomerates with pebbles of more ancient rocks in a felspathic and quartzose matrix. These conglomerates seem to follow the sinuosities of the old coastline, and only appear intermittently in their original form, being as a rule much altered by hydrothermal action induced by pressure and folding. The latter subject has been treated at great length by Lossen.[1]

A comparison of this description with that given by Hull[2] of the Dingle and Glengariff Grits of Ireland may be of interest. He records—

1. Conglomerate.
2. Red and green grits.
3. Purple slates passing unconformably below the (? Lower) Old Red of Cork. And he suggests that the Foreland group of North Devon, of which the base is not seen, described by Jukes[3] as "thick massive grits of green and red colour, with purple slates similar to many parts of the (? Lower) Old Red of the south-west of Ireland," corresponds with these grits.

The Cornish Gedinnian.

Turning now to the Cornish beds, and commencing east at Looe, where the variegated slates of the Upper Gedinnian are in undoubted apposition to the beds referred to by Collins[4] as Upper Silurian, and by Ussher[5] inadvertently as 'Gedinnien,' but which I consider are undoubtedly Taunusian of the 'Siegener Grauwacke' facies, as evidenced by the following typical fossils found by myself and others:—

[1] Z. deutsch. Geol. Ges., 1867, 1877, 1883.
[2] Geol. Mag., Dec. II, V (1878), p. 529.
[3] Additional Notes (Dublin, 1867).
[4] Journ. Roy. Inst. Cornwall, viii (1884), p. 167.
[5] Summary of Progress Geol. Survey for 1900.

Onychia capuliformis, Koch. ? *Capulus subquadratus*, Frech.
Pleurotomaria (?) *striata*, Goldf.
Conocardium, sp.
Limoptera (?) *lepida*, Sandb.
Lodanella mira, Kays.
Orthis circularis, Sow.
Orthis personata (*hipparionyx*), Zeill.
Strophomena murchisoni, A. & V.
Strophomena explanata.
Rhynchonella livonica, v. Buch.
Rensællaria ? strigiceps, Roem.
Spirifer primævus, Stein.
Spirifer mercurii, Goss.
Stropheodonta gigas, M'Coy.
Athyris undata, Def.
Tentaculites grandis, Roem.
Nereitopsis cornubicus, Green.
Petraia.
Pleurodictyon problematicum, Goldf.

We find the Dartmouth slates referred to by Williams[1] as 'ichthyoferous killas' running along the coast to Old Mills, near Hendrasick, with cleavage planes dipping south. A fault there would seem to carry the strike of the beds north-west, and on the western side of the fault they are tilted at a very high angle, 80–85° north-west, the inclination gradually diminishing to 60–75° towards Talland (where the variegation is well seen) and Polperro, continuing on to a little west of Lantivet Bay (where the remains of Pteraspidian fishes are unusually abundant). From this point they are deflected, but have the same dip, leaving the Taunusian beds of Fowey to the south, and continue on in a north-west direction through Tywardreath and St. Austell to St. Stephens, as described by De la Beche.[2]

Until now we have only encountered the upper beds of the series, but at St. Austell Bay a complicated system of faults alluded to by De la Beche[3] has apparently caused an upcast of the country to the west, and from this point the lower beds of the series, and at some places even the subjacent older rocks, are exposed. These lower beds consist chiefly of grits varying much petrologically, but mostly felspathic. This variation in a coast deposit, which would naturally vary according to the rocks from which it is derived, is not surprising. Subsequent earth-movements, folding, and overthrust faults, well described by Hill[4] in his sketch of the Porthscatho and Falmouth beds, account in many places for the immediate contiguity and alternation of grits and slates, while during deposition sea currents must have had a great local influence.

The trend of the main northern mass of these grits is well described by A. K. Barnett,[5] who records "the occurrence of several beds of arenaceous rocks approaching a conglomerate distinct from the red and variegated sandstones and argillaceous slates associated with them." "The most western of these beds at Petervale St. Agnes, dip south with same dip at Callestock, in Chiverton Valley. Beds having same line of strike at Marhasan Voaz, Treworgan, St. Erme, Trehane Vean, Trewadra, and Cuskain, also in the railway cuttings from Venton Glidor to Tarnoweth Wood, in the road cutting between Grampound and Probus, and east from Grampound to Pentuan Cliffs. These beds have the same general

[1] Trans. Roy. Geol. Soc. Cornwall, vi (1841), p. 124.
[2] Report on Cornwall, pp. 80, 82.
[3] Report on Cornwall, p. 303.
[4] Trans. Roy. Geol. Soc. Cornwall, xii (6), 1903, . 406.
[5] Proc. Miners' Assoc. Devon and Cornwall, 1873, p. 93.

appearance and composition throughout their length. The constituent detritus at Ladock, Trevalsa, and Pentuan is as large as peas or nuts." De la Beche also refers to these beds[1] flanked by the slates of St. Stephens and Probus respectively north and south of them.

The main southern mass of these grits passes from Mevagissey, Gorran, Caerhayes, Portholland, north of Portlooe and Carne to Treworlas, from which point it has been traced and described by Hill[2] as Porthscatho beds, south of Falmouth by Helford to Looe Pool and Helston.

The succeeding lower beds have been described by the same author under the name of 'Veryan Beds,' and he includes in them apparently the coarse conglomerates which I consider to be the base of the Gedinnian and corresponding to the base of the Devonian system on the Continent.

The discovery of fossils of Ludlow age in the Caerhayes limestone, referred to in the GEOLOGICAL MAGAZINE for July, 1904, tends to confirm this view. The unconformity of these conglomerates with the underlying rocks would appear probable from the included fragments of similar slates and quartzites. The junction of the Gedinnian with the underlying beds seems to be in many instances accompanied by pillow-lavas, a note on which will be given by Mr. Prior later on.

V.—NOTE ON *ACTINOCAMAX*, MILLER; ITS IDENTITY WITH *ATRACTILITES*, LINK.

By G. C. CRICK, Assoc. R.S.M., F.G.S., of the British Museum (Natural History).

IN a paper entitled "Observations on Belemnites," which was communicated to the Geological Society of London in April, 1823,[3] J. S. Miller defined the genus *Belemnites* thus:—"A cephalopodous? molluscous animal provided with a fibrous spathose conical shell, divided by transverse concave septa into separate cells or chambers connected by a siphuncle; and inserted into a laminar, solid, fibrous, spathose, subconical or fusiform body extending beyond it, and forming a protecting sheath." In May of the same year Mr. Miller contributed to the same Society another paper[4] in which he instituted the genus *Actinocamax* for "spathose bodies which resemble the belemnitic guard in general appearance, but are distinguished from it by presenting, instead of the terminal cavity intended for the reception of the chambered shell, a protruding and convex base."

Miller defined the genus in the following words:—"A club-shaped spathose concretion, consisting of two nearly equal longitudinal adhering portions. Apex pointed; base a convex but obtuse cone. The whole formed of a series of enveloping fibrous

[1] Report on Cornwall, 1839, p. 83.
[2] Trans. Roy. Geol. Soc. Cornwall, xii (6), 1903, p. 406.
[3] Trans. Geol. Soc., ser. II, vol. ii, pt. 1 (1826), pp. 45–62.
[4] Ibid., pp. 63–67.

laminæ." The only species mentioned, *A. verus*, is characterized as follows:—"A club-shaped spathose semitransparent horn-coloured concretion; base convex, obtuse, conical; apex submamillar. Sides depressed towards the lower end, showing two longitudinal, towards the apex branching, impressions of blood-vessels." This was stated to be from the "Chalk, and sometimes inclosed in the flints imbedded in it," of Kent, Wiltshire, and Sussex.

Although subsequently united by some authors with the genus *Belemnitella* and by others merged in the genus *Belemnites*, *Actinocamax* is now usually employed as a distinct genus to include certain belemnites from the Chalk.

Mr. C. D. Sherborn has, however, called my attention to H. F. Link's "Beschreibung der Naturalien-Sammlung der Universität zu Rostock," of which the third part, published 25th December, 1807, is devoted to "Fossile Ueberbleibsel organischer Körper, sogenannte Versteinerungen." After defining (p. 8) the genus *Belemnites* as "a conical, internally radiate crystalline shell, within which is found another many-chambered (the alveolus),"[1] Link proceeds to describe (p. 9) a new genus *Atractilites* thus:—[2] "A spindle-shaped, internally radiate crystalline shell, without alveolus," the only species given being *A. belemniticus*, respecting which he states: "the spindle-shaped Belemnites are quoted by many authors, but often confounded and not exactly described. We possess specimens completely pointed at each end. On one there are distinct traces of a foliaceous texture, in other respects they are quite similar to the usual Belemnite. I have broken a specimen and found internally the radiate structure of the Belemnite, but absolutely no alveolus, therefore they cannot be referred to the former genus" [*Belemnites*].

From the extracts given above it is quite clear that Miller's *Actinocamax* is a synonym of Link's *Atractilites*. Link's name has priority of publication, his work having been published in 1807, whilst Miller's paper was not read before 1823, and not published before 1826. The name must not, however, be confounded with the Belemnoid genus *Atractites* of Gümbel[3] from the Lower Lias and Upper Trias.

[1] The term 'alveolus' is here used for the chambered part of the shell, but this is now known as the phragmocone, the term 'alveolus' being applied to the conical cavity in the guard that receives the phragmocone.

[2] As Link's work is very rare we have thought it advisable to give the description in Link's own words; it is as follows:—

"*Atractilites.* Atractilit. Eine spindelförmige, inwendig strahlig krystallisirte Schale, ohne Alveole.

"*A. belemniticus.* Belemnitischer Atr. Die spindelförmigen Belemniten werden von vielen Schriftstellern angeführt, aber oft verwechselt und nicht genau beschrieben. Wir besitzen an beiden Enden völlig zugespitze Exemplare. An dem einen bemerkt man deutliche Spuren einer blättrigen Textur, sonst sind sie den gewöhnlichen Belemniten ganz ähnlich. Ich habe ein Stück zerschlagen und inwendig die strahlige Bildung der Belemniten aber durchaus keine Alveole gefunden, daher man sie nicht zu der vorigen Gattung bringen kann."

[3] C. W. Gümbel: "Geognostische Beschreibung des bayerischen Alpengebirges," etc., 1861, p. 475.

Some of the forms that are referred to the genus *Actinocamax* do not exhibit the convex alveolar end referred to by Miller; a short explanation may therefore perhaps be of interest.

The form of the alveolar end of the guard in this genus depends upon the forward extent of the calcification of the component layers of the guard. All the species of *Actinocamax* possessed phragmocones. In the typical form *A. verus* the alveolar end is convex or more or less conical, the apex of the cone being sometimes occupied by a minute rounded shallow depression, indicating the position of the protoconch or commencement of the phragmocone. During the growth of the guard the alveolar portion of each component layer remained uncalcified, the extent of the uncalcified portion increasing with each successive layer (see Fig. *a*). Consequently, when during fossilization the uncalcified portion decayed and was lost, the phragmocone became detached, and the alveolar end of the guard assumed a convex or pyramidal form.

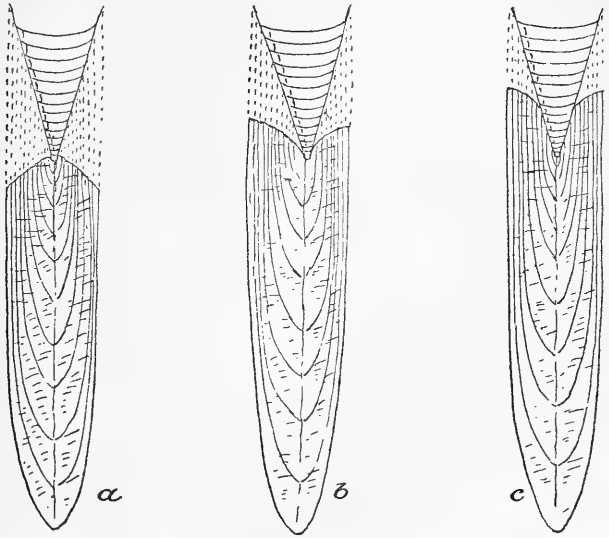

Diagram of longitudinal sections of different forms of *Actinocamax*. The dotted lines indicate the uncalcified part of the guard that is lost during fossilization. *a*, typical form, *A. verus*; *b*, *A. granulatus*; *c*, *A. quadratus*.

If during the growth of the guard the alveolar portion of each component layer remained uncalcified, whilst the extent of the uncalcified portion gradually increased with each successive layer, but much less rapidly than in the typical form, then the fossilized portion of the guard would have a conical hollow alveolar end (Fig. *b*) having an angle greater than that of the alveolus or of the phragmocone. Such a form is *A. granulatus*.

Again, if the earlier (inner) layers of the guard were completely calcified, and the rest remained uncalcified in the neighbourhood of the alveolus, whilst the extent of the uncalcified part increased with each successive layer, but less rapidly than in the typical form, then the removal of the uncalcified portion during fossilization would produce a guard having a more or less funnel-shaped alveolar end (Fig. *c*), of which the apical or posterior portion only would form part of the alveolus, whilst the anterior part of the cavity would have a greater angle than that of the alveolus or of the phragmocone. This form of alveolar end is illustrated by *A. quadratus*.[1]

It may also be noted that the alveolar end is frequently less dense and more friable than the rest of the guard, having probably been originally less perfectly calcified; it is therefore easily broken, causing the alveolar end to present the foliaceous appearance by no means uncommonly found in *A. quadratus*.

It would therefore seem that during the progress of development calcification of the alveolar end extended further and further forward, producing a progressive deepening of the alveolar cavity. This course of development is indicated also by the observations of Dr. Rowe,[2] who points out that in the examples which he refers to *A. granulatus* there is a progressive deepening of the alveolar cavity as the Belemnite ascends in the zone.

VI.—The Descriptive Nomenclature of Ripple-mark.

By A. R. Hunt, M.A., F.G.S.

OVER twenty years ago, in 1882, I ventured to controvert a doctrine which was at the time maintained with remarkable unanimity by all geologists, and which was taught in all the current textbooks. It was that the ordinary ripple-mark of the seashore was formed by continuous water-currents of some kind; the current of water taking the place and performing the office of the current of wind which ripples the surface of sand-dunes.

As it was a question of authority and textbooks I ventured to join issue with those of perhaps the greatest weight, viz., the series of which several editions were published by Mr. Jukes and Sir Archibald Geikie. I stated my thesis, and the object of my paper, in the following plain words:—

"I shall endeavour in the present paper to prove that ripple-marks formed under water are, as a rule, completely independent of the rise and fall of tides, of tidal currents, and of sea beaches; and that they have little in common with the current-mark, that owes its origin to a continuous current of air or of water" (Proc. Roy. Soc., 1882, p. 2).

[1] This is the type-species of Bayle's *Goniotenthis*. Explication de la carte géologique de la France, publiée par ordre de M. le Ministre des travaux publics, Tome quatrième, Atlas, Première partie—Fossiles principaux des terrains, E. Bayle, 1878, pl. xxiii, figs. 6–8.

[2] Proc. Geol. Assoc., vol. xviii, pt. 4 (1904), p. 271, fig. 12.

In my recapitulation I wrote, "Marine ripple-marks are formed by alternate currents set up by waves" (Proc. Roy. Soc., 1882, p. 18).

In 1883 three very important papers were published on the subject by MM. De Candolle and Forel and by Professor G. H. Darwin, F.R.S. Thus, in March, 1884, less than two years after the publication of my own pioneer paper, I was able in a paper on Sea Beaches and Sea Bottoms to direct the attention of students of wave-action to the three important papers referred to above, and also to some earlier observations of Professor Forel published in the *Bulletin de la Société Vaudoise*, etc., for February and March, 1878. The last-named publications give Prof. Forel the right of priority so far as wave-current ripple-mark is concerned.

Professor Darwin went further than any previous experimenter by demonstrating the action of eddies and vortices in collecting loose sand into ripple-mark, as soon as the incipient ripple-marks are established. Previous observers had indicated the agents, viz. wave-currents, but Professor Darwin demonstrated their mode of action.

As soon as the above papers appeared Sir Archibald Geikie allowed them their full weight, as will appear by a comparison of the third and fourth editions of his textbook with earlier works. For instance, to be as brief as possible, in the Manual of 1872 (Jukes & Geikie) we read:—Ripple-mark "is produced on the sea-beach . . . . because of the moving current of water as the tide advances or recedes" (p. 192).

In Sir Archibald's first edition of his Textbook we read:—"Water (or air) gently agitated *in a given direction* [italics mine] throws the surface of sediment into ripples. . . . Their general direction . . . suffices to indicate the quarter whence the chief movement of the water has come" (p. 483).

In the Textbooks of 1893 and 1903 there is a complete revolution. We now read: "They have been produced by an oscillation of the medium (water or air) in which the loose sand has lain. In water an oscillatory movement, sometimes also with a more or less marked current, is generated by wind blowing on its surface. The sand grains are carried backwards and forwards. By degrees inequalities of surface are produced which give rise to vortices in the water. . . . . In regular ripple-mark the forms are produced by water oscillating relatively to the bottom and the consequent establishment of a series of vortices."

No one without a minute study of ripple-mark could appreciate the extreme accuracy of phraseology and description in the above few lines. I may, however, remark that the 'alternate currents,' for which I contended single-handed in 1882, are the actual currents in opposite directions set up by waves, and not the reversal of the direction of a steady current of wind or water created locally by vortices.

I need scarcely express my deep sense of gratitude to Sir Archibald Geikie for having so promptly recognised the importance of very unorthodox doctrines at a time when it was almost impossible to obtain a patient hearing for them in England.

In the present article I propose to call attention to the extreme ambiguity of the phraseology in common use in the discussion of sand-ripples and cognate phenomena.

With reference to the meaning of 'breadth' and 'amplitude' a distinguished mathematician writes, "I cannot regard these questions of phraseology of much importance." It no doubt matters nothing when the ideas are clear, but I feel sure that inaccurate or inadequate terms, and especially when they are avowedly descriptive terms, must end in confusion of thought.

In the case of 'ripple-mark,' Sir Archibald Geikie summarily disposes of the difficulty by rejecting all such expressions as 'current-mark' and 'ripple-drift,' which, though accurate as far as they go, are calculated to mislead. Both expressions might lead the reader to suppose that ripple-mark can only be produced by the drifting action of a continuous current of air or water, whereas current-mark and ripple-drift might well be regarded as specific forms of the genus ripple-mark.

The foregoing three terms, together with 'wave-marks' as used by Dana, are a truly misleading quartette. 'Ripple-marks' are collections of sand in the form of water-ripples. There is no pretence that they are made by water-ripples. But current-mark, a completely parallel expression, professes to describe collections of sand in the form of ripples made by a current. The 'current' here is avowedly the agent, whereas the 'ripple' is merely the illustration of the effect. In Dana's 'wave-marks,' an expression even more closely allied to 'ripple-marks,' the 'wave' is the agent and not merely the illustration. In 'ripple-drift' we have a still further element of confusion, as here 'ripple' is not the illustration, but has come to mean the actual sand, which has been collected in ripple-like forms by drifting.

'Wave-mark' would be an excellent term descriptive of ordinary marine ripple-mark were it not that 'wave' would indicate the agent, whereas 'ripple,' which is no more than a small wave, would be used in an entirely different sense. Moreover, Dana has used 'wave-marks' for a very unimportant marine phenomenon, viz., the faint mark which is very occasionally left by a wave on a sandy beach.

If ripple-marks and waves are to be subjects of discussion, it is absolutely necessary that some definite meaning should be attached to descriptive terms such as height, length, breadth, and amplitude.

We will now inquire how these terms are actually used in the case of real waves.

What do we understand by the height of a sea-wave? A sailor undoubtedly measures height from trough to crest. For instance, in October, 1887, the Admiralty communicated to the Press a letter from Captain Fisher descriptive of a voyage of the battleship "Inflexible." He mentioned that "the waves were occasionally twenty-four feet high and three hundred feet in length." This height is obviously from trough to crest, and even so, very high for the wave-length.

Physicists, on the other hand, regard height as from mean water-level to crest, unless the height from trough to crest is distinctly stated. In a letter to me in 1884, the late Professor G. G. Stokes refers to "the elevation or depression above or below mean level"; and again, "Taking it [the wave] as eight feet above or below mean level in the shoal, sixteen feet from crest to trough in all" (Trans. Devon Assoc., vol. xix, pp. 513, 514). Yet in the paper to which Professor Stokes' letter was appended, I, from force of habit, whenever I used the term height, referred to height from trough to crest. The one measurement is of course treated as being exactly double the other, though it is not necessarily so with breakers in shallow water.

What is understood by the 'length' of a wave? In the case of sea-waves, which are fairly uniform in size at the same time, English writers mean by 'length' the distance from crest to crest. If, however, we have to regard a wave as isolated, it has then but one crest, and we may treat the total length as the length of the elevated water added to the length of the depressed water, both at the level of repose of the water. What, then, is understood by the 'breadth' of a wave? This is a term rarely met with, but would probably mean the extent of a wave measured along its crest. We now come to 'amplitude.' What is the amplitude of a wave? So far as I am aware, 'amplitude' with physicists is always connected with the idea of motion, the amplitude of a wave of ether, air, or water being regarded as the extent of the oscillation or vibration of the medium, caused by the passage of a wave.

In the course of my correspondence with Lord Rayleigh and Sir G. G. Stokes on the question of sea-waves, although both those eminent physicists supplied me with much information, I do not remember a single instance of their use of the term amplitude. If used for 'height' it would be redundant, and for shore-breakers inaccurate, as in shallow water the crests contract in length, and the height of the wave from trough to crest greatly exceeds the relative height in deep water, where it is equal to the amplitude of vibration of the water itself. The increasing height of the shortening crest came out clearly in tank experiments.

We note, then, that even in the well-studied case of sea-waves, which are real waves, we have to be careful that we do not confound the height from mean level with the height from trough, and that we do not confound amplitude with either of those terms.

A difficulty has arisen owing to the indiscriminate application of the simple terms height, length, and amplitude (which in the case of true waves are technical terms with stereotyped meanings) to forms which simulate waves, such as ripple-mark, snowdrifts, and even mountains and valleys. And even so, the terms are not always used in the same sense by different authors. It is always necessary to ascertain the exact meaning of each author.

Professor Forel, in describing his ripples and experiments, speaks of the 'longeur' of his tank, and of the 'hauteur' and 'largeur' of his ripple-mark, but strictly limits 'amplitude' to the extent of the water-oscillation which forms the ripple-mark. What to an English observer is the crest to crest *length* of ripples, is to Professor Forel their 'largeur' or 'breadth.'

Professor Darwin speaks of a "rotational oscillation with a jerking motion of small amplitude";[1] of the height of ripples, and of the 'wave-length' of ripples. With him also 'amplitude' expresses the idea of motion.

Ripple-marks so closely imitate in form motionless water-ripples (such as may be seen in a sharp current) that it is most natural to describe them by the phraseology used for true waves, such as 'height' and 'wave-length.' But even here we do well to remember that the height of a sand-ripple can never be synonymous with the height of a water-ripple, since the latter is referred to the level of repose of the water. The sand-ripple reposes corrugated as comfortably as it does flat. In fact, the height of ripple-mark is from trough to crest, and therefore does not even correspond with the 'height' of water-ripple, which is from crest to mean level.

In 1900 I was nominated by Section C a member of a joint committee with Section E to investigate 'Terrestrial Surface Waves.' I was reluctant to accept the nomination, which had been made in my absence, because, as I at once pointed out, I could see no geological bearing in the subject, which related in the first place to snow phenomena, and I knew nothing about it. On receipt of the first report I found that I was quite uncertain as to the meaning attached by the committee to the technical terms used in describing the dimensions of snowdrifts. In fact, I might go further, as I do not understand the terms used to describe the object of the committee's researches, viz. 'terrestrial surface waves.' I found that both snowdrifts and snow-ripples were described exactly as though they were real waves, and not merely wave-like forms. The following quotation will indicate my difficulty:—

"The height of these waves [of snow] was generally not more than six inches. They are flatter than the homologous æolian sand ripples, the wave-lengths being often forty or fifty times the amplitude. . . . There are also regularly undulating surfaces carved by the wind in more coherent snow . . . it is proposed to call them *undulates*" (Rep. Brit. Assoc., 1901, p. 398).

It will be observed that the geographers have captured the entire wave-nomenclature, e.g., ripples, wave-length, height, amplitude, and undulating. If we refer to Murray's Dictionary we shall find that the primary meaning of amplitude is width or breadth; that its astronomical meaning is angular distance; and that its physical meaning is the vibration of a particle. With regard to the word 'undulating,' we have Pope's line "Through undulating air the sounds are sent." The geographical and geological use of 'amplitude' to express height forces the word into a meaning in direct conflict with both its ordinary use and its derivation. Professor Lapworth, in his address to Section C, points out that the form of the "wave or fold of the geologist resembles that of the

[1] Proc. Roy. Soc., 1883, p. 2.

wave of the physicist, as also does the form of the surface-wave of the geographer" (Rep. Brit. Assoc., 1892, p. 701). No doubt geographers and geologists have as much right to the dictionary as physicists, but in the present case, the investigation of ripple-mark, the result is inconvenient for the following reason, viz., that as it is now admitted that marine ripple-mark is to a great extent made by waves, if we attempt to discuss the formation of ripple-mark in any detail the waves will require their own terminology for their own use.

The following incident illustrates the importance of exact phraseology. My Ripple-mark paper, though promoted to the rank of a much cited authority, survived eighteen years scatheless, until in 1900 my friend Dr. Vaughan Cornish stated in Section C that an error therein had misled German students. I was not surprised at the detection of an error, but at its having escaped so long. I pointed out that the alleged error was in a quotation. Dr. Cornish replied that I was held responsible for it. On referring to Professor Forel's paper I noted that he had actually quoted the censured passage, but only on the authority of its author, the Rev. John Gilmore, as cited by me. The passage had clearly not misled Prof. Forel, nor did he hold me responsible for it. What, then, had misled the German students? It was simply this. The Rev. John Gilmore, in describing the struggles of the lifeboat men on the Goodwin Sands, wrote, "The heavy seas have driven the sands into high ridges, and the gullies between these are waist-deep and full of running water with the sand soft and quick at the bottom." And again, "On the Goodwins where . . . . the waves break and the tide rushes with tenfold power, the little sand ripples of the smoother shore become ridges of two or three feet high." In referring to these ridges and gullies made by "heavy seas" and rushing tides in quicksands, I used the expression 'wave-marks,' carefully avoiding the technical term 'ripple-mark.' But, alas! I was unaware that the German equivalent for ripple-mark is 'wellenfurschen,' or wave-furrows, so the German students must naturally have concluded that when I described ridges and gullies as 'wave-marks' I meant to describe their own German wave-furrows, which are no more than the ordinary English ripple-mark and Professor Forel's 'rides du fond,' otherwise wrinkles on the bottom. I was unaware that Dana had previously appropriated the term 'wave-marks' for another purpose. No doubt it would have been more accurate to have described the ridges and gullies on the Goodwins as wave-and-tidal-current-marks; but the quotation of a record of a fact, far too valuable to lose, could not have misled experimentalists, and in fact did not do so.

It is by no means always easy to distinguish offhand true ripple-mark from corrugations in fine-grained rocks caused by pressure, and in a well-known case at the east end of Meadfoot Sands, Torquay, the evidence is conflicting. If only a squeeze it is a remarkably good imitation of the genuine article. If genuine, and a case of ripple-mark complicated by pressure in finest grits associated with slates, it is interesting as occurring in the Lower

Devonian rocks without a trace of shallow-water conditions. Associated with these corrugated rocks there is a band of some inches of badly preserved shells suggestive of some great destruction of the submarine fauna; what Gwyn Jeffreys would have described in modern seas as a charnel-house of shells. The currents were clearly sharp, but transitory, as the grit and slate beds are not confused, and the thickness of the shell band very regular. The corrugations are symmetrical, so must be wave-formed and not continuous current-formed, that is, if they are ripple-mark at all. Now in considering such a case as this we have to realise the presence of waves heavy enough to disturb depths at which fine silt and mud can accumulate. This depth, disturbed only on rare occasions, will depend on the height (crest to trough) of the waves. The amplitude of the reciprocating currents over the bottom will depend on the height (crest to trough) of the waves and the depth of the water, while the number per minute of the double currents, or their frequency, will depend on the period of the waves. Now the technical terms required for this description are height (crest to trough), length, amplitude, period, and frequency. The terms height and length will apply to ripple-marks equally well; but with amplitude, period, and frequency ripple-marks have nothing to do. If we use amplitude for the height of a ripple-mark we use a stereotyped wave-term in a different sense; while, if we use the term wave-length for the ripples, our thoughts are at once directed to the true waves which formed them, waves which really possessed wave-length, which the ripple-marks only possess by courtesy.

My own work in ripple-mark, which was undertaken solely to establish the doctrine of alternate wave-currents, received its full fruition when Sir Archibald Geikie accepted the doctrine of the "oscillation of the medium" in his textbook of 1893. That fact accepted, all the rest, the interesting consequences, must follow in time. But they will follow sooner if we can avoid confusion of ideas being perpetuated by ambiguous and even conflicting nomenclature. Were this a paper on ripple-mark itself it would be easy to run through the great textbooks and manuals and indicate where the different authors have followed the wrong trail. I will, however, quote one very useful and popular dictionary of scientific terms. In Webster's Dictionary, ed. 1876, we read, "Ripple-mark. (Geol.) A mark on the surface of a rock resembling that made by receding waves on a sea beach." Now waves on a falling tide have often effaced ripple-marks on the flats of a sea beach, but have never created them. The efficacy, or even the existence, of a *receding* wave is as imaginary as that of the efficacy of the advancing or receding tide, moving towards or from the shore at the rate of a few hundred feet or less in some six hours. The wave has ceased to exist before any water recedes from off the beach.

So far as I am aware, no paper on ripple-mark has appeared in any geological publication since Dr. Sorby's "Structures produced by the Currents, etc.," in the *Geologist* in 1859. The literature is scattered far and wide. Sir Archibald Geikie has given the references to the papers of Messrs. Sorby, De Candolle, Forel, and Darwin. To these I would add the shrewd observations of that king among observers, De la Beche, in his "Geological Observer," and several papers by Dr. Vaughan Cornish in the publications of the Geographical Society which have appeared since I retired from the fray.

In May, 1903, I concluded a paper on Vein Quartz with a quotation from a letter written by Dr. Sorby in 1889—"There are many things connected with it [granite] about which we know much less than is desirable." Let me conclude this paper with the last few lines of the same author's 1859 paper on the "Structures produced by Currents": "Those [experiments] which I have made already, though not nearly sufficient to clear up many highly important questions, are still sufficient to give very great encouragement; and I therefore feel anxious to induce others to turn their attention to this branch of research, being convinced that it cannot but yield a bountiful harvest of fact when studied with perseverance and zeal." To this conviction, now forty-five years old, we may still add our fervent Amens.

P.S.—Since the above was written, I received, on the 1st of July, *Nature* for June 30th, and Dr. Nansen's "Bathymetrical Features of the North Polar Seas," etc. Dr. Nansen observes (p. 137), "ripple-marks, however, are not merely formed by waves, but also by currents." *Nature*, referring to experiments made by Mr. F. Ayrton at the Royal Society conversazione, asserts, with the emphasis of italics, "It was also shown that ripples are *not* produced by a *steady* current of water flowing over sand." Dr. Vaughan Cornish writes: "The true current-formed sand-wave I find to be produced as soon as the velocity of the stream causes the water to be turbid with a heavy charge of sand in eddying suspension. The process can be watched in the shallow streams of sandy tidal foreshores" (Geographical Journal, August, 1901, p. 198). I have noticed this result myself.

In the same paper (p. 200) Dr. Cornish writes, "Professor Osborne Reynolds found that in his model estuaries the ripples 'formed by the alternating action of the tide' had a wave-length equal to twelve times their amplitude ($4 = 12$ H)."

If Professor Reynolds used the terms wave-length and amplitude I should have to retire discomfited, as I had the honour to serve on his committee; but I find that what Professor Reynolds wrote was, "Some of the ripples were from hollow to crest as much as one-fourth the mean-rise of the tide, the distance between them being twelve times their height" (Rep. Brit. Assoc., 1889, p. 343). Professor Reynolds avoids the technical wave terms.

The apparent contradictions of writers on ripple-mark are so surprising that one fails to see how the student, or even the text-book writer, can find his way through the mist. However, the contradictions are easily explained, as there are several ways of producing rippled sand-surfaces. If not trespassing too much on the patience of the readers of the Geological Magazine I should like some day to make an attempt to show how the trick is done, and how ripple-mark concerns geologists, not as a mere unimportant detail of rock-structure, but as an important factor and index in the great problem of marine erosion. In the meantime I may refer to Dr. Nansen's admirable epitome of the evidence of marine erosion in his work above referred to, and also to Dr. Cornish's papers in the Geographical Journal.

VII.—Contributions to the Geology of Ceylon:

III. The Balangoda Group.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineralogical Survey of Ceylon.

The name 'Balangoda group' is proposed for a series of granitic and pegmatite-like rocks, intrusive in, but distinct from, the Charnockite series; first met with in the Balangoda district, but evidently widely distributed over a large area between Balangoda and Hatton. The rocks are best described as granites, but occur most often in rather narrow dykes, after the manner of pegmatites. Yet there is no reason for separating the smaller from the larger masses, and the term granite is applied to both. The group (of which a more detailed account will ultimately be needed) includes in particular zircon granite, allanite granite, magnetite granite, and granite without conspicuous accessory minerals; as well as the probably similar rocks in which the hitherto unlocated minerals geikielite, baddeleyite, rutile, fergusonite, thorite,[1] thorianite, etc., may be looked for; and the vein of pegmatite at Gampola, which consisted of quartz, felspars, and biotite, with apatite, ilmenite, tourmaline, and the new mineral described as thorianite [2] as accessory minerals.

These granites are intrusive in the Charnockite series, and though frequently occurring in lenticular masses (Denagama) with a disposition parallel to that of the foliation planes of the charnockites, have often been observed to transgress these foliation planes and to behave as intrusive rocks. Contact phenomena have not, however, been observed, except perhaps in a slight tendency to a peripheral fineness of grain in the intrusive rocks. At the junctions granite and charnockite are usually welded together, there being no absolutely hard line of separation, although the junction may be called sharp; in the case of the larger masses no good junctions have been seen.

A description of the rocks is given below, with special reference to the localities where they can be seen:—

Zircon granite.—This rock was seen *in sitû* at several points, and is the best known member of the group. The finest and longest exposure is on Massena estate, six miles from Balangoda; here a considerable mass of granite, fully two miles in length and

[1] W. Dunstan, *Nature,* 1904, p. 510.
[2] "Spolia Zeylanica," vol. i, pt. 4 (1904), p. 112; and *Nature,* loc. cit.

averaging perhaps a hundred yards in width, runs, parallel to the Charnockite foliation-strike, along the trough-like strike valley of the Massena Oya, in which the main part of the estate is found. The rock occurs in enormous masses, both *in sitû* and in great boulders, amongst which the Massena Oya finds its way. Two rows of curiously weathered masses stand out of the swamp below the bungalow; good specimens very rich in zircon can be collected here. The rock usually shows no trace of foliation in small specimens; but foliation (vertical, with strike about 15° N. of W.) is evident in an exposure *in sitû* near the middle of the estate, near the 'lines.'

The rock consists essentially of quartz, felspar, and biotite, with zircon and ilmenite as characteristic accessory minerals, and apatite as a microscopic constituent. The content of zircon varies greatly from specimens in which a crystal can hardly be found to others

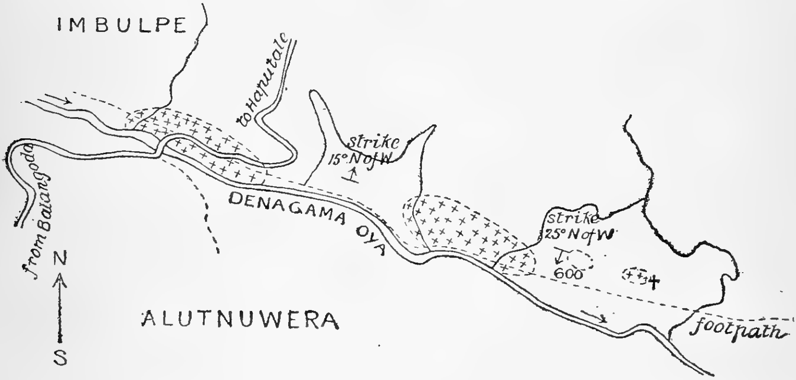

FIG. 1.—Rough sketch-map of zircon granites near Denagama Oya bridge, near Balangoda, Sab, Ceylon. ××× zircon granites; † zircon granites well foliated. Scale, 5 inches = $1\frac{1}{2}$ miles.

in which it forms a noteworthy proportion of the rock. The zircon occurs in moderately good, idiomorphic, stumpy, prismatic crystals, generally terminated, the forms *m* (110), *a* (100), *p* (111), *e* (101) being certainly present; the colour is hair-brown, often quite pale; in thin section no colour is seen; the longest individuals exceed $\frac{3}{8}$ inch in length, but most are somewhat smaller. The rock itself is relatively fine-grained, the quartz and felspars rarely exceeding in diameter the length of the longest zircons. The felspars include orthoclase (sometimes microperthitic) and an acid plagioclase with s.g. near to that of orthoclase. The biotite occurs in ragged crystals, macroscopically nearly black, but brown in thin section, and with pleochroism from warm brown to pale straw colour. Ilmenite is common, occasionally moulding the zircons, and generally partly altered to 'leucoxene.' Apatite is fairly abundant in six-sided terminated prisms about $\frac{1}{40}$ inch in length. The general structure is hypidiomorphic, only the zircon and apatite occurring in well-developed crystals.

Another exposure (Map, Fig. 1) is seen near the bridge over the Denagama Oya, about 6 miles from Balangoda on the Haputale road. Small idiomorphic zircons ($\frac{1}{16}$ inch) are scattered sparingly in the rock, which resembles that of Massena estate, but is of somewhat coarser grain. Ilmenite is common, the zircon quite scarce. Other exposures are found along the line of strike on the left bank of the stream. The granite seems to form a series of lenticular masses. At one point the rock becomes well foliated (as if by pressure), the small crystals of biotite being closely packed and sweeping round the augen orthoclase. Well-formed zircons $\frac{3}{8}$ inch in length are to be found.

A similar foliated zircon granite is exposed by the roadside $1\frac{1}{2}$ miles further on, just beyond the 91st milepost; the zircons vary from $\frac{1}{16}$ to $\frac{1}{8}$ inch in length, and are of the usual light-brown colour.

No junctions were observed in the instances above referred to.

Near Haldummulla and about 18 miles from Balangoda a small granitic dyke was seen in the Weli Oya valley about half a mile above the road, crossing foliation in the Charnockite series and containing a few minute zircons just visible to the naked eye.

In the Bamberabotuwa district a large number of small intrusive pegmatites or granite dykes were examined on Hopewell estate (15–16 miles from Balangoda), where they are well exposed, and cross the foliation of the Charnockite series in all directions; only two were found to contain minute crystals of zircon sparingly distributed. Zircon may occur in others, but so rarely as to be overlooked. This exhausts the list of localities where macroscopic zircons have been seen *in sitû*.

Zircons of all sizes (up to $1\frac{1}{2}$ inches or more) occur abundantly in every stream and river gravel, and are found in quantities when gemming operations are carried on, joining a large proportion of the heavy residue (*nāmbu*[1]) at the bottom of the gemming-basket: the clear-coloured varieties are of value as gems; the remainder is rejected. The irregular zircons described by Mr. Spencer[2] occur in this way in various parts of the Balangoda and Bamberabotuwa districts. Near Kondrugala zircon is very abundant in large individuals. Well-developed twins on *e* (101) are found. With the zircon are associated 'thorianite,' thorite, ilmenite. Large zircons have also been found in gemmings from the Hatton district. Zircon is also abundant over a wide area in the Southern Province in the Galle, Matara, and Morawaka districts, and no doubt also at Rakwana; the same rocks may be expected to be met with in these districts.

Allanite granites.—Allanite granites are well exposed in two places in the Balangoda districts. It is some years since Mr. W. D. Holland discovered a granite or pegmatite dyke, crossing foliation in the Charnockite series, in the bed of the Wewel Dola near the lower end of his estate of Dik Mukulana, and containing allanite in some abundance. The determination of allanite was confirmed

[1] A Sinhalese term which may with advantage be adopted.
[2] *Nature*, April 14th, 1904, p. 575.

by a partial analysis made for Mr. Holland, and by Mr. G. T. Prior, to whom a sample was submitted. The granitic dyke is composed of quartz, felspar, hornblende, allanite, biotite, pyrite.

The felspars include porphyritic orthoclase and also a series of smaller individuals of orthoclase and plagioclase (some of the latter are porphyritic like the orthoclase), forming with quartz the finer-grained portions of the dyke. Allanite and hornblende occur in varying amount, both being locally very abundant. Biotite is scarce. Pyrite occurs chiefly in secondarily deposited films.

A better exposure of allanite granite is found in the lower part of Denagama estate, about seven or eight miles from Balangoda. A conspicuous dyke, three to four feet thick, crosses the left branch of the stream, which runs through the tea below the path, and forms a conspicuous ledge inclined at a low angle to the foliation. The granulites are inclined at a very similar angle, but it can be seen clearly that the dyke does not keep strictly to the foliation planes; moreover, a few short processes, six inches to a foot in width, project into the rock underlying the dyke, clearly showing the intrusive character of the latter. The dyke is coarse-grained, and consists mainly of orthoclase (porphyritic idiomorphic individuals often about 3×1 inches), quartz, and biotite, the latter in long thin crystals (measuring e.g. $9 \times 1 \times \frac{1}{4}$ inches) scattered in all directions through the rock.

In these two dykes the allanite is very unevenly distributed, being in places very abundant, and elsewhere almost or quite absent. The allanite forms thin tabular idiomorphic as well as more irregular individuals; the largest attain a length of three inches, those of medium size measure about $1 \times \frac{1}{2} \times \frac{1}{4}$ inch. A curious point is that the allanite seems to form a centre for radiating cracks in the rock, giving it a rather conspicuous appearance, of which a diagram is given in Fig. 2 (Denagama).

The allanite is macroscopically black (in thin section brownish olive-green), and has a resinous lustre and conchoidal fracture; hardness about 6; sp. gr. 3·2 to 3·5; before the blowpipe it intumesces strongly.

Magnetite granite.—A small dyke 2 inches wide and of the usual character, but containing irregular individuals of magnetite about $\frac{3}{4}$ inch in diameter, was seen in the bed of the Wewel Dola at Dik Mukulana. Another dyke 6 inches wide, containing similar magnetite, was observed on Hopewell estate.

The Gampola pegmatite.[1]—This rock consisted mainly of orthoclase, quartz, and biotite, and contained apatite, tourmaline, ilmenite, and uraninite ('thorianite') as accessory minerals.

Granites without conspicuous accessory minerals.—These are of fairly general distribution in the Balangoda district, sometimes occurring in the form of dykes (usually less than three feet in width) in very considerable abundance. It is possible that a much more extended search might reveal the presence of macroscopic zircons in some of these rocks; for the most part, however, they

[1] "Spolia Zeylanica," vol. i, pt. 4 (1904), p. 512.

are similar to the granitic rocks described above, but without the characteristic accessory minerals. There is a considerable exposure of reddish granite on the Ratnapura road about a mile below Balangoda, and this is known as a locality for 'graphic granite.' A tendency to graphic structure was noticed in many of the rocks already described. Smaller masses (dykes) are common at Dik Mukulana (11 miles from Balangoda) and on Hopewell estate,

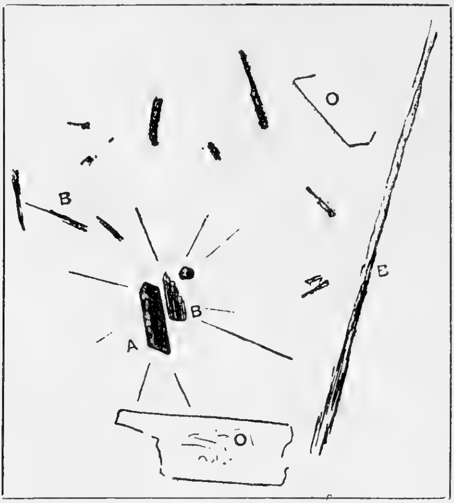

Fig. 2.—Structure of allanite granite; Denagama estate, Balangoda. *A*, allanite; *B*, biotite; *O*, orthoclase; remainder quartz and felspar. Present scale, × 5½ times.

15 miles from Balangoda, and at many other points. These granites (as well as others containing zircon) are also well exposed on Herimitegala estate, about 8 miles from Balangoda.

The list of types of rock belonging to the Balangoda group actually met with is now exhausted. There can be no doubt that many other varieties will be found, and it is evident that some are likely to be of great interest. Since, however, detrital zircon is exceedingly abundant, yet is known *in sitû* in a few localities only, it is clear that the chance of finding any particular one of the other and rarer minerals *in sitû* must be rather small.

REVIEWS.

I.—Dr. Fridtjof Nansen's Researches into the Bathymetrical Features of the North Polar Seas.[1]

THIS elaborate volume is the outcome of Dr. Nansen's Arctic Explorations, of which we have narratives in his "First Crossing of Greenland" (1890) and his "Farthest North" (1897), both

[1] Published by the Fridtjof Nansen Fund for the Advancement of Science (with 29 plates). Christiania, 1904.

delightful works of travel and adventure in inhospitable and little-known regions, and fortunately for most of us Britishers written in the English language. The most recent volume here under our notice deals with those great problems of submerged lands and ocean basins for the most part held fast in the embrace of perennial ice, and of which the depth can only be known by the sounding line let down through the ice-cap itself. As well known, "Nansen's Farthest North" was reached on the 7th April, 1895, in N. lat. 86° 13′ 6″, where the depth of the ocean reaches 3,000 metres, a depth which may be presumed to extend to the pole itself. Certain it is that deep ocean water is under the North Pole; not "an open sea," as was once announced by Kane, the American Arctic explorer. The whole structure and arrangement of land and sea, whether ice-covered or open, is admirably represented in the bathymetrical chart of the North Polar Seas which accompanies Nansen's recent volume, and under its guidance I propose to consider some of the suboceanic features which arrest attention. The centre of the chart being the pole, it embraces in its circumference all the region bordering on both sides the Arctic circle; and on looking at the chart we are at once struck by three leading features indicated by distinctive colours—the lands, by dark shade; the continental shelf or platform, by yellow; and the deep ocean, by various shades of blue. The varying depths are all worked out by isobathic lines founded on the soundings, a system of suboceanic delineation hitherto much neglected by British cartographers, but capable of opening up many new facts of suboceanic geography; this, indeed, is the only way of placing before us in a graphic manner the various physical features below the waters of the ocean, whether they be terraces, old river valleys, gulfs, or deep ocean. Of this system of illustration Dr. Nansen has made abundant use both for pourtraying the form of the sea-floor and for plotting transverse sections similar to those which may be drawn by means of contour-lines to illustrate the form of the land.

The continental shelf is continuous all round the margin of the land with the exception of one remarkable interval lying along the meridian of Greenwich between Spitzbergen and the north-east corner of Greenland, where the floor of the ocean bed rises to within 786 metres of the surface in the form of a narrow bank descending rapidly into the deep water of the Arctic Ocean on the one side and into that of the Norwegian Gulf on the other. It is, in fact, a submerged saddle. The narrowest part of the continental shelf lies off the Lofoten Islands, but spreads in a broad nearly level sheet all round the coast of the Europe-Asian Continent to that of the North American Continent. From its surface rise the Spitzbergen and Franz Josef groups of islands, together with Novaia Zembla and the New Siberian Islands. Its average depth near the outer margin may be taken at 200 metres, but in some places it is over 300 metres. All the way from Spitzbergen along the Europe-Asian Continent it breaks off in a steep declivity, descending into the Arctic Ocean by gradients varying from 5½ to 20 degrees in steepness; the steepest portion of the declivity being situated between depths of 200 and 1,000 metres. Thus it will be seen that there is a remarkable similarity in the bathymetrical conditions of the polar regions and those of the North Atlantic; in both there is the continental shelf, and the steep exterior slope or declivity, leading down to the floor of the outer ocean at depths of about 2,500 metres (8,140 feet). But another point of similarity is the existence of channels or 'fjords,' traversing the platform and opening out on the ocean at great depths. Some of these submerged fjords decrease in depth towards their outlet on the deep ocean, as for example the Vardœ Murman Channel along the coast of East Finmarken, resembling in this respect the Norwegian fjords. The cause of this shallowing of the submarine fjords is necessarily obscure, but is in all probability partly attributable to glacial moraine matter piled up at the Glacial Period upon the melting of the ice. On a former occasion I have dwelt upon this remarkable feature in the case of the Norwegian fjords.[1]

In addition to the continental shelf, there occurs a feature not generally recognised on the Atlantic border, called by Nansen "the coast platform" (strand fladen), descending to only a few metres (10 to 15) below sea-level and covered by numerous shoals and sunken rocks. The coast-platform is often incised by channels parallel to the coast or outer margin of the platform itself. The formation of the marginal shelf is discussed by the author, who regards it as "a comparatively young formation, the greater part of which must have been formed after the Norwegian Continental Shelf" (p. 112). If this be so, the coast-platform would appear to be a "raised beach," formed after the continental shelf during the period of the rise of the land at the close of the Glacial Period.

Those who doubt the existence of suboceanic river valleys will not find support from Dr. Nansen. According to this author, the Europasian continental shelf is seamed by numerous submerged channels. The Norwegian fjords are often continued under the waters of the outer sea, descending to depths of 400 metres (1,312 feet) or more. In the neighbourhood of the Franz Josef Islands good examples of submerged valleys are indicated; others occur north of Andoe. At the same time the author considers that in some cases the deep channels may be due to faulting. The submerged valleys are not shown on the bathymetric map, which is on too small a scale for the purpose, but they are shown on the sections, of which there are many in the volume of great interest. It is to be regretted, however, that Dr. Nansen has adopted a scale so exaggerated as 1 in 50 for the vertical; the result of which is to cause the hills and elevations on the land side to take the appearance of the spires of churches! A scale of 1 in 10 would have been sufficient for the delineation of the features, and would have appeared less unnatural.

The volume is accompanied by a fine geological map of Norway, and the isobathic contours by which the features of the submerged

[1] "The Physical History of the Norwegian Fjords": Trans. Victoria Institute, vol. xxxiv (1902).

lands and sea-bed are determined are carried out all over the ocean as far as the soundings have permitted. There can be no question that this work is the most important contribution to our knowledge of the Arctic submarine features which has yet appeared, and the author embodies in it as far as possible the work carried out in the same field by other explorers. EDWARD HULL.

II.—FOSSIL FLORAS OF CAPE COLONY. By A. C. SEWARD, M.A., F.R.S., etc. (Annals of the South African Museum, vol. iv, part 1; 122 pages, pls. i–xiv, and 8 text-figures. 1903.)

THIS memoir is undoubtedly one of the most important and complete that has yet appeared on the South African fossil floras. It contains a full description and many figures of the specimens collected by the Geological Commission of Cape Colony from four distinct formations.

Beginning with the flora of the *Uitenhage series*, among the ferns described and figured may be noticed *Onychiopsis mantelli* and *Cladophlebis browniana,* both of which occur in the Wealden of Sussex. Numerous fronds of the Cycadophyta are figured, especially of the genus *Zamites,* and also a new species of *Nilssonia. Araucarites Rogersi* is described as a new form of Araucarian cone. The author concludes that the "Uitenhage plants include types in part characteristic of Wealden and in part indicative of Jurassic floras. On the whole there is a balance in favour of a Wealden horizon."

The next flora described is that of the *Stormberg* beds. The following new species are among the plants figured:—*Schizoneura krasseri,* also known from China, *Callipteridium stormbergense* and *Chiropteris zeilleri,* two fine fern-like fronds, the latter being known from a single specimen in the British Museum, and *Baiera stormbergensis,* a large leaf of the Ginkgo type. Species of *Thinnfeldia, Tæniopteris,* and other genera typical of the Rhætic period, are also described and figured.

Among the plants of the *Ecca series,* in addition to *Glossopteris* and other well-known members of the Glossopteris flora, several genera of considerable importance are described from South Africa for the first time. *Neuropteridium validum,* already known from beds of similar age in India and South America, is represented by a large frond of which a figure is given. A new species of *Psygmophyllum, P. kidstoni,* is described; a type of leaf doubtfully referred to the Ginkgoales, which also occurs in the Permo-Carboniferous rocks of Europe. The Lycopodean genus *Bothrodendron,* represented by a new species, *Bothrodendron leslii,* is recorded for the first time as occurring with members of the Glossopteris flora; a further example of the association of northern and southern generic types in the Permo-Carboniferous rocks of South Africa.

Lastly, from the *Witteberg series* (? Devonian), an obscure fragment of a Lepidodendroid plant and examples of *Spirophyton* are figured. The nature of the latter is discussed, and the conclusion is held that these 'fossils' do not represent the remains of plants.

III.—Annals of the South African Museum, Vol. IV, Part 3: Brachiopoda from the Bokkeveld Beds (pls. xx–xxiii); by F. R. C. Reed, M.A., F.G.S.—Part 4: The Trilobites of the Bokkeveld Beds (pls. xxiv–xxviii); by Philip Lake, M.A., F.G.S.—Part 6: Mollusca from the Bokkeveld Beds (pls. xxx–xxxii); by F. R. C. Reed, M.A., F.G.S. 1903–1904.

THESE three papers on the fauna of the Bokkeveld Beds of South Africa introduce to us a number of interesting forms, many of which are new species. The plates of illustrations are good, and the text bears evidence of very careful work on the part of the two authors. The Devonian age of the Bokkeveld Beds is apparently settled, and the authors agree in stating that the South African species of this date show a remarkable agreement with the forms of both North and South America, and yet a dissimilarity from those of Europe. This is the conclusion of Mr. Reed (pp. 192, 193) from a study of the Brachiopods, and he gives a comparative table of the South African and South and North American species. Then Mr. Lake says of the Trilobites that they show "that the beds may be referred with certainty to the Devonian, and it is probable that they belong to the lower division of that formation. Few of the forms have any near allies in Europe. . . . . The Phacopidæ, on the other hand, are much more closely allied to the forms which have been described from Brazil and Bolivia" (p. 202). And of the Mollusca Mr. Reed says, "The evidence of the Mollusca points the same way as that of the Brachiopoda, and emphasizes still more strongly the affinities of the fauna with that of the American Continent" (p. 269).

One irritating practice we should like to bring to the notice of the editor of these Annals—that the explanations do not face their own plates; such is the case in Parts 3 and 4, but in Part 6 it is accomplished by turning one plate the wrong way and making one leaf do double duty. Even this is bad, and surely it is not worth the paper saved. In our opinion all plates should face the same way; and each plate should have its own flyleaf, bearing its own explanation and no more, opposite to it. With this exception both authors and editors may be congratulated on an excellent publication. And we may ask why the British Museum of Natural History does not publish similar Annals, and so make known to the world the wealth of new species which it contains? S. S. B.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 8th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Palæontological Sequence in the Carboniferous Limestone of the Bristol Area." By Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

The zonary divisions established by the author are given in the table on p. 101 in the form in which they are finally set out, after emendation and further revision of a preliminary working system.

For several reasons the author chooses the corals and brachiopods as zone and sub-zone fossils, and he has selected genera for zone-indices and circuli (or species-groups) for sub-zonal indices. A circulus is defined as an aggregate of all the species which possess, in common, a large number of essential properties, and are the results of similar chains of evolution. To secure definiteness photographic figures are introduced, not only to illustrate new specific names, but to convey the precise sense in which well-known specific names are employed in the paper. The relative acceleration of the two groups employed is not identical in different localities, and there is a small relative displacement of one group upon the other, even within the area considered by the paper. The strata in

	Zones.	Sub-zones and Horizons.	
VISEAN.		ϵ	
	Dibunophyllum	(D$_2$) *Lonsdaleia floriformis.* (D$_1$) *Dibunophyllum*, sp. nov.	
	Seminula	(S$_2$) *Productus Cora* (mut.). (S$_1$) *Productus semireticulatus.*	(Caninia-Zone.)[1]
		δ	
TOURNAISIAN.		(C) *Syringothyris*, sp. nov.	
		γ	
	Zaphrentis	(Z$_2$) *Schizophoria resupinata.* (Z$_1$) *Spirifer* aff. *clathratus.*	
		β	
	Cleistopora......	(K$_2$) *Spiriferina octoplicata.* (K$_1$) *Productus*, sp. nov.	
		α	
	Modiola	(M) *Modiola lata.*	

[1] Employed throughout the preliminary working system.

which the indices of two successive zones are found to overlap one another are referred to as 'horizon α, β, γ,' etc.

The detailed stratigraphical portion of the paper deals with all the important sections and isolated exposures in the Bristol area:—The Avon section, the Sodbury section, the Farland area, the Tytherington section, the Clevedon and Portishead area, isolated exposures, and the Backwell-Wrington mass. In each case there is given (1) a description of the position at which each zone or sub-zone is exposed and of its lithology; (2) a list of the corals and brachiopods found in the zone or sub-zone, with notes on their abundance; (3) a comparison with the same horizon in other parts of the Bristol area, and notes on the peculiarities of the section under discussion. In dealing with the Avon section an analysis is given of Stoddart's paper, and reference is made to his collection. The details of this portion of the paper are next summed up in tables and discussions of the ranges and maxima of the corals and brachiopods within the Bristol area. This is followed by a comparison of the last-named area with that of the Mendips, resulting in the conclusion that, when allowance is made for small variations (which are tabulated) the palæontological sequence agrees remarkably in the two areas.

The author next gives a summary of M. Lohest's discussion of the parallelism of the Belgian sequence with that of the Avon section, and adopts the Belgian divisions of Tournasian and Viséan for the lower and upper parts of the Carboniferous Limestone. A comparison is also instituted with M. Mourlon's grouping, and it is remarked that the Brachiopods mentioned by M. Mourlon and Professor Dewalque occur in the same order in the Bristol area as in Belgium, and are correspondingly characteristic of the beds. The author claims that in the area with which he deals, his table of ranges is sufficient to enable any worker to zone any exposure with a considerable degree of accuracy. In conclusion, notes are given on all the important species and circuli dealt with; and descriptions of a number of new species, circuli, and mutations.

2. "On a small *Plesiosaurus* Skeleton from the White Lias of Westbury-on-Severn." By Wintour Frederick Gwinnell, Esq., F.G.S.

The remains described were found on the beach, and had evidently recently fallen from the cliff above, which is made up of the Upper Rhætic beds, including the *Estheria*-bed and the White Lias Limestone. The matrix of the specimen corresponds with the White Lias in colour, texture, and material, and it is similarly traversed by fissures often coated with dendrites. The remains include more than twenty small dorsal vertebræ, with spinous and transverse processes, lying in natural sequence. A pseudomorph of the spinal cord in calcite occurs also in position. Several slender ribs, and indications of other bones, probably from the pectoral or pelvic arches, also occur in the slab, but are not yet worked out. Hitherto only single vertebræ or fragmentary bones of *Plesiosaurus* have been recorded from this horizon in Britain. At present it has not been found possible to assign the fossil to any existing species.

3. "The Evidence for a Non-Sequence between the Keuper and Rhætic Series in North-West Gloucestershire and Worcestershire." By Linsdall Richardson, Esq., F.G.S.

The section at Wainlode Cliff shows a transition in the 'Bone-bed' from a thin pyritic stratum of an inch or so in thickness and crowded with fish-remains to a micaceous sandstone-bed, usually devoid of such remains and about a foot thick, but containing Strickland's *Pullastra arenicola.* This sandstone is seen in many Worcestershire sections, and may be called the 'bone-bed equivalent.' Thus, as the bed which is full of vertebrate remains, or the Bone-bed (Bed 15 of the author's sections), can be traced in a single section laterally into a sandstone-bed devoid of those remains, the contemporaneity of the two developments is considered satisfactorily established. Particular stress is laid upon the fact that above this main 'Bone-bed' the component deposits of the Rhætic are remarkably persistent, while below it such persistency is not found. Black shales are generally present below the Bone-bed or its equivalent in Worcestershire, but in places there comes in a sandstone between them and the 'Tea-green Marls.' At Dunhampstead the Rhætic rocks are thicker than at any other locality in Worcestershire. At Denny Hill, near Gloucester, the 'Bone-bed' rests directly on the 'Tea-green Marls'; there is no infra-Bone-bed deposit of Rhætic date. At Garden Cliff, however, a comparatively thick accumulation is seen in that position. The anticlinal and synclinal areas established in the Mid and North Cotteswolds by Mr. S. S. Buckman are referred to; and it is found that the greatest thicknesses of the Rhætic rocks under the Bone-bed coincide with synclines, and the least thicknesses with anticlines. The Moreton and Birdlip anticlines are especially mentioned, as also the syncline of Cleeve Hill and that between Painswick and Stroud. Thus Dunhampstead, where the Rhætic deposits below the Bone-bed are thicker than anywhere else in Worcestershire, is situated on a continuation of the Cleeve Hill synclinal axis; Denny Hill, where the 'Bone-bed' rests directly upon the 'Tea-green Marls,' is near the westward continuation of the Birdlip anticline; and Garden Cliff, where the infra-Bone-bed deposit is thickest, is situated on a continuation of the synclinal axis which runs near Painswick. Thus the earth-pressures recognized in later times were probably at work at the close of the Keuper Period. As the area, once covered by the waters of the Keuper sea and the diminished representatives of that sea in the form of lakes, gradually sank, the Rhætic ocean slowly encroached upon the land-surface, flowing up the depressions in the undulating expanse of marls, and successive overlaps of the several infra-Bone-bed deposits resulted: the greatest overlap apparently taking place during the formation of the Bone-bed. At those localities where the distribution of the infra-Bone-bed deposits indicates elevation of the Keuper Marls in immediate pre-Rhætic times, it is noticeable that there is also a non-sequence at the base of the Lias.

CORRESPONDENCE.

THE 'YOREDALE' ROCKS OF NORTH DERBYSHIRE.

Sir,—I was pleased to see in your last issue Mr. J. A. Howe's protest against the application of the term 'Yoredale' to the series of rocks which are found between the Millstone Grits Series and the Massif of North Derbyshire.

The name 'Yoredale' was first used geologically by Phillips in his "Geology of Yorkshire," pt. ii, pp. 36–7, and he leaves no doubt as to the character of the group of rocks to which he applied the term. "We shall choose as a general standard of reference for this complex series of rocks, that district where this character of complexity is the greatest. The upper end of Wensleydale is adopted. The total thickness of the Upper Limestone Series in this situation is about one thousand feet, and it consists of the following groups—constituting what I term *the Yoredale Series.*" Hereafter follows the succession of the beds from the Main Limestone to the shales below the Hardraw Scar Limestone of that district, a series having perfectly definite lithological and palæontological characters, and anyone who has visited the vale of the river Ure will have been delighted with the 'country' selected as the 'type.'

Unfortunately for students, however, Phillips also described, as belonging in part to the Yoredale Series, another and widely different development of rocks, whose position had evidently puzzled him greatly, for their description, with peculiar inconsistency on the author's part, comes under the heading "Millstone Grit Series in Craven" (p. 72). It is this development whose correlative occurs in the Peak District, but which is totally unrepresented in the Yoredale area, and which, for that reason, it is wrong to denominate 'Yoredales.' Farey's term, 'the limestone-shales,' although by no means an ideal name for the group, has right of priority, and at any rate possessed the negative virtue of causing no confusion or misconception as to the character or position of the measures; nor did it commit the user to any theories.

The series under discussion is a very important one, whose thickness in places is 1500 feet; it gives to the localities of its development surface features which are totally different to those of the typical Yoredale country; it contains a characteristic fauna; and it is worth a distinctive name.

Familiarity with both types leads me to commend the wisdom of selecting such a name as 'Pendleside Series' for this group, and I believe the distinction thus marked cannot fail to be of service to workers in the science. John T. Stobbs.

Dunelin, Basford Park, Stoke-on-Trent.
21*st July*, 1904.

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THE GEOLOGICAL MAGAZINE

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"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

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.

SEPTEMBER, 1904.

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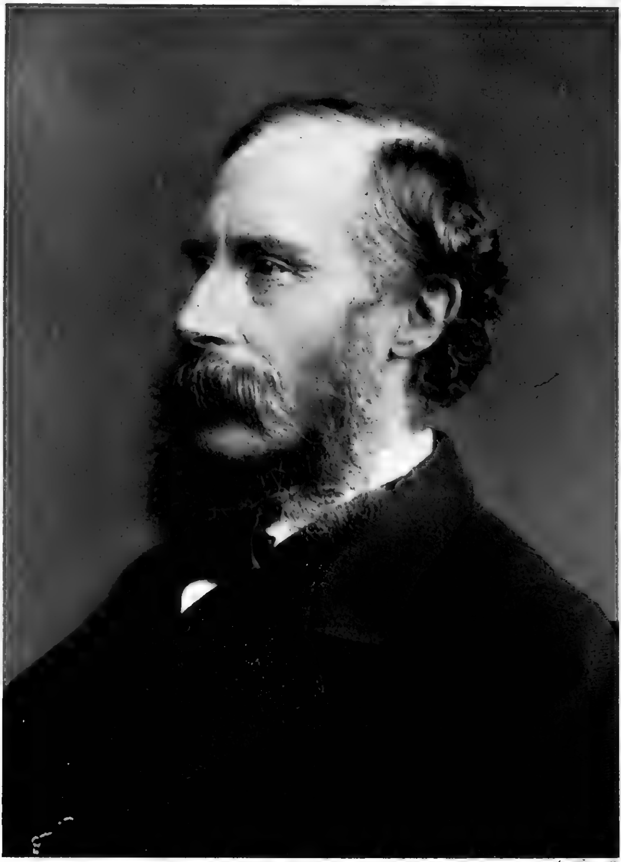


Very truly yours
W. H. Hudleston.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. IX.—SEPTEMBER, 1904.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Wilfrid Hudleston Hudleston, J.P., M.A., F.R.S., F.L.S., F.G.S., F.C.S., etc.,

(WITH A PORTRAIT,[1] PLATE XIV.)

GEOLOGY is a science which owes, not only its inception, but its continued existence largely to its non-professional disciples and lovers. In fact, of the two classes existing at the present time, the 'amateur' and the 'professional,' it would by no means be difficult to show that the former gave birth to the latter, and that some of the best living professional geologists have been recruited from the ranks of the amateur class. To a small band of early amateurs we are indebted for the foundation alike of the Geological Society and the Geological Survey in this country.

At the beginning of the last century—indeed, during the first half of it—geological teachers were scarce, and Natural Science had not attained a recognised position in our public schools. But for the early training received from William Smith (known as "the father of English geology") we might never have heard of his distinguished nephew, Professor John Phillips. Nor can we omit to recall the illustrious names of Hutton, Macculloch, Greenough, Conybeare, Fitton, Broderip, Darwin, Godwin-Austen, Fisher, Sorby; with Buckland, Sedgwick, Phillips, Forbes, Morris, Prestwich, Green, Bonney, and Nicholson, among our past University Lecturers; and De la Beche, Griffith, Portlock, Murchison, Ramsay, Jukes, and Geikie, as leaders of Surveys; and Hutton, Lyell, Poulett-Scrope, Huxley, Geikie, and others, among our classical geological writers, most of whom studied geology and palæontology in their early years as amateurs, and several of whom remained so all their lives.

Now, all is changed. Owing to the numerous centres for public instruction and the introduction of Natural Science teaching in our Universities, a large number of fully trained geological students is

[1] The portrait of Mr. Hudleston is reproduced by kind permission of "The Biographical Press Agency," 16, Henrietta Street, Strand, W.C.—Ed. Geol. Mag.

being turned out annually "for home and colonial consumption," and we need no longer rely altogether upon the casual crop of young men having an innate love of the science, which may prompt them to take up geology because they are interested in it. Many, indeed, nowadays may be "called," but possibly not all those "chosen" have a genuine love for the science they affect.

It is pleasant to record the scientific services of one who, while he belongs to the non-professional class of geologists, has yet achieved a very large amount of most excellent work, both in geology and palæontology, and has, by his merit, won for himself the blue ribbon of the science. Wilfrid Hudleston Hudleston (formerly Simpson) was the son of Dr. John Simpson, of Knaresborough, who married Elizabeth Ward, heiress of the Hudlestons of Cumberland, and by letters-patent assumed the name of Hudleston in 1867. Wilfrid, the eldest son, was born at York on June 2nd, 1828, being the descendant of three generations of Yorkshire 'medicine-men.' From 1831 to 1834 his parents resided at Harrogate, where he remembers meeting his first playfellow, Henry Clifton Sorby—afterwards a distinguished geologist, an LL.D., F.R.S., and President (1878–80) of the Geological Society of London—then a schoolboy in the neighbourhood. Young Simpson received his early education at St. Peter's School, York, from which he was transferred to Uppingham School, and subsequently entered St. John's College, Cambridge, where he graduated B.A. in 1850. As a boy and an undergraduate he evinced no special predilection for geology beyond a strange boyish curiosity to know what the earth was made of. In his last term at Cambridge he attended Sedgwick's lectures, and was much impressed with the manner and appearance of that distinguished geologist. On leaving Cambridge he devoted some time to the study of the Law, and was called to the Bar in 1853, but never practised. A considerable portion of the twelve years 1850–1862 was spent in foreign travel in various parts of Europe and North Africa.

Mr. Simpson accompanied Professor Alfred Newton, of Cambridge, and Mr. John Wolley, in the pursuit of Ornithology, to Lapland, spending the Summer of 1855 in that country. He subsequently explored the Eastern Atlas, Algeria, in company with Canon Tristram and Mr. Osbert Salvin. Afterwards, more than twelve months were occupied in travels and collecting in Greece and Turkey. During this time attention was given to the physical and geological features of the various countries visited, but Ornithology occupied a foremost place.

From 1862 to 1867, his long period of distant travel being mostly over, Mr. Simpson began a special course of scientific studies, selecting more particularly Natural History and Chemistry. During this time he studied at Edinburgh under Playfair and Stephenson Macadam, and subsequently for three sessions at the Royal College of Chemistry in London under Hoffmann, Frankland, and Valentine. At that time he was undecided whether to take Chemistry or Geology as his principal subject, when an accident determined his studies in favour of the latter. Mr. Simpson had the good fortune to meet Marshall Hall at Chamounix in the Summer of 1866, and on their return to England he was speedily introduced to many persons interested in geological science, of whom Professor John Morris may be regarded as the chief. There are still many who can recall the remarkable magnetic attraction of Morris over his pupils and associates, and this was just the kind of influence which Mr. Simpson, now become Mr. Wilfrid Hudleston, required to enlist him as a geological recruit and in due course to make him a "knight of the hammer" for the rest of his life. A close friendship was at once formed, which was only terminated by the death of Morris in 1886. In 1867 Mr. Simpson (a fortnight only before he changed his name to Hudleston) was elected a Fellow of the Geological Society of London, and four years later he became a member of the Geologists' Association.

About this period, 1867–71, Professor Morris was in the habit of extending his geological excursions far into the country, and out of this practice grew the improved excursions of the Geologists' Association, which, under various leading geologists, offered, without exception, the best instruction in geology which could be obtained, "*at the bed-side*"! Mr. Hudleston was not slow to profit by these excursions, and when he became Secretary in 1874 his interest was further enhanced by preparing reports on the various districts visited, some of which attain the dimensions of a respectable memoir. It was not until 1872 that he ventured on publication, and it may be noticed of many of his earlier papers that they have a decided bias towards chemical geology, in which subject he always took a deep interest. His papers on "The Yorkshire Oolites" (1873–8) and "The Corallian Rocks of England" (written in conjunction with Professor J. F. Blake, 1877) soon established his reputation as one of our leading geologists.

In 1881 Mr. Hudleston was elected President of the Geologists' Association, in which body he had already served the office of Secretary for three years, from 1874 to 1877, during which time, besides the duties of his office, he organised the excursions, prepared the reports, and carefully recorded the scientific work accomplished, earning for himself (said Mr. Carruthers) "the lasting gratitude of the Association" (see Annual Report, 1877, vol. v, p. 75). The Reports of Excursions directed by him are full of original observations, notably those relating to the Vale of Wardour (1881) and the West Riding of Yorkshire (1882). The cordial relations which have always existed between Mr. Hudleston and the Geologists' Association were further evinced in March, 1892, when an illuminated address of congratulation on his recent election to the chair of the Geological Society, signed by a numerous body of members, was presented to him by Professor Blake, then President of the Association.

Mr. Hudleston resided for many years in Cheyne Walk, Chelsea, but in 1883 he removed to Oatlands Park, Surrey. This rustication, however, interfered with his scientific engagements, and he again took up his residence in town, at 8, Stanhope Gardens, South

Kensington. In 1890 he married Miss Rose Benson, second daughter of the late William Heywood Benson, Esq., of Littlethorpe, near Ripon.

On the death of his old friend, Professor Morris, in 1886, Mr. Hudleston succeeded him as one of the Editors of the GEOLOGICAL MAGAZINE, to which, since 1879, he has been a frequent contributor.

He is a keen student of recent and fossil mollusca, and was one of the founders of the Malacological Society.

In 1886 accompanied by his friends Dr. Henry Woodward, F.R.S., and Mr. C. E. Robinson, Memb. Inst. C.E., Mr. Hudleston made some experimental dredgings, with the aid of a Brixham trawler and her crew, along the English Channel and in and near Torbay, for the purpose of studying marine mollusca and observing their living habitats; and in the following year he engaged a Grimsby steam-trawler and her crew, and, accompanied by Mr. C. E. Robinson and the late lamented Martin F. Woodward, of the Royal College of Science (second son of Dr. Henry Woodward), he spent three weeks in a dredging cruise in the English Channel to the west of Portsmouth and along the French coast.

In 1886 Mr. Hudleston became one of the Secretaries of the Geological Society of London, an office which he continued to hold until 1890. Following Sir Archibald Geikie, D.Sc., LL.D., F.R.S., Mr. Hudleston was in 1892 elected to fill the office of President, and during the two years in which he occupied the chair he delivered two important Addresses, dealing with the recent work of the Geological Society, which he passed critically in review, taking the papers on Tertiary and Secondary formations in 1893 and those on the Palæozoic and Fundamental rocks in 1894.

Three years later, in 1897, Mr. Hudleston was awarded the highest honour which the Council could bestow, the Wollaston Gold Medal of the Geological Society, in recognition of his valuable contributions to our knowledge, treating of chemical, mineralogical, palæontological, and stratigraphical geology. Special reference was made to his "Monograph on the Inferior Oolite Gasteropoda," which contained no less than 514 quarto pages of letterpress and 44 quarto plates of fossils. The labour involved in collecting, cleaning, and developing the Oolitic Gasteropoda procured for this work, all of which are now arranged in his private Museum in Stanhope Gardens, occupied Mr. Hudleston, with the co-operation of A. H. Bloomfield, Henry Keeping, B. Reynolds, Peter Cullen, and others, over a period of twenty years, fresh excavations having occasionally been made in quest of new species or to obtain better examples of those already known. In addition to this, some private collections, including those of Mr. S. S. Buckman and Mr. Darrel Stephens, were acquired by purchase. The Gasteropoda alone number many thousand specimens, carefully labelled and arranged, the 'types' being all specially marked. It is not too much to say that this was in all respects a model of what a monograph should be. No previous author had taken such pains to verify in the field the horizons from which the fossils had been obtained, nor studied more fully the Continental types figured from equivalent strata.

Early in January, 1895, Mr. Hudleston, accompanied by his wife and his friend Professor J. F. Blake, F.G.S., left London for Bombay, where they arrived towards the end of the month. After leaving Professor Blake duly installed as organizing Curator of the Museum at Baroda, to which he had just been appointed, Mr. Hudleston continued his journey towards the north-west frontier of India. The geological results of this expedition are embodied in the second part of his paper "Notes on Indian Geology," read before the Geologists' Association during the presidency of the late General C. A. McMahon, December, 1895 (see Proc. Geol. Assoc., xiv, pt. 6, February, 1896), who himself contributed an appendix on some of the rock-specimens collected. After making a rush for Simla, which is by no means an agreeable place in February, Mr. and Mrs. Hudleston proceeded across the Punjab to the banks of the Jhelum. Here they had an opportunity of ascending Mt. Tilla, the eastern extremity of the Salt Range, and thence transferred their base of operations to Rawal Pindi, whence Jamrood, Abbotabad, Murree, and finally Srinagar itself were visited.

Mr. Hudleston has been invited to preside over or take part in the Councils and Committees of numerous scientific Societies. He was elected President of the Devonshire Association for the Advancement of Science, Literature, and Art, of the Yorkshire Naturalists' Union, and of the Malton Field Naturalists' Society; and has for some years past acted as a Vice-President of the Dorset Natural History Field Club. He has been a member of the Council of the Royal Geographical Society, and was President of the Geological Section of the British Association at Bristol in 1898.

Quite recently Mr. Hudleston achieved an excellent piece of field geology by investigating the structure of Creechbarrow-in-Purbeck (see Geol. Mag., 1902, pp. 241–256, and 1903, pp. 149–154, 197–203), which affords an object-lesson for younger hammerers to take pattern by.

The accompanying list of Mr. Hudleston's more important papers will best attest the energy and ability of their author, and the pleasure which he still continues to take in all the scientific questions of the day.

Of these 58 memoirs and papers, extending over a period of 32 years, the last appeared so recently as July of the present year (see Geological Magazine, No. 481, pp. 337–382), and deals with "the Tanganyika problem," and is a most valuable contribution to, as well as a criticism of, Mr. J. E. S. Moore's recently published work on this subject. Indeed, we have the testimony of Professor Cornet himself upon this point. In the first place Mr. Hudleston enters upon a critical examination of the peculiarly marine-looking gasteropod shells which are thought by Mr. Moore to be homœomorphic with certain shells from beds of the Inferior Oolite of Western Europe, and are thus inferentially regarded as descendants of those forms. Mr. Hudleston finds that the evidence of an ancestral connection between certain of these halolimnic genera (namely, *Typhobia*, *Bathanalia*, *Limnotrochus*, *Chytra*, *Paramelania*, *Bythoceras*, *Tanganyicia*, *Spekia*, and *Nassopsis*) is not nearly so strong as was anticipated from the inferences already drawn by Mr. Moore; nevertheless, a fairly good *primâ facie* case for the *originally marine* origin of these exceptional organisms has been made out by Mr. Moore, but the supposed connection, in long ages past, of Lake Tanganyika with an arm of the Jurassic sea is held to be highly improbable, if not wholly impossible. In the second place Mr. Hudleston has collected together much of the scattered evidence as to the geological history of this vast Lake-area, some of which had escaped Mr. Moore's notice, especially the works of Professor Cornet of Mons, M. Barrat, and Mr. Molyneux, etc.

From a general consideration of the case it is apparent that the great longitudinal faults, folds, furrows, or "graben," as they are named, in which Tanganyika and the other lakes lie, are *not older than the Tertiary period*, and cannot therefore have formed a refuge in Secondary times for the remnant of an old Jurassic *marine* fauna in its hollows. Indeed, it seems probable that *a large portion* of the elevated interior region (composed of Archæan, Granitoid, and other ancient rocks) may have been a land-area from Triassic times or even earlier.

A magistrate and a landed proprietor in Dorsetshire and the West Riding of Yorkshire, Mr. Hudleston is a keen sportsman, loving both fishing and shooting, and divides his time between his country house at West Holme, near Wareham, Dorset, and his town residence, and still enjoys the meetings of the Geological, the Geographical, and other Societies, in the work of which he feels the same enthusiasm as of old.

LIST OF GEOLOGICAL PAPERS, ETC., BY WILFRID H. HUDLESTON.

1872. (With Mr. F. G. H. Price) "Excavations on the Site of the New Law Courts": Proc. Geol. Assoc., vol. iii, p. 43.

1873–8. "The Yorkshire Oolites": Proc. Geol. Assoc., vol. iii, p. 283; vol. iv, p. 353; vol. v, p. 407.

1874. Reports of Excursions to Oxford and Northamptonshire: Proc. Geol. Assoc., vol. iv, pp. 91 and 123.

1875. Reports of Excursions to the Isle of Thanet, to Charnwood Forest, and to East Yorkshire: Proc. Geol. Assoc., vol. iv, pp. 254, 307, and 326.

1875. Appendix. [On the Occurrence of Phosphates in Cambrian Rocks.] Quart. Journ. Geol. Soc., vol. xxxi, p. 376.

1876. Reports of Excursions to the Medway, to Reading, and to Swindon–Faringdon: Proc. Geol. Assoc., vol. iv, pp. 503, 519, 543.

1877. (With the Rev. J. F. Blake) "The Corallian Rocks of England": Quart. Journ. Geol. Soc., vol. xxxiii, p. 260.

1877. (With Mr. Davey) Report of an Excursion to Wantage: Proc. Geol. Assoc., vol. v, p. 137.

1877. Appendix. [Chemical Composition of some Lizard Rocks.] Quart. Journ. Geol. Soc., vol. xxxiii, p. 924.

1878. Report of an Excursion to Chipping Norton: Proc. Geol. Assoc., vol. v, p. 378.

1878. "Gneiss Rocks of the North-West Highlands": Proc. Geol. Assoc., vol. vi, p. 47.

1879. Review of Daubrée's "Géologie expérimentale": GEOL. MAG., Dec. II, Vol. VI, p. 421.

1879. Review of Sterry Hunt's Chemical and Geological Essays: Geol. Mag., Dec. II, Vol. VI, p. 554.

1880. Reports of Excursions to Oxford and Aylesbury: Proc. Geol. Assoc., vol. vi, pp. 338 and 344.

1880–1. "Corallian Gasteropoda of Yorkshire": Geol. Mag., Dec. II, Vol. VII, p. 241; Vol. VIII, p. 119.

1881. Report of an Excursion to Salisbury, Stonehenge, etc.: Proc. Geol. Assoc., vol. vii, p. 134.

1881. "On the Geology of the Vale of Wardour": Proc. Geol. Assoc., vol. vii, p. 161.

1881. Review of Wallace's "Island Life": Geol. Mag., Dec. II, Vol. VIII, p. 84.

1881. "Gasteropoda of the Portland Rocks": Geol. Mag., Dec. II, Vol. VIII, p. 385.

1881. Notes on the Geology of Keswick, and Report of an Excursion to the Lake District: Proc. Geol. Assoc., vol. vii, pp. 213 and 236.

1881. Presidential Address on "Deep Sea Investigation": Proc. Geol. Assoc., vol. vii, p. 245.

1882–5. "Gasteropoda of the Oxfordian and Lower Oolites of Yorkshire": Geol. Mag., Dec. II, Vol. IX, pp. 145, 193, and 245; Dec. III, Vol. II, pp. 49, 121, 151, 201, and 252.

1882. Review of King and Rowney's work on the so-called *Eozoon Canadense*: Geol. Mag., Dec. II, Vol. IX, p. 231.

1882. Report of an Excursion to the Isle of Purbeck: Proc. Geol. Assoc., vol. vii, p. 377.

1882. Report of an Excursion to the West Riding of Yorkshire: Proc. Geol. Assoc., vol. vii, p. 420, and Proc. Yorks. Geol. Soc., vol. for 1882, p. 113.

1882. "First Impressions of Assynt": Geol. Mag., Dec. II, Vol. IX, p. 390.

1882. Presidential Address on "The Geology of Palestine": Proc. Geol. Assoc., vol. viii, p. 1, and Proc. Yorks. Geol. Soc., vol. for 1883, p. 174.

1883. "Notes on the Diamond Rock of South Africa": Proc. Geol. Assoc., vol. viii, p. 65.

1883. "On a recent Hypothesis with respect to the Diamond Rock of S. Africa": Min. Mag., vol. v, p. 199.

1883. "On a Collection of Fossils and Rock-specimens from West Australia": Quart. Journ. Geol. Soc., vol. xxxix, p. 582.

1883. Review of Barrois' "Geology of the Asturias, etc.": Geol. Mag., Dec. II, Vol. X, p. 273.

1884. Review of Sterry Hunt's "Geological History of the Serpentines": Geol. Mag., Dec. III, Vol. I, p. 276.

1884. "Mollusca from South Australia": Geol. Mag., Dec. III, Vol. I, p. 339.

1884. Presidential Address to the Malton Field Naturalists' Society; Malton, 1885.

1885. "Further Notes on the Geology of Palestine": Proc. Geol. Assoc., vol. ix, p. 77. On p. 101 of this volume the analogy between the Jordan Valley fissure and the East African fissure lakes, such as L. Baringo, is suggested.

1885. (With Mr. H. B. Woodward) Report of an Excursion to Sherborne and Bridport: Proc. Geol. Assoc., vol. ix, p. 187.

1886–7. "On a Recent Section through Walton Common," and further notice: Quart. Journ. Geol. Soc., vol. xlii, p. 147, and vol. xliii, p. 443.

1887–96. Monograph of the Gasteropoda of the Inferior Oolite: Palæontographical Society.

1887. Report of an Excursion to Aylesbury: Proc. Geol. Assoc., vol. x, p. 166.

1889. Report of an Excursion to Weymouth: Proc. Geol. Assoc., vol. xi, p. 49.

1889. "Geological History of Iron Ores" (being the Presidential Address delivered to the Yorkshire Naturalists' Union at Sheffield in November, 1888): Proc. Geol. Assoc., vol. xi, p. 104.

1889. Presidential Address to the Devonshire Association (Tavistock): Trans. Dev. Assoc., vol. xxi, p. 25, and Geol. Mag., Dec. III, Vol. VI, pp. 500 and 558.

1890. "Mollusca from South Australia": Geol. Mag., Dec. III, Vol. VII, p. 241.

1892. (With Mr. E. Wilson) "A Catalogue of British Jurassic Gasteropoda": Dulau & Co.

1893–4. Two Presidential Addresses to the Geological Society of London on "Some Recent Work of the Society": Quart. Journ. Geol. Soc., vol. xlix, Proc., p. 65, and vol. L, Proc., p. 58.
1895. "Notes on Indian Geology, including a Visit to Kashmir": Proc. Geol. Assoc., vol. xiv, p. 226.
1896. (With Mr. Monckton) Report of an Excursion to Swanage, Corfe Castle, Kimeridge, etc.: Proc. Geol. Assoc., vol. xiv, p. 312.
1897. Review of Dr. C. Irons' "Life and Work of Dr. Croll": Geol. Mag., Dec. IV, Vol. IV, p. 71.
1898. Address to the Geological Section of the British Association at Bristol: Report (Trans. Sect. C), p. 852, and Geol. Mag., Dec. IV, Vol. V, p. 458.
1899. "On the Eastern Margin of the North Atlantic Basin": Geol. Mag., Dec. IV, Vol. VI, pp. 97 and 145.
1901. (With others) "A Day in West Purbeck": Proc. Dorset Field Club, vol. xxii, p. liv.
1902. (With General C. A. McMahon) "Fossils from the Hindu Khoosh": Geol. Mag., Dec. IV, Vol. IX, pp. 3 and 49.
1902. "Creechbarrow; an Essay in Purbeck Geology": Proc. Dorset Field Club, vol. xxiii, p. 146. See also Geol. Mag., Dec. IV, Vol. IX, p. 241, and Vol. X, pp. 149, 197.
1902. Review of Bertrand's "Panama" (a memoir published in 1899): Geol. Mag., Dec. IV, Vol. IX, p. 419.
1903. "Chesil Beach": Proc. Dorset Field Club, vol. xxiv, p. 1.
1903. Review of Tempest Anderson's "Volcanic Studies": Geol. Mag., Dec. IV, Vol. X, p. 160.
1904. Review of Messrs. Freshfield & Garwood's "Round Kanchenjunga": Geol. Mag., Dec. V, Vol. I, p. 74.
1904. "On the Origin of the Marine (Halolimnic) Fauna of Lake Tanganyika": Trans. Victoria Inst. for 1904, and as a Supplement in the July number of the Geol. Mag., Dec. V, Vol. I.

Mr. Hudleston is also the author of a considerable number of reviews and notices, some of which have appeared in the Annals and Magazine of Natural History, and others in the Geological Magazine, for the most part anonymously.

II.—Note on a Palæozoic *Cypridina* from Canada.

By Professor T. Rupert Jones, F.R.S., F.G.S.

In the Annals and Magazine of Natural History, ser. vii, vol. i (1898), pp. 333–334, pl. xxvii, a numerous series of fossil Ostracoda, with bivalved carapaces, having more or less resemblance to those of *Cypridina*, were described and figured. The specimens selected had been collected by various observers in different regions; and comprised two from the Tertiary of France, two from the Cretaceous of Belgium, one from the Permian of Durham, seven from the Carboniferous of Britain, three from the Devonian of Devon, three from the Upper Silurian and two from the Lower Silurian (Ordovician) of distant regions. References were made to several allied Palæozoic forms; and one other species from the Carboniferous of North America (Ulrich) and two from the Upper Silurian of Scania (Moberg) ought to have been mentioned.

We have now to notice another old Cypridinal form (the internal cast of a left valve), probably of Ordovician age. It has come to hand from Colonel C. C. Grant, of Hamilton, Ontario, Canada, who exposed it in breaking up some blocks of limestone, probably belonging to the Trenton series, from a 'glacial drift' at Wenoma, on the shore of Lake Ontario, not far from Hamilton.

This limestone is largely composed of a small gregarious variety of *Isochilina Ottawa*, Jones (see GEOL. MAG., July, 1903, pp. 300–304); and in this condition it resembles other specimens collected by Colonel Grant, and sent by him to the British Museum.

The particular specimen under notice is shown in Fig. 1. It approaches in lateral outline to *Cypridina brevimentum*, Jones, Kirkby, and Brady (Foss. Entom. Carbonif., pt. i, 1874, p. 16, pl. ii, figs. 15–19, especially fig. 15*a*). It differs, however, from that species in the following particulars:—

It is more definitely oblong; straight on the back, with its postero-dorsal angle, and not the postero-ventral part, projecting. The hook or hood is narrower and sharper than in *C. brevimentum*; attenuated partly by loss of substance.

The notch below is deeper than in the figures quoted; and it has a bold outline with an ogee curve. The cast itself has suffered a slight damage by having lost some of its convex surface, and the middle part of both its ventral and its dorsal edge, when it was being detached from the block. With the above-mentioned distinctive characters we may regard it provisionally as a separate species, with the name of *Cypridina antiqua*, sp. nov.

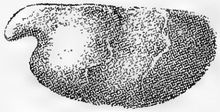


FIG. 1.—*Cypridina antiqua*, T. R. Jones, sp. nov. Magn. 3 diam. Of Ordovician age? From Glacial Drift (limestone of the Trenton series), Wenoma, on the shore of Lake Ontario, near Hamilton, Canada.

This internal mould of a left valve (Fig. 1) is somewhat decorticated across the middle of its convexity. The cast consists of dark-grey, fine-grained, and slightly micaceous mudstone, distinct from the limestone to which it is attached. It measures 15 millimetres in length and 10 in height (from dorsal to ventral edge).

III.—NOTE ON A SMALL ANTICLINE IN THE GREAT OOLITE SERIES AT CLAPHAM, NORTH OF BEDFORD.[1]

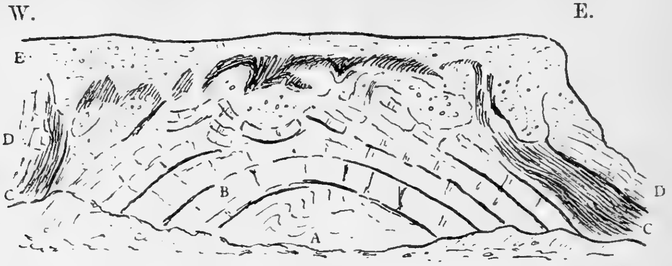
By HORACE B. WOODWARD, F.R.S.

IN the broad Alluvial tract which borders the Ouse between Oakley and Clapham, north of Bedford, there is a gravel-pit in which a small anticline of the Great Oolite was abruptly encountered amidst the regularly stratified river-deposits. The pit is situated immediately north of the Oakley road and east of the Midland Railway.

The trend of the fold was N.N.W. and S.S.E., and the upraised strata consisted of Great Oolite Limestone and Clay, with bordering portions of Cornbrash, and probably also of Kellaways Beds. The ridge was exposed over a space about 20 yards in length, and the arch of Oolite strata, about 18 yards in breadth, was clearly displayed in a transverse section, flanked on either side by undisturbed beds

[1] Read before the Meeting of the British Association, Cambridge, August, 1904.

of river gravel and sand; the whole being opened up to a depth of 10 or 12 feet. Prior to the excavation there was no indication of the disturbed strata, although they actually reached the surface. The arch, however, was coated with Great Oolite Clay, which had been disarranged superficially and intermixed with gravel.



SECTION AT CLAPHAM, NORTH OF BEDFORD.

		feet.
Soil and gravel, etc.	E. Brown loam and stony loam and clay, and irregular pockets of brown and white gravel intermixed with C.	
Cornbrash.	D. Marly and flaggy limestone with *Ostrea flabelloides* ...	2
Great Oolite Clay.	C. Dark-blue clay	up to 3
Great Oolite Limestone.	B. Grey limestones	5 to 6
	A. Marly clay with *Ostrea Sowerbyi.* Marls and limestones (seen in pit, further south).	

The Great Oolite Clay, less disturbed on the flanks of the anticline, was thinner than that exposed by the Bedford waterworks, south of Clapham: an attenuation possibly resulting from the flexure. The limestones below were bent into an arch and slightly broken, while the lowest strata of marly clay with *Ostrea Sowerbyi* were much squeezed up. The Cornbrash, a flaggy limestone with *Ostrea flabelloides*, was seen at the base of the pit on the eastern side of the arch, and traces of sands (resembling those of the Kellaways Beds) were noticeable a little distance away on the western side.

The adjacent deposit, a white gravel, with brown decalcified portions resting irregularly on a 'piped' surface of it, was made up mainly of Oolite limestone, together with rolled Oxfordian and other fossils, quartz, quartzite, jasper, flint pebbles, and subangular and angular flints. It yielded also a partially decomposed block of rhomb-porphyry, evidently derived from the Boulder-clay which covers the higher grounds; and the occurrence of this Scandinavian rock is of interest, as hitherto no example has been recorded south of Norfolk.[1] A portion of a molar of *Elephas primigenius* was likewise obtained from the gravel—the age of which is evidently subsequent to the Boulder-clay of the district.

With regard to the age and origin of the small anticline, there is no particular evidence. It must have been formed prior to the

[1] See Professor P. F. Kendall: "Eighth Report of Committee on Erratic Blocks of the British Isles," Rep. Brit. Assoc. for 1903.

accumulation of the gravel, and unfortunately little more can be said with confidence.

The Ouse follows a serpentine course from the neighbourhood of Sharnbrook to Bedford, a distance in a direct line of rather more than six miles, and all the way the bed of the river lies practically on the Great Oolite Series—the normal dip being locally counteracted by slight undulations and occasional faults. It is possible that the small anticline may be connected with these earth-movements, but as its direction is contrary to that of the gentle folds above noted, this supposition does not appear to be probable.

Again, it might be surmised that the flexure was purely local and superficial, that perhaps glacial action had been the cause; but of this there is no distinct evidence either for or against. All that can be reasonably inferred is that the superincumbent portions of Kellaways Beds and Cornbrash—the latter but a thin band of rock in the immediate district—had been planed off the dome prior to or during the period of maximum glaciation, when the Boulder-clay which crowns the adjacent plateau was laid down. The erosion of the softer strata flanking the anticline was perhaps due to the action of the river, if not to torrential waters in the later phases of the Glacial period; and possibly the arch of Oolite limestones stood out as a low ridge or islet in the broad course of the river, until the inequality was levelled up by the accumulation of the valley deposits.

IV.—*Linthia oblonga* (Orbigny) from Sinai.

(PLATE XV.)

By R. Bullen Newton, F.G.S.

In a collection of Cretaceous fossils from Sinai obtained by Mr. T. Barron, F.G.S., which has been entrusted to me for determination by the Geological Survey of Egypt, I found several specimens of *Linthia oblonga*, a form of Echinoid which appears to have escaped the attention of modern writers on the palæontology of the Sinai Peninsula. In tracing the history of this species it is ascertained that d'Orbigny first figured and described it under the genus *Periaster* during the year 1856 in the Pal. Française Terr. Crétacés Échinodermes, pl. 900, pp. 275, 276, where it is referred to as having been collected by M. Lefébvre at Mount Garèbe, near Suez, from rocks regarded as of Turonian age, in association with *Radiolites*.

Dr. Martin Duncan[1] next determined the species among Mr. Bauerman's fossils from Sinai, which are preserved in the Museum of the Geological Society of London. It was collected at Wady Nagh el Bader (= Wadi Budra), Duncan listing it as one of the commonest forms of the collection found in association with *Radiolites*, and belonging to an horizon equivalent to the Cenomanian of France.

[1] Duncan, P. M., "Note on the Echinodermata, etc., etc., from the Cretaceous Rocks of Sinai": Quart. Journn. Geol. Soc., vol. xxv (1869), pp. 44–46.

At a later date, M. Cotteau[1] recognized this Echinoid as occurring in the Turonian rocks of Algeria under the name of *Linthia oblonga.* On this occasion a change in the generic title was effected, without, however, any explanation being given by the author. This change was obviously necessary on grounds of priority, since Desor's *Linthia* of 1853 (*Actes Soc. Helvétique,* vol. xxxviii, p. 278) was synonymous with *Periaster*, founded by d'Orbigny in 1856.

During the year 1899 M. Fourtau[2] published a revision of the Fossil Echinoids of Egypt, containing a reference to *Linthia oblonga.* Besides quoting its occurrence in Algeria, he stated that the species was common in the neighbourhood of Angoulême, France, where it had been found at the base of the Angoumian deposits, and was consequently Upper Turonian. Moreover, M. Fourtau furnished a remark on the original locality given by d'Orbigny which is of interest to reproduce here: "Je ne connais point de Gebel Garèbe, près de Suez, seule une petite éminence au pied de l'Abou Daragué[3] porte le nom de Krouéba, c'est peut-être là que Leféblvre l'a récoltée à moins que ce ne soit dans les couches qui bordent le massif central granitique du Gebel Garib à 220 kilométres au sud de Suez sur les côtes de la mer Rouge, entre cette montagne et Gebel Zeit."

As this appears to embrace all the important references to *Linthia oblonga*, we will now attempt to solve the position of the original locality as given by d'Orbigny. According to his account M. Lefébvre collected the species at "Mont Garèbe, près Suez," a spot which appears to be unknown to M. Fourtau. An examination of the map, however, demonstrates that there is an eminence called Jebel Gharbi or Gharabi in a slightly south-easterly direction from Suez, which is in the neighbourhood of Wadi Budra, overlooking the Ramleh plain of Sinai. Although the specimens could not have been obtained from Jebel Gharbi itself, that being of granitic structure, it is quite possible that Lefébvre collected his material at Jebel Dhalal, which is in the vicinity, and where Mr. Thomas Barron knows the Cenomanian rocks to be present. Some of the best specimens of *Linthia oblonga* in the collection of the Geological Survey of Egypt have been obtained at Wadi Budra, as were Duncan's in previous years. This area of Sinai may therefore be regarded as the special habitat of the species, rather than those localities situated in the Eastern Desert of Egypt bordering the Gulf of Suez and the Red Sea, as suggested by M. Fourtau.

The Turonian age of *Linthia oblonga* as determined, at any rate, for the Sinai occurrence by d'Orbigny, is not now accepted, more especially as that author described *Hemiaster cubicus* and *Clavaster*

[1] Cotteau, Peron, & Gauthier: "Échinides Foss. Algérie," vol. ii (1879), fasc. 6, p 75 (no figure given).

[2] Fourtau, R., "Révision des Échinides Fossiles de l'Égypte": Mém. Instit. Égyptien, vol. iii (1899), fasc. 8, pp. 631, 632.

[3] These place-names, which are difficult to find on ordinary maps of the district, will be found in an excellent topographical map accompanying M. Fourtau's paper, "Voyage dans la Partie Septentrionale du Désert Arabique": Bull. Soc. Khédiviale Geographie (Caire), 1900, ser. v, No. 9, p. 576.

cornutus also from Mont Garèbe, which are true Cenomanian species; and, moreover, we have it on the authority of Professor Rothpletz [1] that no Turonian rocks have been identified in the Sinai Peninsula, thus fully confirming the previous work of Duncan, who from an examination of the assemblage of fossils in this region was led to regard it as generally of a Cenomanian character. This horizon is also supported by the specimens collected by the Geological Survey of Egypt, which contain such fossils in association with *Linthia oblonga* as *Exogyra Africana* and *Exogyra Olisiponensis*.

In connection with *Hemiaster cubicus* it is interesting to note that according to modern writers that species is a frequent Cenomanian fossil of Sinai; yet Duncan never identified it in the Bauerman Collection, nor has the present writer been able to recognize it among the specimens collected by Mr. Barron. Professor A. Rothpletz [2] noted the occurrence of *H. cubicus* in the Cenomanian beds of Sinai during 1893; M. Fourtau [3] recognized it at Wadi Budra, etc., in beds of Lower Cenomanian age; Dr. Blanckenhorn [4] has also listed the species from similar regions of Sinai; whilst Dr. Hume [5] has met with it at Jebel Gunnah, in the eastern part of the peninsula, associated with *Pseudodiadema variolare* and *Heterodiadema libycum*. M. Fourtau's latest contribution on this subject calls attention to the eccentricity of the apex in *H. cubicus*, and the varieties of form that he has observed in the species, his examples coming from the neighbourhood of the Convent of St. Paul in the Arabian Desert, where the species is said to be characteristic of the base of the Cenomanian of Egypt. But it is not likely that any confusion could have occurred in the identification of these echinoids when the details of the test are considered. There is the great difference in form, as also in the pore structure of the anterior ambulacrum, whilst the presence in *Linthia oblonga* of a lateral as well as the peripetalous fasciole creates even a more striking separation. This lateral fasciole, which in the posterior region is situated beneath the anal orifice, is, unfortunately, not always definable, so much depending upon the state of preservation of the test; but it is traceable on Duncan's specimens in the Geological Society and also on some of those collected by Mr. Barron. There is a stratigraphical distinction also which deserves to be mentioned. According to M. Fourtau, *H. cubicus* belongs to the base of the Egyptian Cenomanian, whereas *L. oblonga*, from its association with *Exogyra*

[1] Rothpletz, A., "Stratigraphisches von der Sinaihalbinsel": Neues Jahrbuch, vol. i (1893), pp. 102–104.

[2] Rothpletz, A., "Stratigraphisches von der Sinaihalbinsel": Neues Jahrbuch, vol. i (1893), pp. 102–104.

[3] Fourtau, R., "La Côte Ouest du Sinai," Bull. Soc. Khédiviale Géographie (Le Caire), 1898, ser. v, No. 1, pp. 1–35; "Révision des E'chinides Fossiles de l'E'gypte," Mém. Instit. E'gyptien, vol. iii (1899), fasc. 8, pp. 605–608, 628; "Note sur *Hemiaster cubicus*, Desor, et ses variations," Bull. Mus. Hist. Nat. [Paris], 1903, No. 3, pp. 177–180.

[4] Blanckenhorn, Max, "Neues zur Geologie und Paläontologie Aegyptens": Zeitsch. Deutsch. Geol. Ges., vol. lii (1900), see chart facing p. 33.

[5] Hume, W. F., "Geology of Eastern Sinai": Geol. Mag., 1901, p. 203.

Africana and *E. olisiponensis*, is of Upper Cenomanian age. In fact, no Lower Cenomanian fossils have been recognized in the collection of the Geological Survey of Egypt, and, moreover, several of the species are found to pass up into the Turonian stage in other countries, as Dr. Choffat[1] has proved in connection with his researches in Portugal.

In conclusion, therefore, it is hoped that this note may claim the attention of the palæontologists of Egypt, and that *Linthia oblonga* may take its place in all future faunistic lists connected with the palæontology of Sinai.

I am indebted to my colleague, Dr. F. A. Bather, of the British Museum, for some useful suggestions during the preparation of this paper.

Linthia oblonga, Orbigny.

Periaster oblongus, Orbigny: "Pal. Française Terr. Crétacés Échinodermes," 1856, pl. 900, pp. 275, 276. P. M. Duncan, "Note on the Echinodermata, etc., from the Cretaceous Rocks of Sinai": Quart. Journ. Geol. Soc., vol. xxv (1869), pp. 44–46 (no figure or description).

Linthia oblonga, Cotteau, Peron, & Gauthier: "E'chinides Foss. Algérie," vol. ii (1879), fasc. 6, p. 75 (not figured). Fourtau, "Révision E'chinides Foss. E'gypte": Mém. Instit. E'gyptien, vol. iii (1889), fasc. 8, pp. 631, 632 (not figured).

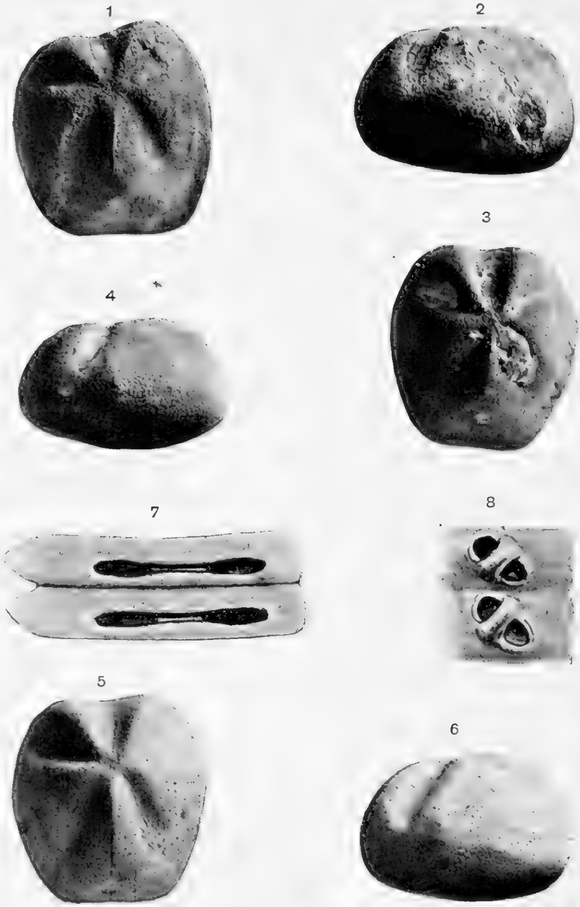
The test measurements of the three specimens selected for illustration are as follows:—

	(9004)	(9003)	($S\frac{3}{11}$)
Length	31	28	30 mm.
Width	27	21	27 mm.
Height	20	18	19 mm.

Nos. 9003 and 9004 represent Duncan's two principal specimens, and $S\frac{3}{11}$ is one of the Wadi Budra examples collected by Mr. T. Barron. All these are of the average size, although larger and even smaller ones are among the specimens of the Egyptian Survey Collection. The details of structure, so amply given in the original description, are well seen, although in the majority of the specimens it is not always possible to trace the lateral fasciole and its course beneath the anal aperture. This feature is, however, preserved in specimens represented by Figs. 4 ($= S\frac{3}{11}$) and 6 (= 9003). The structure of the pores, as observed in the anterior ambulacrum (Pl. XV, Fig. 8) and in the antero-lateral ambulacra (Pl. XV, Fig. 7), corresponds with that figured by d'Orbigny. The largest of Duncan's specimens (Fig. 1 = 9004) shows well-preserved apical characters, whilst the pores of the madreporite are observable on some eroded specimens obtained by Mr. Barron from the top of Jebel Safariah ($S\frac{3}{42}$).

The apex is anterior or nearly central in this species, although the abactinal views of the specimens selected for figuring present the idea of great eccentricity, a feature which has been brought about through slightly tilting the specimens so as to include the anal orifice. It is noticeable also that the right anterior corner of some of the specimens appears to be slightly higher than the left,

[1] Choffat, Paul: "Recueil de Monographies Stratigraphiques sur le Système Crétacique du Portugal," 1900.



Linthia oblonga (Orbigny).

Cretaceous (Cenomanian): Sinai.

a fact which is more than usually accentuated in the case of Duncan's largest specimen (see Pl. XV, Fig. 1), and although such a phenomenon may be due to some kind of deformity it is possible, as suggested by Dr. Bather, that it may have a wider and more structural explanation.

LOCALITIES.—Duncan's specimens collected by Mr. Bauerman were obtained at Wadi Nagh el Bader, and are preserved in the Museum of the Geological Society bearing the numbers 9003 and 9004. The specimens in the Geological Survey of Egypt Collection were obtained by Mr. Barron from the following places:—Wadi el Araba (S $\frac{3}{5}$, 4117); Wadi Budra (S $\frac{3}{11}$, 3614), examples numerous and associated with *Exogyra Africana*; south end of Wadi el Araba (S $\frac{3}{12}$, 3815), also found with the above-named shell; head of Wadi Esba (S $\frac{3}{24}$, 3870), found with *Hemiaster Heberti* and *Exogyra olisiponensis*; Wadi Sifa (S $\frac{3}{28}$, 4021); near top of Jebel Safariat (S $\frac{3}{42}$, 4066), specimens numerous, but with eroded and worn tests, which are generally devoid of detailed characters, except that some of them show the madreporite.

EXPLANATION OF PLATE XV.

LINTHIA OBLONGA.

Cretaceous (Cenomanian): Sinai.

FIG. 1.—Abactinal view of Duncan's largest specimen (9004), slightly tilted to show the anal region.
,, 2.—Left side view of same specimen.
,, 3.—Abactinal view of Duncan's second specimen (9003), also slightly tilted to show anal region.
,, 4.—Left side view of same, exhibiting the peripetalous and lateral fascioles.
,, 5.—Abactinal view of one of Mr. Barron's specimens (S $\frac{3}{11}$), tilted as before, for anal characters.
,, 6.—Left side view of same, showing obscure fascioles.
,, 7.—Pores of the antero-lateral ambulacra, enlarged.
,, 8.—Pores of the anterior ambulacrum enlarged, showing their oblique character and the dividing calcareous band.

Figs. 7 and 8 represent enlargements, whilst the remaining figures are of the natural size.

V.—ON THE OCCURRENCE OF AN OPISTHOCŒLIAN DINOSAUR (*ALGOASAURUS BAURI*) IN THE CRETACEOUS BEDS OF SOUTH AFRICA.

By R. BROOM, M.D., B.Sc., Corr. M.Z.S. Lond.

LAST year, while the Port Elizabeth Brick and Tile Company were quarrying a clayey rock at Despatch, near Uitenhage, a number of bones were discovered in the rock. Though the discovery created some little interest, no one seems to have appreciated the scientific value of the find, and large numbers of the bones were made into bricks. A few fragments of vertebræ and ribs have been collected by the Port Elizabeth Museum, and recently an attempt has been made to rescue some more of the bones that still remain in the rock. So far a number of very imperfect fragments of vertebræ—cervical, dorsal, and caudal—a fairly good femur, an imperfect scapula, portions of many ribs, and an ungual phalanx, have been discovered. The examination of these remains leaves no doubt that the skeleton is that of an Opisthocœlian Dinosaur of moderate size.

The scapular fragment represented the larger portion of the lower half of the bone of the right side. The posterior border is missing, but as the coracoid border is preserved, as well as a portion of the anterior, a very good idea can be obtained of the shape of the bone. As will be seen by the figure, it resembles considerably the scapula of *Brontosaurus*, though of very much smaller size. When complete, the greatest breadth from the prescapular border to the posterior part of the glenoid process would probably be about 200 mm.

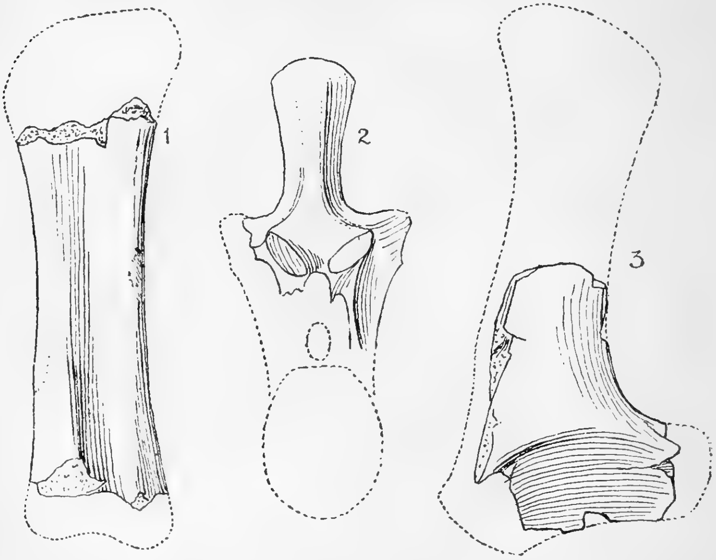


FIG. 1.—Left femur of *Algoasaurus Bauri*. × $\frac{1}{7}$.
FIG. 2.—Posterior dorsal vertebra of *Algoasaurus Bauri*. × $\frac{1}{7}$.
FIG. 3.—Right scapula of *Algoasaurus Bauri*. × $\frac{1}{7}$.

The femur has lost the upper and lower ends, but otherwise is perfect. Indications of both condyles can be seen at the lower end, so that a clear idea can be obtained as to how much is missing. A considerable portion of the upper end is lost, but it is probable that the upper end was shaped as in *Diplodocus*. The fourth trochanter for the femoro-caudal muscle is of much smaller size than in either *Brontosaurus*, *Diplodocus*, or *Morosaurus*, from which we may probably infer that the tail was less powerfully developed in the South African than in the American forms. When complete, the femur is estimated to have been 500 mm. in length, or about one-third the size of that of *Diplodocus*. Across the narrowest part the femur measures 120 mm.

Most of the vertebræ are too fragmentary to warrant description, but from the fragments it is manifest that the vertebræ have borne considerable resemblance to those of *Diplodocus*. The few fragments of centra of the body vertebræ show the peculiar excavations seen in the centra of the American types. The best preserved vertebra is the one figured. It is probably one of the posterior dorsals. The spine shows a complicated arrangement of laminæ very similar to that of the spines of the posterior dorsals of *Diplodocus*, but owing to the condition of the specimen it is difficult to represent this in the figure. The height of the vertebra, when complete, would probably be about 450 mm., or less than half the size of the last dorsal of *Diplodocus*.

I propose to name this new reptile *Algoasaurus Bauri*, after the late George Baur, whose early death removed from the ranks of investigators one who could ill be spared.

VI.—Note on a Pillow-lava apparently forming a continuous horizon from Mullion Island to Gorran Haven in Cornwall.

By G. T. Prior, M.A., F.G.S.

The basalt of Mullion Island, with the intercalated radiolarian chert, is well known from the descriptions of Teall and Howard Fox.[1] It is a fine-grained minutely vesicular basalt, consisting mainly of radiating felspar laths and interstitial pale purplish-brown augite, and occurring in peculiar pillowy or bale-like masses. Owing to this curious structure and its intercalation with the chert the basalt is considered to be a submarine lava.

A well-marked horizon of radiolarian chert similar to that of Mullion Island has been traced by Mr. Howard Fox[2] from that island across the Lizard peninsula to Porthallow, and thence to the other side of Falmouth Bay to Pendower and Gorran Haven.

Lately, in the company of Mr. Upfield Green, I have made a collection of igneous and other rocks from the north of the Lizard, south of Helford river, and from the neighbourhood of Gorran and Caerhayes on the other side of Falmouth Bay. Many of the volcanic rocks are almost precisely similar, both in pillow structure and in microscopical characters, to the Mullion Island basalt. The following is a list of the localities, besides Mullion Island, at which this particular kind of basalt was found:—

Tregidden.—The basalt occurs here in two quarries on opposite sides of the stream; in one of them to the east the pillow structure of the rock is well marked. In microscopical characters the basalt is precisely similar to that of Mullion Island. It is finely vesicular, and shows minute interlacing felspar laths with much interstitial pale purplish-brown augite, and little or no iron-oxides. It varies in coarseness of grain, and in parts is much altered, so that the augite is unrecognizable. To the west of Tregidden, nearer to Mullion Island, precisely similar basalt was met with at Trethewy

[1] Quart. Journ. Geol. Soc., vol. xlix (1893), p. 211.
[2] Trans. Roy. Geol. Soc. Cornwall, xii (1), 1896, p. 39.

and near the Methodist Chapel at St. Martin, but at Trethewy the specimen obtained, which was coarsely vesicular, was found loose on a heap of pebbles, and at St. Martin there is some doubt whether the rock was actually *in situ*.

Still further west, at Lower Garras 'gravel-pit,' was found a crushed and brecciated radiolarian chert, exactly similar in microscopic characters to that of Mullion Island.

Roskruge Lane and Higher Boden.—In the lane leading from Roskruge to Higher Boden, on the right-hand side, occurs an andesitic basalt showing large porphyritic felspars. Under the microscope these phenocrysts are seen to occur in a groundmass consisting of a mesh of felspar laths with interstitial dark grains of what is probably altered augite. Some yards distant, on the same side of the road, to the east of a small stream, was found a basalt consisting of felspar laths and interstitial brown augite, precisely similar to the Mullion Island rock, but of slightly coarser grain. Similar basalt occurs in a quarry farther up the lane on the left-hand side near Higher Boden. The association of a basalt like that of Mullion Island with a markedly porphyritic variety is repeated on the other side of Falmouth Bay in a quarry near Tubbs Mill (see below).

Porthallow.—The rock at Porthallow is similar to some of the varieties of basalt found at the quarries near Tubbs Mill on the other side of Falmouth Bay (see below). It shows a trachytic mesh of felspar laths with dark interstitial grains of altered augite, and passes on the margin into a spherulitic glass.

Nare Head (east side of Falmouth Bay).—On the top of Nare Head was found a basalt consisting, like the Mullion Island rock, of felspar laths and interstitial purplish-brown augite, but containing also a few porphyritic felspars. It was associated with a variety of much coarser grain, approaching a dolerite in character. At Pennare Wallas, north of Nare Head, occurred a radiolarian chert similar to that of Mullion Island.

Quarries near Tubbs Mill (north of St. Michael Caerhayes).—In a quarry east of Trevennen, on the right-hand side of the road leading to Tubbs Mill, occurs a basalt showing fairly well-marked pillow structure. The rock is like the Mullion Island basalt, and consists of felspar laths and altered interstitial augite. As in the case of the Porthallow rock, it passes on the surface of the pillows into a glass showing well-marked spherulitic structure. In the large quarry just north of Tubbs Mill is seen the close association of a finely vesicular basalt, consisting of felspar laths and pale purplish-brown augite, precisely similar to the Mullion Island rock, with a variety showing a similar groundmass, but with numerous fairly large porphyritic felspars. A similar association of a basalt like the Mullion rock with a porphyritic variety occurs also in an overgrown disused quarry amongst osiers to the east of Trevennen on the left-hand side of the road leading to Tubbs Mill.

Great Perhaver Beach.—A mass of basalt showing well-marked pillow structure and microscopic characters, similar to those of the

Mullion Island basalt, forms the projecting headland at the south end of the Great Perhaver Beach, north of Gorran Haven.[1]

These localities mark out almost precisely the same horizon as the radiolarian cherts of Mr. Howard Fox. The curve followed by this pillow-lava is also fairly parallel to that of the well-known quartzite of the Meneage and Gorran districts, to the slate containing limestone lenticles with Upper Silurian fossils, and to that of the conglomerate placed by Mr. Upfield Green at the base of the Gedinnian. Fragments of an altered basalt very similiar to the Mullion Island rock were found in this conglomerate along Gillan Creek, at Flushing and Lestowder Beaches.

NOTICES OF MEMOIRS, ETC.

I.—British Association for the Advancement of Science. Cambridge Meeting, 1904.

Address to the Geological Section by Aubrey Strahan, M.A., F.R.S., F.G.S., President of the Section.

It is forty-two years since the British Association last met in Cambridge, and we may turn with no little interest to the record of what was taking place at a date when the science of geology was still in its infancy, and in a University where its promise of development was first recognised. Dr. John Woodward, the founder of the Woodwardian Chair, had been dead 176 years, but his bequest to the University had not long begun to bear fruit, for the determination to house suitably the collection of fossils and to provide for the reading of a systematic course of lectures was not arrived at until 1818. In that year Adam Sedgwick, on his appointment to the Woodwardian Chair, began a series of investigations into the geology of this country, which made one of the most memorable epochs in the history of British geology. At the Cambridge meeting of 1862 he had therefore held the Professorship for forty-four years, a period sufficient to spread his reputation throughout the civilised world as one of the pioneers of geological science.

Towards the close of his life Sedgwick gave expression to the objects which he had had in view when he accepted a Professorship in a science to which he had not hitherto specially devoted his attention. "There were three prominent hopes," he writes, "which possessed my heart in the earliest days of my Professorship. First, that I might be enabled to bring together a collection worthy of the University, and illustrative of all the departments of the science it was my duty to study and to teach. Secondly, that a geological

[1] Igneous rocks occur at the top of Greeb Head and at Little Perhaver Beach, but they are of more acid trachytic type than the Mullion Island rock, and show large porphyritic crystals of oligoclase in a fine-grained felspathic base with little or no development of ferromagnesian minerals. Fragments of somewhat similar trachytic rocks, but containing shreds of opacite suggestive of altered soda-pyroxenes or amphiboles, were found in a crushed breccia of grit and slate on the north-east of Porthluney Cove.

museum might be built by the University, amply capable of containing its future collections; and lastly, that I might bring together a class of students who would listen to my teaching, support me by their sympathy, and help me by the labour of their hands."

We, visiting the scene of his labours more than thirty years after he wrote these words, witness the realisation of Sedgwick's hopes. The collection is not only worthy of the University, but has become one of the finest in the kingdom. It is housed in this magnificent memorial to the name of Sedgwick, on the completion of which I offer for myself, and I trust I may do so on behalf of this Section also, hearty congratulations to the Woodwardian Professor and his staff. Finally, I may remind you that at this moment the Directorship of the Geological Survey and the Presidential Chair of the Geological Society are held by Cambridge men; that the sister University has not disdained to borrow from the same source; and lastly, that it is upon Cambridge chiefly that we have learned to depend for recruiting the ranks of the Geological Survey, as proofs that Cambridge has maintained her place among the foremost of the British schools of geology.

Though he had taken a leading part at former meetings of the Association, Sedgwick's advanced age in 1862 necessitated rest, and this Section was deprived to a great extent of the charm of his presence. It benefited, however, in the fact that the Presidential Chair was occupied by one of his most distinguished pupils. Jukes was one of those men the extent of whose knowledge is not readily fathomed. It has been my experience, and probably that of many others in this room, to find that some conclusion, formed after prolonged labour and perhaps fondly imagined to be new, has been arrived at years before by one of the old geologists. Such will be the experience of the man who follows Jukes' footsteps. Turning to his Address given to this Section in 1862, we find much of what is now written about earth-movement and earth-sculpture forestalled by him, with this difference, however, that whereas the custom is growing of using a phraseology which may sometimes be useful, but is generally far from euphonious, and not always intelligible, he states his arguments in plain, forcible English.

It may raise a smile to find that Jukes thought it necessary in 1862 to combat the view that deep and narrow valleys had originated as fissures in the crust of the earth, and that the Straits of Dover must have been formed in this way, because the strata correspond on its two sides. But we shall do well to remember that the smile will be at the public opinion of that day, and not at Jukes himself. In no branch of geology have our views changed more than in the recognition of the potency of the agents of denudation. In 1862 it was necessary to present preliminary arguments and to draw inferences which in 1904 may be taken as granted.

The evidences of the prodigious movements to which strata have been subjected, and of the extent to which denudation has ensued, cannot fail to strike the most superficial observer. Both mountain and plain present in varying degree proof that sheets of sedimentary material originally horizontal are now folded and fractured. But after a momentary interest aroused by some example more striking than usual, glimpsed, it may be, from a train-window, the subject is probably dismissed with an impression that such phenomena are due to cataclysms of a past geological age and have little concern for the present inhabitants of the globe. These stupendous disturbances, it might be argued, can only have taken place under conditions different from those which prevail now. We are familiar with mountain-ranges in which their effects are conspicuous; we have carried railways over or through them and have been troubled by no cataclysmic movements of the strata. Apparently the rocks have been fixed in their plicated condition, and are liable to no further disturbance. Parts of the world, it is true, are subject to earthquakes accompanied by fissuring and slight displacement of the crust, but not even in earthquake regions can we point to an example of such thrusting and folding of the strata being actually in progress as have taken place in the past. Nor, again, can volcanic activity be appealed to, for some of the most highly disturbed regions are devoid of igneous rocks. Volcanic eruptions are more probably the effect than the cause of the disturbances of the crust. Nowhere in the world therefore, it will be said, can we see strata undergoing such violent treatment as they have experienced in the past. How, then, can we dispute the inference that the forces by which the folding was produced have ceased to operate?

Before accepting a conclusion which would amount to admitting that the globe is moribund and that the forces by which land has been differentiated from sea have ceased to act, we shall do well to look more closely into the history of the earth-movements to which any particular region has been subjected. The investigation is one which calls for the most intimate knowledge of the geological structure, and, as time will admit of my dealing with a small area only, I shall confine my observations to England and Wales, selecting such facts as have been established beyond dispute.

At the outset of the investigation we find reason to conclude that the movements, so far as any one region is concerned, have been intermittent. Evidence of this fact is furnished wherever any considerable part of the geological column is laid open to view. Sheets of sediment, aggregating perhaps thousands of feet in thickness, have been laid down in conformable sequence, all bearing evidence of having been deposited in shallow seas. The inference is inevitable that that period of sedimentation was a period of uninterrupted subsidence. But sooner or later every such period came to an end. Compression and upheaval took the place of subsidence, and the strata lately deposited were plicated and brought within the reach of denudation. Illustrations of the recurrence of these movements abound, and I need dwell no further upon them than to remark that movements of subsidence and upheaval may be seen to have alternated wherever opportunity is afforded for observation.

On extending our observations we are led to infer that the movements of the crust were developed regionally, not universally. The areas of subsidence, for example, evidenced by the marine formations had their limits, though those limits did not coincide with the shores of existing seas, nor has reason been found to believe that the proportion of land to sea has varied greatly in past times. The limits of the area affected by any one movement of upheaval are more difficult to determine, but the effects were manifested in the crumpling up of comparatively narrow belts of country, and are easy of recognition.

Further than this, we ascertain that the movements of one region were not necessarily contemporaneous with those of adjoining regions. The forces operating upon the crust of the earth came into activity in different places at different times, and, while some Continental tracts have been but little disturbed from early geological times, there are parts of the globe which have been the scene, so to speak, of almost ceaseless strife. Among the latter we may include the British Isles.

These are commonplaces of geology, and I mention them merely to emphasise the fact that the geological structure of these islands is the result of movement superimposed upon movement. Obviously, therefore, in order to gain a comprehensive view of the operations which were in progress in any one region during any one epoch, we have to find some means of distinguishing the movements of that epoch and of eliminating all which preceded or followed it. This, briefly, is the problem which has engaged the attention of geologists for many years past, and upon which I propose to touch.

The determination of the age of a disturbance is seldom easy, and among the older Palæozoic rocks is often impossible; but at the close of the Carboniferous period, during the great Continental epoch which led to and followed upon the deposition of the Coal-measures, there came into action a set of movements of elevation and compression, which generally can be distinguished both from those which preceded them and from those which have been superimposed upon them. The distinction depends upon the determination of the age of the rocks affected by the movements. For example, a movement by which the latest Carboniferous rocks have been tilted from their original horizontal position is obviously post-Carboniferous. On the other hand, if Permian rocks lie undisturbed upon those tilted Carboniferous rocks, it is equally obvious that the movement was pre-Permian. Now it happens that earth-movements of the date alluded to were particularly active in the British Isles, and played an important part in shaping the platform on which the Permian and later rocks were laid down. Though they have been more completely explored than others in the working of coal, their further investigation is of the greatest economic importance. I have attempted, therefore, briefly to sketch out the principal lines along which earth-movements of that age came into operation in England, premising, however, that by Permian I mean the Magnesian Limestone series, and not the "Permian of Salopian type," which is now known to be partly of Triassic but principally of Carboniferous age. In the course of the investigation we shall find reason to conclude that several at least of the movements followed old axes of disturbance, lines of weakness dating from an early period in the history of the habitable globe; and, again, that some of the latest disturbances of which we have cognisance were but renewals of movement along the same general lines.

One of the most clearly proved examples of pre-Permian faulting in the Carboniferous rocks occurs in the Whitehaven Coalfield. The fault forms the south-eastern limit of the Coal-measures, and has been precisely located for a distance of six miles. In its course towards the south-west it passes under five outliers of Permian rocks, and finally is lost to sight under the Permian and Trias of St. Bees. The dislocation in the Carboniferous rocks amounts to about 400 yards, but the Permian rocks have not been even cracked; though broken and displaced by numerous faults of later date, they pass undisturbed over this great dislocation, the movement along it obviously having ceased before they were deposited. This fault forms part of the upheaval which brought the older rocks of Cumberland and Westmoreland to the surface, and in that sense it may be said to form the north-western frontier of the Lake District.

On the north-eastern side also of the Lake District the Permian rocks rest upon uptilted Carboniferous strata, but the axis of upheaval runs in a north-north-westerly direction and defines what we may regard as the north-eastern frontier. Along this frontier much movement has taken place in post-Permian times, but the unconformable relations of the Permian and Carboniferous rocks enable us to distinguish that part of the tilting which intervened between the two periods. On the south-eastern frontier also the Carboniferous rocks had been upheaved and denuded before the Permian sandstones were laid down. A huge fault, along which Carboniferous rocks have been jammed from the east in a multitude of plications against Silurian, runs from Kirkby Stephen by Dent to Kirkby Lonsdale, and thence trends south-eastwards by Settle. It is highly probable, though it has not been proved, that this fault is of pre-Permian age. That the Pendle axis which upheaves the Lower Carboniferous rocks between Settle and Burnley is pre-Permian is placed beyond doubt by the fact that an outlier of Permian rests upon the denuded crest of the anticline near Clitheroe.

The south-western frontier is defined by a still more marked unconformable overlap by the Permian strata, which here pass over the edges of the lowest members of the Carboniferous series and come to rest upon the Lake District rocks.

We have thus defined the sides of an oblong tract which was upheaved in the period we are considering. The older rocks forming the northern part of that tract had already had imposed upon them a dominant north-easterly strike by a pre-Carboniferous movement of great energy. As a result also of that and other movements they had been subjected to vast denudation, not only in the Lake District, but throughout the north-west of England generally. But while it is doubtful whether any of the physical features then produced have survived, it seems to be beyond dispute that it was in consequence of the pre-Permian movements that the older rocks of the Lake District were freed from their Carboniferous covering, and that to this extent the district may be said to have been blocked out in pre-Permian times. The detailed sculpturing resulted from later movements, with which we are not now concerned.

During this same period there rose into relief that part of the Pennine axis which runs between Lancashire and Yorkshire. The doming up of the Lower Carboniferous rocks and the wildness of the moorlands which characterise their outcrops have impressed all who have had occasion to cross from the one populous coalfield to the other, and have gained the name of the 'backbone of England' for this anticlinal axis. Whether, however, it can be regarded as one axis or as the result of several movements is doubtful, but not material for our present purpose. Regarded as a geological structure it is not continuous with that part of the Pennine axis which runs along the north-eastern frontier of the Lake District.

Passing westwards from the Pennine axis, we cross the deep and broad Triassic basin of Cheshire, which may be regarded as the complement of the dome of elevation of Derbyshire. To the west of this, again, we reach a part of North Wales which was more or less shaped out by the earth-movements which came into action between the Carboniferous and Permian periods. Two leading faults traverse the district. The one runs in a north-north-westerly direction across Denbighshire and introduces that little bit of "Cheshire in Wales" known as the Vale of Clwyd. Though there has been some later movement along this fault, it was in the main pre-Triassic, which statement, in view of the perfect conformity between the Permian and Trias, amounts to saying that it was pre-Permian. The other passes across Wales in a north-easterly direction along the Dee Valley at Bala, and reaches the Triassic basin between Chester and Wrexham. The date of this fault has not been worked out in detail, but the fact that it is associated with a pre-Triassic anticline, where it reaches the Triassic margin, proves that it is in part at least of pre-Triassic age. In Anglesey also there has been strong post-Caboniferous folding in the same north-east to south-west direction.

It is to be noticed, further, that the Carboniferous rocks maintain their characters to their margins on the flanks of the Clwydian Hills and other ranges of Silurian rocks in North Wales. Both along the coast, and even in a little outlier preserved near Corwen by an accident of faulting, they show a persistence of type and of detail in sequence which could hardly have been maintained had the Silurian uplands existed in Carboniferous times. The inference that the uplands of Denbighshire and Flintshire are the result of post-Carboniferous upheaval is strengthened by the fact that the Carboniferous rocks reposing on their flanks are tilted at an angle which would carry them over their tops. This part of North Wales, therefore, presents a history corresponding in its main events with that of the Lake District. It had undergone elevation and denudation in pre-Carboniferous times on a scale so vast that rocks showing slaty cleavage and other indications of deep-seated metamorphism had been laid bare. But in both cases it was in consequence of the post-Carboniferous movements that the leading physical features as they exist to-day began to take shape.

In both these regions pre-Carboniferous movements had been extremely active. For example, an axis of compression and upheaval ranges from north-east to south-west, involving the Lake District, the Isle of Man, and Anglesey. It belongs to the Caledonian system of disturbances which is developed on a large scale further north, and which sufficed here to cause slaty cleavage and presumably the extrusion of the Shap granite. I mention this pre-Carboniferous axis to point out that it offers an explanation of the direction taken by the post-Carboniferous disturbances of Whitehaven, Pendle, Anglesey, and possibly Bala. With the exception of the last-named they lie well within the region affected, and alone among the post-Carboniferous axes take that particular direction.

The Pennine axis ends as a particular feature in South Derbyshire and North Staffordshire on the margin of a deep channel filled with Triassic marl, which extends westwards from Nottingham into Shropshire. In this part of England there springs into existence a remarkable series of disturbances tending to radiate southwards. The westernmost of these is the great fault which forms the western boundary of the North Staffordshire Coalfield. Recent work by Mr. W. Gibson has shown that the vertical displacement of the Coal-measures amounts to no less than 900 yards, but that it is far less, though recognisable, in the Trias, proving that the disturbance was in the main pre-Triassic. The fault ranges from Macclesfield in a south-south-westerly direction, is lost to view under the Trias near Market Drayton, but is recognisable further on in the great dislocation which passes along the western side of the Wrekin, and thence through Central Shropshire by Church Stretton to Presteign in Radnorshire, and thence into Brecknock.

The second is the Apedale Fault of the North Staffordshire Coalfield. In working the coal this disturbance has been found to possess the structure of a broken monocline, a fold with fracture such as may be regarded as an early stage in the formation of an overthrust from the east. It runs through the coalfield in a direction slightly east of south, and then passing under the Trias of Stafford ranges for Wolverhampton and Stourbridge. This fault is mainly pre-Triassic, but what Mr. Gibson believes to be a continuation of it, following the same direction as far south as Hanbury, certainly effects a great movement in the Trias.

The third disturbance runs on the east of the Forest of Wyre Coalfield in a direction a little west of south. Here, as I learn from Mr. T. C. Cantrill, the thrust from the east is obvious, for Old Red Sandstone has been pushed from that direction against and even over Coal-measures, while the strata have been forced up into a vertical position for some miles. In South Staffordshire all the Carboniferous rocks, including the "Salopian Permian," are involved in this and the previously mentioned movement, proving that both disturbances were of post-Carboniferous date.

Traced southwards this disturbed belt leads to Abberley, and there connects itself with the well-known Malvernian axis. The broken belt known by that name runs north and south, and may be followed almost continuously from Worcestershire to Bristol. It presents evidence of having been a line of weakness through a large part of the world's history, as shown by Professor Groom, and of having yielded repeatedly to earth-stresses; but there is seldom difficulty in distinguishing the movements which were effected during the period under consideration. For example, near and south of Abberley the Coal-measures are clearly involved in a thrust from the east, which was sufficiently energetic to turn over a great belt of Old Red Sandstone and other rocks beyond verticality for some miles. Further south, again, among repeated proofs of the ridging up of the old axis in several pre-Carboniferous periods, we find evidence of post-Carboniferous elevation along the same general line. Throughout this same region there has been also post-Triassic dislocation, which, however, is on a comparatively small scale. That the Carboniferous rocks were greatly disturbed before the Trias was laid down is proved by the great unconformity between the two formations.

The Malvernian axis continues southward by Newent, but perhaps with diminishing intensity. On its west side a broad syncline rolls in the tract of Carboniferous rocks which underlies the Forest of Dean. The syncline trends north and south, and is shown to be of pre-Triassic age by the fact that the Triassic strata on the banks of the Severn do not share in the synclinal structure. Here we must leave the Malvernian axis for the present.

The fourth disturbance ranges along the Lickey Hills, which, diminutive as they are, tell a story of great geological significance. They range in a south-south-easterly direction, and in the fact that they are formed of extremely ancient rocks furnish evidence of immense upheaval. From the relations of these ancient formations to one another we may gather also that the upheaval was due to a recurrence of movement along the same axis at more than one geological date, but at the same time we find no difficulty in distinguishing that part of the movement which took place between Carboniferous and Triassic times, for the Coal-measures are tilted up on end along the flanks of the axis, while the Trias passes horizontally over all the tilted rocks. A clue to the southward extension of the axis under the Secondary rocks is furnished by some faulting as far as Redditch, here also there having been a renewal of movement on a small scale in post-Triassic times.

The fifth disturbance runs through Warwickshire, and includes the low ridge of ancient rocks which ranges through Atherstone and Nuneaton in a south-easterly direction. About fifteen miles to the north-east Archæan rocks form the parallel ridge or series of ridges of Charnwood Forest, while the intervening space is overspread by Trias, resting partly on Carboniferous and partly on older strata. The structure of the Carboniferous and older strata is dominated by what is known as the Charnian movement, which includes disturbances of several ages ranging in a south-easterly direction. That part of the movement which was post-Carboniferous is identifiable by the fact that Coal-measures are tilted on either side of the ridges of old rocks. They once overspread both ridges, but were removed by denudation as a consequence of upheaval before the Trias was deposited. It has been found also in working the coal, as I am informed by Mr. Strangways, that there are large faults having the south-eastward or Charnian direction which shift the Coal-measures, but do not break through the overlying Trias. The evidence, therefore, of a great Charnian movement having taken place during the period under consideration is conclusive. The disturbance ranges as a whole in the direction of Northampton, where, in fact, borings have reached the Charnwood rocks at no great depth.

The five great disturbances which I have briefly indicated tend to converge northwards, but their exact connection with the Pennine axis is not known. What may be only a part of that axis trends for Charnwood through a tract of Lower Carboniferous rocks exposed at Melbourne, between the Yorkshire and Leicestershire Coalfields, but the Triassic channel I have already mentioned intervenes, and the structure of the rocks underlying the red marl is unknown. The channel itself appears to be of Triassic age, for not only is the depth of marl in it suggestive of its having been a strait in the Triassic waters, but its northern margin has been found by Mr. Gibson to coincide with, and perhaps to have been determined by, faults known to be mainly of pre-Triassic age. One of these, with a downthrow of 400 yards to the south, runs from Trentham through Longton, and south of Cheadle, while another ranges from near Nottingham to the north of Derby.

We come now to the south-west of England, where we find striking proofs of a still more energetic movement than any yet mentioned having intervened between the Carboniferous and Triassic periods. The central part of the Armorican axis, as it has been called, after the ancient name of Brittany, trends nearly east and west, and keeps to the south of our South Coast; but we have opportunities in Devon and Cornwall of seeing some of the stupendous effects produced along its northern side. A belt of country measuring some 130 miles in width has been completely buckled up. Slaty cleavage was superimposed upon the intricate folds into which the strata were being thrown, while after or towards the close of these phenomena granite was extruded at several points along the belt of disturbance, a little north, however, of the line along which the oldest rocks were brought up to the surface. In Devon the Culm-measures are fully involved in the movement, but on the other hand the Permian strata, while containing fragments of the cleaved and metamorphosed rocks, are themselves wholly free from such structures. The age of the folding, cleavage, and extrusion of the granite is thus definitely fixed as having been subsequent to the deposition of the Culm-measures, but previous to that of the Permian rocks.

But we may fix the age still more closely. A broad syncline of Carboniferous rocks traverses Mid-Devon, and is succeeded northwards by an anticline and by an extrusion of granite at Lundy Island, the age of which, however, has not yet been definitely ascertained. Still further north in a series of folds and overthrusts which traverse the southern margin of South Wales we can recognise the last effects of the great Devonshire movement at a distance of not less than 130 miles from the central axis, the ground-swell, so to speak, subsiding as it receded from the distant storm-area. Here the higher Carboniferous rocks are involved, and thus prove that this part at least of the Armorican disturbance was of post-Carboniferous age.

In Dorset, Somerset, and Gloucestershire the Palæozoic rocks pass eastwards under Secondary formations, and are seen no more in the south of England. That the disturbance continues, however, is inferred from the fact that it has been traced across a large part of the continent of Europe in the one direction and across the south of Ireland in the other. The determination of its position therefore, and especially of the effects of its intersection with the Midland disturbances, is of the greatest importance in view of the possible occurrence of concealed coalfields under the Secondary rocks. One such intersection is open to observation.

The Malvern and Devonshire disturbances intersect in Somerset. On investigating their behaviour as they approach we may notice in the first place that the subsidiary axes which form the northernmost part of the Devonshire disturbance in South Wales die away one after the other towards the east. Thus an east and west disturbance at Llanelly runs a few miles and disappears. The more important Pontypridd anticline, which traverses the centre of the coalfield, fades away near Caerphilly, while the coalfield itself terminates a little further east, its place on the same line of latitude being taken by the Usk anticline, which trends southwards and south-westwards. So far it might be inferred that the east and west folds die away on approaching the north and south Malvernian axis. But the Cardiff anticline, which lies south of and was more energetic than those mentioned, crosses the Bristol Channel and, emerging on the other side in a complicated region near Clevedon and Portishead, passes to the north of Bristol and holds its course right across the coalfield at Mangotsfield. The coalfield, however, lies in what is part of the Malvernian disturbance, for it occupies a syncline running north and south along the west side of the main axis of the upheaval. Though the interruption is local and the strata recover their north and south strike to the south of it, yet the east and west axis obviously holds its course right through the Malvernian structure.

Still further south, in the direction in which the east and west movements gradually increase in energy, a series of sharp folds is well displayed in the coast of South Wales and in an island in the Bristol Channel, ranging for that part of the east and west disturbance which is known as the Mendip axis. This name has been applied to a series of short anticlines which are arranged *en échelon* along a line ranging east-south-east, but each of which runs east and west. Among them we may distinguish the Blackdown anticline, the Priddy anticline, the Penhill anticline, north of Wells, and the Downhead anticline, north of Shepton Mallet. With one exception they all die out eastwards after a course of two to ten miles, but the Downhead anticline holds its course into the Malvernian disturbance, the two engaging in a prodigious *mêlée* south of Radstock. From that much shattered region the Downhead anticline emerges, but the Malvernian axis is seen no more, and, so far as can be judged under the blanket of Secondary rocks, comes to an end.

Mention has been made of the fact that many of the subsidiary east and west folds die away on approaching the Malvernian axis. In a general way we may attribute their disappearance to the influence of the north and south movement, for it is commonly to be observed in these great belts of disturbance that they are composed of a number of parallel anticlines or elongated domes of upheaval, constantly replacing one another; it is a common feature also that these subsidiary folds replace one another not exactly in the direction in which they point, but that they lie *en échelon* along a line slightly oblique to it. The behaviour of the South Wales and Mendip folds is in accordance with these observations, and may be taken to indicate that the effects of the east and west disturbance reached further north in South Wales than they did in Somerset, or, in other words, that they failed to penetrate as far into the region where north and south movements were in progress as in the region where there were no movements in that direction.

The fact that the east and west folds keep their course across the north and south wherever the two actually meet comes out prominently, and supports the inference that they dominate the structure of the Palæozoic rocks which lie hidden beneath the Secondary rocks of the south and south-east of England. Somewhere under this blanket of later formations the east and west axis presumably intersects the other disturbances which traverse the Midlands. To ascertain where and how the intersections takes place will be going far towards locating any concealed coalfields which may exist; but the knowledge can be obtained only by boring, and the number of such explorations as yet made is wholly insufficient. The majority have been made in search of water, and have been stopped as soon as a supply was secured. Near Northampton the older rocks were reached at a small depth on what is believed to be the underground continuation of the Charnian axis, and a boring at Bletchley traversed what is thought to have been a great boulder of Charnian rock, suggesting that the axis is not far off; but with these exceptions the counties of Oxford, Buckingham, Bedford, Huntingdon, Cambridge, and Norfolk are unknown ground. Yet under these counties the axes must run if they keep their course. Where exposed at the surface each post-Carboniferous syncline between two axes contains a coalfield. It remains to future exploration to ascertain whether similar conditions hold good under the Oolitic and Cretaceous areas of Central England.

In speaking of the north and south disturbances I have in more than one case stated that the post-Carboniferous movement was but a renewal of activity along an old line of disturbance. The fact is proved by the unconformities visible among the pre-Carboniferous rocks, and it is important for the reason that the geography of this part of the globe at the commencement of the Carboniferous period had been determined by these movements. It has long been known, for example, that the parts of the counties of Stafford, Warwick, and Leicester traversed by the axes of upheaval were not submerged till late in the Carboniferous period. On the other hand, some of the area lying immediately west of the Malvernian axis was submerged at an earlier date, as is shown by the existence of Carboniferous Limestone at Cleobury Mortimer and, in greater development, in the Forest of Dean. The borings near Northampton also proved the presence of Carboniferous Limestone, a fact which is in favour of the occurrence of concealed coalfields, in so far as it indicates that the whole Carboniferous series may have once existed there. It is remarkable that none of the borings in the south and east of England have touched Carboniferous Limestone, all having passed into older or newer rocks. The existence of that formation is neither proved nor disproved.

The determination of the age of these disturbances and a discussion of the pre-Carboniferous geography may seem at first sight to be only of scientific interest, but that problems of great economic importance are involved has been shown recently. It has long been known that the principal coal-seam of South Staffordshire deteriorates westwards as it approaches the pre-Carboniferous ridge evidenced in the neighbourhood of Wyre Forest. There seemed, however, to be no theoretical reasons why it should not keep its characters on either side of the fault which forms the western boundary of the South Staffordshire Coalfield, inasmuch as that fault came into existence after the deposition of the Coal-measures. A shaft recently sunk has proved the correctness of the inference. The seam has been found to be well developed to the west of the fault, and a considerable addition has been made to our productive coalfields.

So much has been written about the range of the Devonshire disturbance under the south of England that I shall add no more than a brief comment on some of the evidence on which reliance has been placed. We have seen that there has been some post-Triassic movement along old lines of disturbance in North Wales and the Midlands and along the Malvern axis. It is suggestive, therefore, to find that in the region which we believe to be underlain by the east and west disturbance east and west folding forms the dominant structure of the Secondary and Tertiary rocks.

The anticlines of the Vales of Pewsey and Wardour, the London syncline, the Wealden anticline, the Hampshire syncline, and the anticline of the Isles of Wight and Purbeck, not only lie in the range of the axis, but show an increasing intensity southwards, towards what we may suppose to have been the most active part of that axis. A similar structure prevails in the Oolitic rocks also. They too had been thrown into east and west folds before the Cretaceous period, and this earlier set of movements also grew in intensity towards the south. It would seem, then, at first sight that the structure of the later rocks gives an easy clue to the structure of the older rocks buried beneath them. This is by no means the case. That the movements manifested in the Oolitic and Cretaceous rocks followed the same general line as the older movement admits of little doubt, but that the later structures correspond in detail with the earlier is improbable.

A brief examination of the region where the Carboniferous rocks disappear under the Secondary formations will give the grounds for this statement. There we find that the Trias passes over the complicated flexures of the Mendip axis in undulations so gentle as to prove that those flexures had been completed before it was deposited. Nor, again, do the members of the Oolitic group of the rocks cropping out in succession further east show any such folds as those visible in the Carboniferous, and it is not till we have passed over a considerable tract of Secondary rocks in which there are no signs of east and west folding that we reach the anticlines of the Vales of Pewsey and Wardour. Nor can we then fit these folds in the Cretaceous formation on to any visible axes in the Carboniferous rocks. Under these circumstances it would be unjust to suppose that such synclines and anticlines as those of the London and Hampshire basins, or of the Weald, coincide with previously formed synclines and anticlines in the older rocks. They give a clue to the position of the old axis, but not necessarily to the details of its structure. Yet it is upon the determination of the position of the older anticlines and synclines, and of their intersection with the north and south disturbances, that we must depend for locating concealed coalfields. So far but little has been done in the forty-eight years since the question was first mooted by Godwin-Austen. The existence of a coalfield in Kent has been proved, and what appears to be a prolongation of a disturbance from the Pas de Calais along the south-western side of it. The other borings which have reached the Palæozoic floor round London and at Harwich have thrown but little light on the details of its structure. By far the greater part of the ground remains yet to be explored.

In this brief review of the earth-movements of one period, as manifested in one small part of the globe, we have found reason to conclude that they were the result of compression and upheaval; that the crust yielded to the compression by overthrusting and buckling along certain belts; that these belts in the north of England and the Midlands ran for the most part north and south, diverging, however, to the south-west and to the south-east, while in the south of England they took an east and west direction and concentrated themselves along a belt of country which presents the phenomena of crushing on a stupendous scale. We have touched in two cases the flanks of a mountain-range, the Caledonian, which was built and ruined before the Carboniferous period; the Armorican, which was built after that period, and which, though it has stirred so recently as the late Tertiary period, and so energetically as to initiate the physical features and river-system of the south of England, yet expended the greater part of its energy before the Permian period. Lastly, we have found evidence, in the majority of cases, that the disturbances were but renewals of movement along lines of weakness long before established, and that in several cases there has been further renewal along the same lines during successive periods later than the one we have considered. With such a history before us, and with the knowledge that mountain-ranges have been built in other parts of the world by the upheaval of strata of almost recent date, we have more cause to wonder that the internal forces have left this quarter of the globe alone for so long, than reason to believe that they have ceased to exist. Changes of level, however, have taken place in comparatively recent times, and are now in progress. Though almost imperceptibly slow, they serve to remind us that a giant lies sleeping under our feet who has stretched his limbs in the past, and will stretch them again in the future. Nor in view of the fact that the structures I have described have only been revealed by the denudation of vast masses of strata does it seem unreasonable to suppose that they are deep-seated phenomena. The slow changes of level may be the outward manifestation of more complicated movements being in progress at a depth.

It is interesting to speculate on what appearance the globe would have presented had it not been enveloped in an atmosphere and covered for the most part with water. Owing to those circumstances it possesses the power of healing old wounds and burying old scars. In their absence we may suppose that the belts of crushing and buckling would have given rise to ridges growing in size at every renewal of movement, for they would have been neither levelled by denudation nor smoothed over by sedimentation. This globe, we may suppose, would have appeared to the inhabitants of another planet as being encompassed in a network, and we are prompted to ask whether our astronomers can distinguish in any other planet markings that may be attributable to this cause. I must remind you, however, how much more remains to be done than I have been able to touch upon to-day. The map (exhibited) represents one episode only in a long series of events, and a series of such maps would be required to illustrate the first appearance of lines of weakness in the earth's crust, the subsequent renewals of movement along those lines, and the formation of new lines in successive geological periods. With the case thus set out we shall be justified in appealing to the physicists for an explanation of the restlessness of this globe.

II.—Short Notices.

1. South African Geology.—Dr. F. H. Hatch extends our knowledge of the geology of the Transvaal by describing in Trans. Geol. Soc. South Africa (vii, 1904) the Marico district. This is stated to be a great syncline formed by the Pretoria beds, the Dolomite and Black Reef Formations, and the underlying Ventersdorp beds. Dr. Hatch describes the interesting igneous complex to which reference has been made by Molengraaff under the name of the "Plutonic Series of the Bush Veld." In this complex the great development of pyroxenite with associated peridotites would appear to constitute an outer ultra-basic zone. For, as one travels eastwards, one traverses successively zones of a more and more acid type, until rocks are reached in which quartz plays the predominant *rôle.* A rough map attached to the paper explains this succession.

Dr. Corstorphine, in dealing with the Central South African Coalfield (Trans. Geol. Soc. South Africa, vi), considers that the coal of Vereeniging and that of the Orange River Colony, as well as that of the Eastern Transvaal and the neighbouring portion of Natal, is of Ecca Age. Molengraaff (ibid.) concludes that the remarkable tectonics of the Vredefort mountain-land have been caused by the intrusion of a huge granite boss, the Vredefort granite, which phenomenon took place after the deposition of the rocks of the Cape System (Black Reef series, Dolomite series, and Pretoria, or Gatsrand, series), and before the deposition of the strata of the Karroo System; and in the discussion which followed, Hatch said he agreed, and that Molengraaff was also probably correct with regard to the overtilting of the Witwatersrand beds.

J. P. Johnson has described (ibid.) some implement-bearing gravels in the neighbourhood of Johannesburg. These show facies of true Eoliths, Palæoliths, and Neoliths, as compared with European examples, and the author comes to the conclusion that the Bezuidenhont Valley drift must be much newer than the hill-drift of Rordekop, and that the close of the Neogene era in South Africa saw much the same evolution in the culture of its stone-age as did that of the Thames basin and the rest of Britain and Western Europe, and that such progress must have taken an approximately equal length of time.

J. Kuntz (ibid.) gives an interesting example of the pseudomorphosis of quartz pebbles into calcite. T. N. Leslie, in reviewing the fossil flora of Vereeniging, carefully points out the many errors that have occurred in recording various plants from these beds, and gives Seward's final list of plants as showing the Permo-Carboniferous age of these plants as compared with those of India and South America.

The Annual Reports for 1901 and 1902 of the Geological Commission of the Cape of Good Hope provide much matter of special interest. Messrs. Rogers and Schwarz report on a journey from Swellendam to Mount Bay, on a general survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the Cretaceous rock of Eastern Pondoland, and on a geological survey of the Kentani division. The shells and bones in the Cretaceous appear to be rolled and rounded in the lowest beds. The bones include those of Chelonia, and a lower jaw resembling that of *Mosasaurus*, while sharks' teeth also occur. Further reports by the same authors deal with the Matatiele division, with an account of the petrography of the volcanic rocks, and on the divisions of Beaufort West, Prince Albert, and Sutherland. The authors propose a slightly different classification of the Karroo System, in that they separate the Dwyka series from the Ecca.

2. Ceylon.—The Report of the Director of the Mineralogical Survey of Ceylon Administration Reports, 1903, pt. iv (Miscellaneous), has just reached us. The Mineralogical Survey was established in the latter part of 1902 for three years, the objects being an examination of the occurrence of economic minerals in the island with a view to their further development and the preparation of a report descriptive of the mineral resources, as well as the arrangement of the geological collections in the Museum and the accumulation of further specimens, a duplicate series being reserved for exhibition at the Imperial Institute. A separate guide to the geological collections is to be ultimately prepared.

The staff consists of a Director, A. K. Coomáraswámy, an assistant director, James Parsons, an office peon, two overseers, a 'collector' (*sic*), and eight coolies. The staff is sanguine enough to suggest that 1,000 square miles can be superficially surveyed in the course of a year. Perhaps we under-estimate the capacity of the peon.

The greater part of Ceylon consists of ancient crystalline rocks, granulites, or, in a wide sense, gneisses, which belong to the Charnockite series. Mica seems to be the most important economic mineral in the area reported upon, and includes muscovite, biotite, and phlogopite, of which the latter is of chief commercial importance. Graphite, the most important of all the mineral resources of the island, is chiefly distributed in areas outside the range of this report, but sketches of several mines are given. Working, however, depends on the price of the graphite, which is at present low. Iron is the only metal treated of. The precious stones mentioned are Corundum, Moonstone and Garnet, and the other mineral mentioned is Pitchblende (Uraninite), but a footnote states that the materials from Bambarbotuwa and Gampola are probably not Uraninite but a new mineral, whose detailed composition is not yet certain. Mr. Coomáraswámy does not believe in the reported discoveries of Cinnabar, he thinks Sindurankanda was 'salted,' and that there is no geological probability of there being ore of mercury at Kotte.

The arrangement of the Museum goes on slowly but surely, and the Director asks for a special grant to enable him to secure and exhibit a representative collection of gems.

3. *Euceratherium.*—This is a singular quaternary ungulate found by W. J. Sinclair and E. L. Furlong in the caves of the Shasta country, California. Its affinities are not clear. It may be placed in the Ovinæ, but cannot be regarded as intimately related to any existing North American member of that group. The cranium is larger than in the big-horn sheep, while the horn-cores are smaller, are situated much further behind the orbits, and differ greatly in form and curvature. Although there is a resemblance to *Ovibos* in dental structure, the horn-cores are of an entirely different type. A relationship with the cattle is excluded by fundamental differences in dental structure. It is separated from the goats by the presence of a lachrymal pit. This character serves to distinguish *Euceratherium* from *Haplocerus*, from which it differs also in greater size, in the shape and position of the horn-cores, and in the exclusion of the parietal from the cranial roof. The description and plates appear in Bull. Geol. Univ. California Publications, iii, 1904.

4. Geology under the Planetesimal Hypothesis of Earth-Origin.—In the Bull. Geol. Soc. Amer. (xv, 1904) H. L. Fairchild discusses the bearings on several problems in geology of the new hypothesis of earth-origin recently formulated by T. C. Chamberlin. This hypothesis will shortly be printed in full in a new text-book by T. C. Chamberlin and R. D. Salisbury. Its comparison with the nebular theory is thus given by Fairchild : "The old hypothesis assumes the existence of a mass of incandescent vapour, with or without a nucleus, which by condensation and rotation was differentiated into successive rings, the latter being eventually gathered into the planets while still retaining intense heat. From this postulate there necessarily follows the conception of a cooling earth, and hypogeic geology has been founded on the idea of crustal solidification on a molten globe. The new hypothesis holds that the disseminated planet-forming matter had lost its heat while yet existing in the loose form, as rings or wisps of the parent nebula, and that the globular planets were formed by the slow accretion or infalling of cold discrete bodies or particles ('planetesimals').

"The old hypothesis assumes an originally hot globe with shrinking on account of cooling. The new regards the globe as originally and always cold at the surface, and the interior heat as the product of gravitational condensation. The old view requires continuous cooling of the globe, while the new allows the conception of increasing internal heat. The old hypothesis makes the earth of largest size at birth and of constantly diminishing volume. The new regards the earth as beginning with a small nucleus and slowly growing by surface accretion, but with large reduction of volume by compression during and subsequent to the accretionary process. The old hypothesis involves the recognition of a primal heated atmosphere and ocean consisting of the more volatile substances of the earth's mass. The new derives the present fluid envelopes from the earth's interior by a slow process of expulsion due to pressure and heat."

Having thus distinguished the new theory from the old, Fairchild discusses on the new basis the following points: — Origin of the atmosphere and ocean; earliest sedimentary rocks; volcanic phenomena; source of the hydrocarbons; genesis of metalliferous deposits; origin of gypsum and salt; climates; glaciation; diastrophic movements; irregularities of the earth's figure; and life on the earth.

5. The Frank Landslip.—The Department of the Interior of the Dominion of Canada, in their Annual Report for 1903, has issued a report on the disastrous landslide at Frank, by Messrs. R. G. McConnell and R. W. Brock. Turtle Mountain, the eastern face of which gave way on 29th April, 1903, consists of Devonian Limestones resting on Cretaceous shales and sandstones. The Devonian beds dip to the west at an average angle of 50°. The fall occurred about 4.10 a.m., and consisted of a mass of rock half a mile square, and 400 to 500 feet thick. The mass broke across the bedding planes almost at right angles, and therefore the slide falls under Balzer's heading of 'Bergstürtz,' of which it is a typical example. The mass appears to have been shattered into fragments during its descent, and the material seems to have travelled by a succession of great leaps, or ricochets, rather than by a true slide. The bulk of the fallen mass is calculated at nearly 36,000,000 cubic yards, equal in weight to some 80,000,000 tons. The primary cause of the breaking away of the mass from Turtle Mountain is to be found in the structure and condition of the mountain itself. It was ripe for a slide. The steep slopes, the shattered and fractured nature of the rocks, particularly of the basal beds of the limestone series, overlying a thrust-fault, coupled with unusually heavy precipitation, are causes which in themselves are quite sufficient to have produced the slide, and, unaided, the loosened masses would sooner or later have fallen. The report points out the probability of further slides in the same area, and advises the inhabitants of Frank to move up the valley.

REVIEWS.

I. — On some Additional Fossils from the Vancouver Cretaceous, with a Revised List of the Species therefrom. By J. F. Whiteaves, LL.D., F.G.S., etc. Geological Survey of Canada, part v, pp. 309–416, pls. 40–51. (Ottawa, August, 1903.)

THIS is the concluding part of the first volume of illustrated reports upon the Cretaceous fossils from the Queen Charlotte and Vancouver Islands, the first part of which appeared in 1876. It deals more particularly with the fossils which have been obtained from Vancouver and the adjacent islands since 1879. The rocks containing these fossils were named the Nanaimo group by the late Dr. Dawson, and, as now understood, this group appears to be the equivalent, not only of the Chico group of California, but also of the Pierre-Fox Hills or Montana formation of Manitoba, the North-west Territories, and the Upper Missouri country; also, in a general way, of the Upper Chalk of England and the Senonian of the Continent. Dr. Kossmat correlates it more particularly with the upper part of the Senonian. The fossils of this group are very similar to those of the higher beds of the Upper Cretaceous in the Island of Saghalien, in Japan, and Southern India. On the other hand, they very distinctly differ from those in the somewhat older Cretaceous rocks of the Queen Charlotte Islands, and only a few species are common to both formations.

With the exception of a single species of *Unio* and a few doubtful gasteropods, the Nanaimo fauna is exclusively marine. The following are the more salient features of the fauna as enumerated by the author:

Fishes.—These are very few, and only comprise vertebræ of teleosts, the centrum of a vertebra of a Selachian which, in an earlier part, had been described as a new species of *Discina,* and teeth of *Lamna appendiculata.* The fish remains had been submitted to Dr. A. Smith Woodward, F.R.S.

Crustacea.—The Decapoda are fairly numerous, and nine species have lately been described by Dr. Henry Woodward, F.R.S. They belong to the following genera: *Plagiolophus, Palæocorystes, Callianassa, Hoploparia, Enoploclytia, Eryma, Meyeria?, Glyphæa,* and *Linuparus.*

Ammonitidæ.—The genus *Pachydiscus* is largely developed, and no fewer than eight species are enumerated or described. They have been studied by Dr. F. Kossmat of Vienna, and directly compared with allied species from Southern India and Europe. No species of *Pachydiscus* has yet been discovered in the Cretaceous of the Queen Charlotte Islands. *Baculites* likewise does not occur in these Islands, though one species is very common in the Nanaimo group.

Gasteropoda.—A small smooth species of *Cypræa* is present; there are also three large species probably belonging to *Mesostoma,* Deshayes; a *Solariella* hardly distinguishable from *S. radiatula,* Forbes, from the Cretaceous rocks of Saghalien and Southern India; and a large limpet-like shell, which is probably only a variety of *Helcion giganteus,* from the Cretaceous of Saghalien.

Pelecypoda.—A considerable reduction has been made in the number of species of *Inoceramus,* as both the *I. undulatoplicatus,* Roemer, and *I. mytilopsis,* Conrad, are now considered to be synonyms of *I. digitatus,* Sowerby, which occurs in the Cretaceous of Texas, Nebraska, and Saghalien. Also a species of *Unio* has been found, apparently distinct from *U. Hubbardi,* Gabb, from the Queen Charlotte Island Cretaceous.

The new forms are illustrated in the accompanying plates, and a list of the fossils of the Nanaimo group is appended; there is also an index to the generic and specific names occuring in the volume.

II.—"Ueber die Morphologie und Morphogenie der Rugosa." On the Morphology and the Morphogeny of the Rugosa. By N. Jakowlew. From the "Verhandlungen der Russisch-Kaiserlichen [Mineralogischen Gesellschaft," Bd. xli, Lief 2. St. Petersburg, 1904.]

IN a paper under the above title N. Jakowlew deals with the structural peculiarities of the Rugose Corals, seeking to explain these peculiarities in the light of possible relationships between the Rugosa and the Hexacorals.

The most remarkable characteristic of the Rugosa compared with the Hexacorals is their bilateral symmetry, of which the chief expressions are the bent corallum, the presence of a main septum ('hauptseptum'), and of a fossula ('septalgrube').

As many as four fossulæ have been claimed as occurring in some forms of Rugosa, but it is shown that the depressions at the alar septa ('seitensepten') are not to be distinguished by any morphological difference from other interseptal loculi, so that no fossula occurs except in the plane of symmetry of the coral. Nor can any instance be found of two fossulæ occurring in the plane of symmetry. And when one occurs, the septum situated in it has always been found to be the main septum. Therefore the presence of a fossula always indicates the presence of the main septum.

Some would define the main septum as that primary septum which occurs on the convex side of the coral. Nicholson is quoted as an author who does so. It is shown, however, that the peculiarities which distinguish the main septum are the behaviour of the other septa towards it, as shown by their outcrops on the surface of the corallum after the epitheca has been removed. From this aspect the outcrops of the secondaries are seen to be pinnately arranged with regard to that of the main septum, and parallel to that of the counter septum ('gegenseptum'); also those between the alar septum and the main septum (i.e. those in the main quadrants) are parallel to the former, while those between the former and the counter septum (i.e. those in the counter quadrants) meet the alar septum at an angle. Again, the outcrops of the secondary septa in the main quadrants meet the plane of the mouth opening (or, what is the same thing, the lines of growth) at an oblique angle, while those in the counter quadrants meet the lines of growth at right angles.

Thus defined, the main septum is found to occur, often in the same genus, now on the concave and now on the convex side of the corallum. That is to say, the two chief expressions of bilateral symmetry in the Rugosa (the presence of the fossula having been shown to be bound up with that of the main septum), namely the bending of the coral—what might be called 'external bilateral symmetry'—and the presence of the main septum—what might be called 'internal bilateral symmetry'—occur independently of each other. The question naturally arises, which appeared first? Whether the bending caused the bilateral symmetry, or whether "the bending . . . . arises from a tendency in the coral towards bilateral symmetry."

If the bilateral symmetry is the result of the bending, we must imagine a young form, having a hereditary tendency towards radial symmetry, varying from its ancestral type by growing in a curved manner instead of straight. This curved growth became fixed in its descendants, the curved form having been selected owing to some advantage it gained over its straight fellows, possibly by presenting a mouth more or less perpendicular to a horizontal current bearing the food supply. The curvature of the corallum, caused perhaps by unequal growth, perhaps by the falling over of the coral as its bulk increased, or by some unknown agent, induced bilateral symmetry in the soft parts by causing them to gravitate towards the lower side of the mouth opening. The skeleton thenceforward secreted was, therefore, bilaterally symmetrical, because it could only take the shape of the soft parts by which it was formed. This is in the main H. M. Bernard's view, who says that the formation of the fossula would be a natural outcome of this gravitation of the soft parts.

On the other hand, Duerden has suggested that the bilateral symmetry arose from the abortion of two of the six original primary septa. The ancestors of the Rugosa (yet to be discovered!) were radially symmetrical Hexacorals. Variations in these, whereby two primary septa failed to grow above a certain size, were seized upon by natural selection, for the possession of some unknown advantage, and became fixed. The two defective septa were those primaries adjacent to the counter septum. Moreover, in the loculi between these and the counter septum no secondaries appeared. By subsequent growth the secondary septa grew as large as the two defective primary septa, and so the appearance of four primary septa arose.

Of course the abortion of two septa may have been caused by the bending of the corallum, in which case the two hypotheses would only differ in that in the former a radially symmetrical Tetracoral was the original ancestor, while in the latter a radially symmetrical Hexacoral. And the settlement of this point might have some bearing on the question whether the Hexacorals are the descendants of the Rugosa, or whether both had a common ancestor, and, if the latter, whether this ancestor was a Hexacoral or a Tetracoral.

Whatever view of the origin of the bilateral symmetry is taken, the fact remains that the position of the main septum with regard to the bending of the coral has no connection with the origin of that bending. It is only suggested in explanation that the comparative rarity of corals having the main septum on the concave side may be due to the fact that in these the lower part of the mouth opening might be brought too near the sea-bottom to be clear of the injurious sediment rapidly accumulating thereon. And, further, uncertainty is expressed as to the value of the position of the main septum as a systematic character; whether to regard it as of specific or of varietal importance.

A new explanation of the origin of the fossula is suggested. There would be a natural tendency for the soft parts to sink in the spaces between the main septum and the adjacent septa, where the new septa are inserted when, by the growth of the coral, the space became larger than the other interseptal loculi, just before the insertion of a new septum.

Such, we think, are the chief facts brought forward and the chief questions touched upon in this paper, which, while containing new and interesting observations, and raising important questions, does not do much towards solving these questions, and is lacking in arrangement; so much so that it is exceedingly hard to follow any thread of argument running through the whole; and beyond giving a clear definition of the main septum, and showing that it occurs indifferently on the convex and concave side of the corallum, the paper does little but put forward suggestions bearing on the origin of the peculiarities of the Rugosa. W. D. L.

III.—The Geology of the Oolitic and Cretaceous Rocks south of Scarborough. By C. Fox-Strangways, F.G.S. Ed. ii. Memoirs of the Geological Survey England and Wales. pp. i–iv, 1–119. With 11 plates and numerous woodcuts. (London, 1904. Price 4*s.* 6*d.*)

THIS memoir is designed to illustrate and explain sheets 54 and 55 (New Series) of the Geological Survey. It contains a great amount of most useful and interesting information, not only concerning the Secondary Rocks, from the Lower Oolites to the Upper Cretaceous, of the district covered by these sheets, but also deals with various superficial deposits. Further, there are certain remarks concerning the physical and geographical features, but these are somewhat disappointing reading: the author gives the impression that he lacks a firm grip of the principles of these subjects, which have been so ably handled in various modern text-books.

The chief value of the memoir lies in its geological and palæontological information. Looking at it from the foreigner's point of view, we may regret that the author does not indicate his zones more fully throughout his various sections, so that the stranger may see at a glance with what rocks at home he may compare these Yorkshire strata. But a great help to such a stranger are the excellent plates reproduced from photographs, showing characteristic sections. Only here one must be allowed a regret —that the tracing-paper plans covering the plates were not more carefully lettered. A fine feature is spoiled by a small detail; for these plans are not always legible. They lack care in their preparation.

In the matter of illustration the palæontological portion of this memoir has not been liberally treated. The indifferent woodcuts are not creditable to the author's work, for in many cases they fail to give recognizable pictures; and, what is more serious, they are not illustrations made from local fossils. They are just stock woodcuts, and it is plain that they have had a past. They should not be allowed a future.

The palæontological nomenclature claims to be brought up to date. In the phytological portion this it must be admitted has been done—Seward's Catalogue has very properly been followed; but in the zoological part it can hardly be granted. We might suggest that, as authors of such memoirs cannot possibly be specialists in all branches of nomenclature, they would be well advised to follow the latest text-book. They might reasonably plead "Theirs not to reason why," and simply trust the specialists who had contributed to the text-book: on these specialists would fall praise or blame as the case might be. Such a text-book we have now in the Eastman translation of Zittel; but, tested by that, the nomenclature in this memoir is certainly not up to date. For instance, generic names which have been discarded from the text-book on account of prior use, meet us throughout the pages of this memoir, while names which have been in use for many years, and are to be found even in the old Zittel of twenty years ago, are lacking. Only the Ammonite names seem to be up to the modern standard, tested by Eastman, but there is one failure here, viz., the figure given as *Ammonites humphriesianus*, on p. 13, is not that species, for it was separated by Oppel some fifty years ago, and taken by him as the type of his *A. bayleanus.* We are credibly informed, and Oppel himself says the same, that the species does not occupy the same zone as *A. humphriesianus.* It is, therefore, very doubtful if this figure represents a fossil which occurs in Yorkshire at all. It clearly proves the necessity of illustrating each memoir with special figures taken from actual local fossils.

When the reader has been safeguarded in reference to such matters as these to which we call attention, then he will find the memoir an extremely interesting and useful guide to a very important district.

A. B. L.

IV.—Palæozoic Arachnida. By Professor Dr. Anton Fritsch. 4to, with pp. 88, 15 plates, and 99 figures in the text. (Prag, Selbstuverlag, Fr. Rivnác, & Buchdruckerei Dr. Ed. Grégr a Syn, 1904. See also Sitzungsber. k. Akad. Wiss. Wien., cxii.)

This work forms one of a series of Memoirs to the preparation of which Dr. Fritsch has devoted so many years of his long and laborious life in illustration of the fauna of the Coal-formation of Bohemia.

In the present monograph, which is published under the auspices of the Imperial Academy of Vienna, the author has extended the field of his researches, and examines and describes and figures the fossil Arachnida in the Museums of London, Paris, Dresden, Breslau, and Vienna, visited by him in 1903, in order to embrace the whole of the known forms of palæozoic Arachnida from all countries.

The 15 quarto plates and the greater number of the 99 illustrations in the text are drawn by the author's own hand.

Thirty-nine[1] genera and 67 species of Arachnida are here recorded

[1] One genus and species, *Adelocaris peruvianus*, should be cancelled: see p. 473, No. 28.—H. W.

and more or less fully described by the author. Of these, 37 Carboniferous and Permo-Carboniferous species are from Bohemia, 6 Carboniferous are from Silesia, 1 in the Dresden Museum, 1 from the Coal-measures of Bavaria, 2 from France, 1 from Belgium, 1 from Scotland, 5 from England, 1 from South Wales, 1 from Arkansas, and 7 from Illinois, U. S., North America (and 1 very doubtful from Peru); these are Coal-measure forms; whilst of air-breathing Silurian scorpions Gotland has yielded 1, Scotland 2, and North America 1.

The following list may serve to give an idea of the fossil genera and species known at the present time:—

Order ARANEA.

Suborder ARTHARACHNÆ, Haase.

Family ARTHROLYCOSIDÆ (Harger), Fr.

LOWER COAL-MEASURES (STEINKOHLEN FORMATION).

1.—Genus ARTHROLYCOSA, Harger.
- *antiqua*, Harger: Coal-m., Illinois.
- *carbonaria*, Kusta, sp.: ,, Rakonitz, Bohemia.
- *fortis*, Fritsch: ,, ,, ,,
- *Lorenzi*, Kusta, sp.: ,, ,, ,,
- *palaranea*, Fritsch: ,, Radnitz, ,,
- *Beecheri*, Fritsch: ,, Rakonitz, ,,

2.—PROTOLYCOSA, Fritsch.
- *anthracophyla*, Röm.: Coal-m., Silesia.

3.—GERALYCOSA, Kusta.
- *Fritschii*, Kusta: Coal-m., Rakonitz, Bohemia.

4.—RAKOVNICIA, Kusta.
- *antiqua*, Kusta: Coal-m., Rakonitz, Bohemia.

5.—EOTARBIS, Kusta.
- *litoralis*, Kusta: Coal-m., Rakonitz, Bohemia.

Suborder PLEURARANEÆ, Fr.

PERMO-CARBONIFEROUS SERIES.

Family HEMIPHRYNIDÆ, Fr.

6.—HEMIPHRYNUS, Fritsch.
- *longipes*, Fr.: Gas-coal, Nyran, Bohemia.
- *Hofmanni*, Fr.: ,, ,, ,,

Family PROMYGALIDÆ, Fr.

7.—PROMYGALE, Fritsch.
- *bohemica*, Fr.: Gas-coal, Nyran, Bohemia.
- *rotundata*, Fr.: ,, ,, ,,
- *elegans*, Fr.: ,, ,, ,,

8.—PERNERIA, Fritsch.
- *salticoides*, Fr.: ,, ,, ,,

9.—EOPHOLCUS, Fritsch.
- *pedatus*, Fr.: Coal-m., Nyran, Bohemia.

10.—PLEUROLYCOSA, Fritsch.
- *prolifera*, Fr.: Gas-coal, Bohemia.

11.—BRACHYLCOSA, Fritsch.
- *carcinoides*, Fr.: Gas-coal, Bohemia.

12.—PYRITARANEA, Fritsch.
- *tubifera*, Fr.: Gas-coal, Nyran, Bohemia.

Order OPILIONES, Sund.

COAL-MEASURES.

Suborder OPILIONIDÆ, Veri.

13.—NEMASTOMOIDES, Thevenin.
- *elaveris*, Thev.: Coal-m., Commentry, France.

14.—DINOPILIO, Fritsch.
- *gigas*, Fr.: Coal-m., Rakonitz, Bohemia.

COAL-MEASURES.

Suborder MERIDOGASTRA, Thorel.

Family POLIOCHERIDÆ, Scudder.

15.—POLIOCHERA, Scudder.
punctulata, Scudder: Coal-m., Illinois, U.S.A.

Family ARCHITARBIDÆ, Karsch.

16.—GERAPHRYNUS, Scudder.
carbonarius, Scudder: Coal-m., Illinois, U.S.A.
elongatus, Scudder, sp.: Coal-m., Illinois, U.S.A.
17.—ARCHITARBUS, Scudder.
rotundatus, Scudder: Coal-m., Illinois, U.S.A.
subovalis, H. Woodward: Coal-m., Lancashire.

Family, ANTHRACOMARTIDÆ.

18.—ANTHRACOMARTUS, Karsch.
Krejcii, Kusta: Coal-m., Rakonitz, Bohemia.
minor, Kusta, ,, ,, ,,
affinis, Kusta, ,, ,, ,,
socius, Kusta, ,, ,, ,,
volkelianus, Karsch: Coal-m., Silesia.
granulatus, Fr.: Coal-m. (in Dresden Museum).
trilobitus, Scudder: Coal-m., Arkansas.
palatinus, v. Ammon: Coal-m., Palatinate, Bavaria.
19.—BRACHYPYGE, H. Woodward.
celtica, Pocock: Coal-m., Cardiff, South Wales.
carbonis, H. Woodw.: Coal-m., Mons., Belgium.
20.—ANTHRACOSIRO, Pocock.
Woodwardi, Pocock: Coal-m., Coseley, Dudley.
Fritschi, Pocock: ,, ,, ,,
21.—EOTROGULUS, Thevenin.
Fayoli, Thev.: Coal-m., Commentry, France.
22.—VRATISLAVIA, Fritsch.
silesiaca, F. Roemer: Coal-m., Silesia.

Family EOPHRYNIDÆ, Karsch.

23.—EOPHRYNUS, H. Woodward.
prestwicii, Buckland, sp.: Coal-m., Coalbrook Dale, Shropshire.
(*Stenotrogulus*) *Salmii*, Stur.: Coal-m., Silesia.
24.—CYCLOTROGULUS, Fritsch.
Sturii, Haase, sp.: Coal-m., Mahrisch Ostrau, Silesia.
25.—KREISCHERIA, Geinitz.
Wiedei, Gein.: Coal-m., Zwickan, Bohemia.
26.—HEMIKREISCHERIA, Fritsch.
Thevenini, Fr.: Coal-m., Westphalia.
27.—PETROVICIA, Fritsch.
proditoria, Fr.: Coal-m., Petrovic, Rakonitz, Bohemia.
28.—ADELOCARIS *peruvianus*, Packard [said not to be an Arachnide, but a Macruran-Crustacean]: loc. incog. (Jurassic?), Peru.

Order PEDIPALPI, Latr.

Tribe UROPYGI, Thor.

Family THELYPHONIDÆ, Auctorum.

29.—PROTHELYPHONUS, Fr.
bohemicus, Kusta, sp.: Coal-m., Rakonitz, Bohemia.
[GERALINURA (syn. of *Prothelyphonus*?)]
Scudderi, Kusta: Coal-m., Rakonitz, Bohemia.
noctua, Kusta: ,, ,, ,,
crassa, Kusta: ,, ,, ,,
(*Prothelyphonus*) *Cordai*, Fr.: Coal-m., Radnitz, ,,

Order SCORPIONES.

Suborder Apoxypodes, Th. & L.

Family PALÆOPHONIDÆ, Th. & L.

SILURIAN.

30.—Palæophonus, Th. & L.
nuncius, Th. & L.: Upper Silurian, Gotland.
Hunteri, Pocock: Upper Silurian, Lesmahagow.
loudonensis, Laurie: Upper Silurian, Pentland Hills.
(Proscorpius) *Osborni*, Whitfield: Upp. Silur., N. America.

Family ANTHRACOSCORPII, Th. & L.

CARBONIFEROUS FORMATION.

31.—Cyclopthalmus, Corda.
senior, Corda: Coal-m., Bohemia.
32.—Microlabis, Corda.
Sternbergii, Corda: Coal-m., Bohemia.
33.—Isobuthus.
kralupensis, Th. & L., sp.: Coal-m., Kralup, Bohemia.
34.—Eobuthus, Fr.
Rakovnicensis, Fr.: Coal-m., Rakonitz, Bohemia.
35.—Anthrascorpio, Kusta.
juvenis, Kusta: Coal-m., Rakonitz, Bohemia.
36.—Eoscorpius, Meek & Worthen.
carbonarius, M. & W.: Coal-m., Mazon Creek, Illinois, [U.S.A.
anglicus, H. Woodw.: Coal-m., near Dudley.
37.—Mazonia, Meek & Worthen.
Woodiana, M. & W.: Coal-m., Mazon Creek, Illinois, [U.S.A.
38.—Glyptoscorpius, Peach.
caledonicus, Peach, sp.: Carb. R., Eskdale, Scotland.

PERMO-CARB.

39.—Feistmantelia, Fritsch.
ornata, Fr.: Permo-Carboniferous, Lebach, Bohemia.
(Isobuthus?) *Nyranensis*, Fr.: Permo-Carboniferous, Nyran, Bohemia.

There is not the least reason to assume that the Arachnida were better represented in the Carboniferous and the Permo-Carboniferous of Bohemia than in any other Coal-areas of Europe and America; it merely shows that more careful attention has been directed towards the collecting of the fossil fauna of these beds there than elsewhere, and that Dr. Fritsch has been more energetic in describing them than the palæontologists of some other Coal-regions. Much splendid work has, however, been done with the Insect fauna of North America by S. H. Scudder and by the late lamented Charles Brongniart in that of Commentry, France, as well as by the workers in other countries, and we may look forward with confidence to great accessions to our knowledge in this field of research as soon as the splendid material obtainable becomes better known.

Of the Bohemian specimens of special interest may be recorded the remains of *Arthrolycosa carbonaria*, Kusta, from Rakonitz, a genus also met with and described by Harger from the Coal-measures of Illinois, U.S.A., of which good material for four other species have likewise been obtained in Bohemia. It is extremely interesting to record the discovery of a specimen of this genus, *A. palaranea*, Fr., still attached to a leaf of *Cordaites* as in life.

Protolycosa anthracophyla, described by F. Roemer in 1866 from the Coal-measures of Silesia, is also reproduced with care.

Another spider, *Geralycosa*, from Rakonitz, admits of being ably restored by the author, in whose honour it is named by Professor Kusta.

The genus *Hemiphrynus* is also well preserved in a fossil state, showing many details of its anatomy.

Promygale with 3 species has much of its structure preserved both on the upper and under side, especially in *P. elegans* from Nyran, which is honoured with a plate, 2 text-figures, and a vignette on the cover; *Eophlocus*, a long-legged spider from Nyran, shows the reproductive organs and limbs and the general form well preserved.

Anthracomartus is another well preserved type represented by 8 species; 4 from Bohemia, 3 from Germany, and 1 from Arkansas, U.S.A. This round-bodied and very distinctly segmented type is closely allied to *Brachypyge* and *Eophrynus*; in most of these forms the dorsal surface of the body-segments is ornamented by a pattern of minute raised granules. *Anthracosiro* appears not to have possessed this ornamentation on the dorsal surface.

Among the Pseudoscorpions *Prothelyphonus bohemicus*, Kusta, is a remarkably well preserved species, giving nearly every detail of its structure and its attenuated series of abdominal segments.

Good figures are also given of the Carboniferous and Silurian scorpions of Bohemia, England, Scotland, Sweden, and America, of which much has already been written in this country by Woodward, Peach, Pocock, and others.

But space does not admit of our dwelling more fully on this interesting group of terrestrial air-breathing *trachæated* palæozoic Arthropods, the direct descendants of the still more remote aquatic *branchiated* MEROSTOMATA, *Pterygotus*, *Slimonia*, *Stylonurus*, and their allies.

We congratulate Dr. Fritsch upon this interesting monograph, and wish him health and strength to pursue his studies on the fossil fauna of his beloved country of Bohemia which he has done so much to illustrate.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 22nd, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Igneous Rocks of Pontesford Hill (Shropshire)." By Professor William S. Boulton, B.Sc., Assoc. R.C.S., F.G.S.

This paper is confined to a description of the characters and sequence of the rocks within the limits of Pontesford Hill, and no attempt is made to correlate them with those of the Uriconian areas. The hill is a 'plagioclinal ridge,' bounded on all sides by faults; it is made up entirely of igneous rocks, but some of the fine tuffs and volcanic grits show unmistakable signs of deposition in water. There are two distinct groups of igneous rocks: a bedded group, consisting of rhyolites and acid tuffs, with andesites and andesitic tuffs; and an intrusive group of olivine-dolerites. The general strike of the bedded rocks is north-north-easterly and south-south-westerly, parallel to that of the neighbouring Longmyndian rocks; the average dip is about 80° east-south-eastward, but at the extreme south-east of the hill the rhyolite and associated breccias dip in the opposite direction (west-north-westward) at about the same angle. The northern end of the hill consists of rhyolite (the 'northern rhyolite'), about 1,000 feet thick, a pale pink and purple rhyolite with much epidote, chlorite, and secondary quartz, showing vesicular, spherulitic, pyromeridal, and banded structures. Macroscopic and microscopic descriptions of the rocks are given, and the origin of the spherulitic and nodular structures is fully discussed. In many cases, though certainly not in all, the nodules appear to have begun as a vesicle, often irregular in shape, and sometimes with crescentiform spaces round the main cavity, and separated from it by similarly-shaped portions of the glass. The spherulitic fibres appear to develop, not from a central point outward, but locally from vesicles or other cavities, crystals, etc., coalescing finally to form larger and longer growths. The spherulitic type of devitrification is not all of the same age, for fibrous growths traverse small and earlier-formed spherulites, which have been dissolved out and replaced by quartz. The andesitic group is made up of felsitic-looking, gritty pink and green tuffs, passing up into and interbedded with andesitic glassy (palagonitic) and crystal tuffs, hälleflintas, and lavas; the thickness is about 1,600 feet. A thickness of about 150 feet of rhyolite-breccias (glassy and crystal tuffs) and grits succeeds; and this is followed by the south-eastern rhyolite, about 250 feet thick, a dark red or purple, coarsely vesicular, well-banded rock, often with light-green and white amygdules. The andesites consist of oligoclase and malacolite, embedded in a hyalopilitic groundmass containing palagonite, in which ilmenite, leucoxene, and magnetite are embedded. A table of the silica-percentages and specific gravities of the bedded rocks shows that a gap occurs between the 'northern rhyolite' and the more acid of the andesite-tuffs that immediately follow; this, together with a discordance in strike, may indicate a break in volcanic history, a disturbed junction, or that this rhyolite is intrusive. From this point onward, the tuffs and lavas form a continuous series, despite the difference in the average silica-percentage of the andesite group and the rhyolite-breccias. The tuffs thin out to the north-eastward, their lapilli diminish in size, and they become more gritty and washed in aspect in the same direction; facts which all point to the inference that the volcanic vent may have been to the west of the hill. The intrusive rocks are basic, and often amygdaloidal; they are granular or ophitic, and compare in composition with such olivine-dolerites as those of Rowley, the Clee Hills, and Little Wenlock, while they differ considerably from the intrusive dolerites of North Wales.

2. "The Tertiary Fossils of Somaliland, as represented in the British Museum (Natural History)." By Richard Bullen Newton, Esq., F.G.S.

Since the publication, in 1900, of Prof. Gregory's paper, founded on specimens in the Natural History Museum, mostly collected and presented by Mrs. Lort Phillips, the National Collection has been enriched by further series of fossils: the Donaldson-Smith Collection and one presented by Major R. G. Edwards Leckie. The new material is, generally speaking, better preserved than that previously dealt with. The large Lucinidæ and specimens of *Campanile* (previously considered as *Nerinæa*) are very typical of Eocene rocks generally, and they agree with the foraminifera in the Somaliland Limestones in supporting the reference of these rocks to this period. The matrices of these limestones correspond with those surrounding the corals described by Professor Gregory as belonging to the Uradu and Dobar Limestones. Two limestones seem to be represented in the collections—an upper, massive and cherty, often coloured reddish-brown externally; and a lower, of less cherty character and lighter colour. The limestones appear to be capable of correlation with those of the south-eastern corner of Arabia, as well as with those of Sind and Cutch; they can also be traced in connection with the Eocene areas of Egypt and other regions of North Africa, through Europe to the Paris Basin, and so to the Bracklesham Beds of England. The new collections contain some older fossils, but they are not considered in the present paper.

A review of the literature of the subject is given, and the author then proceeds to the description of species of gasteropods, lamellibranchs, echinoids, and corals. Six new species are described and named, and sixteen species or varieties described but not named. An account of the foraminiferal structures of the limestones follows, and the paper closes with a list of the known Tertiary fossils from Somaliland.

3. "The Caernarvon Earthquake of June 19th, 1903, and its Accessory Shocks." By Charles Davison, Sc.D., F.G.S.

The Caernarvon earthquake of June 19th, 1903, was the strongest earthquake indigenous to the county for more than five centuries. Its disturbed area contained about 25,000 square miles, and included nearly the whole of Wales, the North-West of England, the Isle of Man, and several of the eastern counties of Ireland. The centre of the innermost isoseismal (intensity 7) was situated beneath the sea, about 4 miles west of Pen-y-groes, and the longer axis of the isoseismal ran from N. 40° E. to S. 40° W. It is concluded, from the seismic evidence, that the earthquake was caused by a slip of about 16 miles in length along a fault running in the above direction, hading north-westward, and passing either through Clynnog or a mile or two either to the north-west or south-east. In the former case the fault-line might be submarine; and it is pointed out that, if the fault which runs in a south-westerly direction from Aber to Dinlle (on the coast of Caernarvon Bay) were continued underneath the sea to the neighbourhood of Nevin, it would occupy the position assigned to the parent fault by the discussion of the earthquake phenomena.

The principal shock was preceded by an earth-sound, and followed by at least five shocks, originating apparently at the north-western extremity of the principal focus. In addition, six slight shocks and two earth-sounds were recorded by single observers; and, if these be included in the earthquake series, it follows that seismic action was gradually withdrawn from the extremities of the focus and ultimately confined to its central region.

CORRESPONDENCE.

THE KEUPER BASEMENT BEDS.

Sir,—My recent paper in the Geol. Mag. (April, 1904) on the Keuper of Devon recalls the difficulty of tracing horizons in those beds, which I have found in common with other workers in the field in former years. An illustration of this came before me when the British Association met at Bath in 1888. An excursion into the country some miles from Bath had been planned, and was carried out under the conduct of a well-known local 'geologist.' The sections that came under our observation included those of a rather deep cutting on a railway, which, as I understood, had not been long constructed. These sections were very fresh and of quite a mural character, the bare rock being exposed almost everywhere. Yet a strange error of observation was made by almost all the company present; all, I believe, except Professor Boyd Dawkins and myself. The attention of some forty or fifty people—not all amateurs, by any means—was called by the director to some irregularities of bedding in the massive Keuper sandstones, as indicating the line of unconformity between them and the Old Red Sandstone, by that overlap, which we know to be of frequent occurrence. It was nothing of the sort; for after most of the company had been hurried on, on account of the trains, Professor Boyd Dawkins and I made a careful observation of the true line of unconformity near the level of the railway-line. There the Keuper sandstones were seen lying horizontally upon the planed-off, upturned edges of Old Red sandstones and shales, furnishing as typical a case of normal unconformity as one could wish to see. A. Irving.

MISCELLANEOUS.

Museum of Practical Geology.—We are glad to hear that the Museum of Practical Geology will not be closed in future during cleaning. So many people from the country are up in town this time of year that we are surprised that such a sensible concession has been so long delayed. The Museum in future will be open all the year round.

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HORACE B. WOODWARD, F.R.S., &c.

OCTOBER, 1904.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. X.—OCTOBER, 1904.

ORIGINAL ARTICLES.

I.—The Genus *Desorella*.

By Henry Woods, M.A., F.G.S.

(PLATE XVI.)

THE genus *Desorella*[1] was founded by Cotteau in 1855 to include four species from the Corallian named *D. icaunensis*, *D. Orbignyana*, *D. elata*, and *D. Drogiaca*, and one from the Neocomian—*D. incisa*. The first and the last of these five species were subsequently shown to belong to the genus *Pyrina*, the second was placed by Etallon[2] in a new genus, *Pseudodesorella*, whilst the fourth has been referred to *Hyboclypeus*. So that of the five species originally regarded as belonging to *Desorella*, one only, *D. elata*, is left in that genus. Another species, described in 1862 as *Desorella Guerangeri*,[3] was afterwards shown to be a *Pyrina*. Cotteau[4] accepted these modifications, and, in 1873, gave an emended diagnosis of the genus, naming as the type *Desorella elata*, and describing another species, *D. Grasi*. M. Jules Lambert is of the opinion that *Pachyclypeus semiglobus* (Goldfuss[5]) should be placed in the genus *Desorella*.

All the specimens of *Desorella elata* and *D. Grasi* which have yet been described are in the form of internal moulds, consequently the characters of the genus have been hitherto only imperfectly known, so that there was some justification for Duncan's remark, "This is now a very unsatisfactory genus."[6] The description of *Desorella* given below is based on a specimen with the test preserved which was found in the Corallian of Upware. An examination of this specimen supports the view that *Desorella* is closely allied to *Pyrina*, from which it is readily distinguished by its depressed and suborbicular form. Duncan[6] placed *Desorella* in the Nucleolitidæ,

[1] Originally *Desoria*.
[2] E'tudes paléont. Terr. Jurass. du Haut-Jura, pt. ii (1859), p. 16.
[3] Cotteau: Rev. et Mag. de Zool., ser. ii, vol. xiv (1862), p. 193.
[4] Paléont. Franç. Terr. Jur., vol. ix, pp. 333, 384.
[5] Desor: Synopsis E'chin. Foss. (1857), p. 195, pl. xxxvii, figs. 3, 4. Cotteau: Paléont. Franç. Terr. Jur., vol. ix (1873), p. 390, pl. ci. Desor & De Loriol: E'chinol. Helvét. Jurass. (1871), pp. 300, 405, pl. xlvi, fig. 6.
[6] "Revision of the Echinoidea": Journ. Linn. Soc. Zool., vol. xxiii (1889), p. 179.

but as of uncertain position. The simple ambulacra and elongate apical disc clearly separate it from that family. There can, I think, be no doubt that it should be referred to the Echinoneidæ, as was done by Desor, De Loriol, and Cotteau. *Desorella* is also related to *Hyboclypeus*, but is distinguished from it by the absence of a dorsal sulcus.

DESORELLA ELATA (Desor). (Plate XVI.)

SYNONYMY.

1847. *Hyboclypus elatus*, Desor: in Agassiz & Desor, "Catal. raisonné des E'chinides," Ann. Sci. nat., ser. III, vol. vii, p. 152.
1855. *Desoria elata*, Cotteau: E'chin. Foss. de l'Yonne, vol. i, p. 228, pl. xxxiv, figs. 1–3 (*Desorella* on p. 344).
1855. *Desorella elata*, Cotteau: Bull. Soc. géol. France, ser. II, vol. xii, p. 713.
1857. *Desorella elata*, Desor: Synopsis E'chin. Foss., p. 194.
1873. *Desorella elata*, Cotteau: Pal. Franç. Terr. Jur., vol. ix, p. 386, pls. xcviii, xcix, figs. 1, 2.

DESCRIPTION.—Test large, subcircular, subrostrate and slightly truncate posteriorly, flattened, aboral surface regularly convex, margins rounded. Apex slightly posterior to the centre. Base concave, distinctly undulating; peristome sub-pentagonal, oblique, placed a little in front of the centre. Periproct large, ovate, at the posterior end and extending to the margin of the aboral surface; dorsal sulcus absent, the test depressed around the lower part of the periproct.

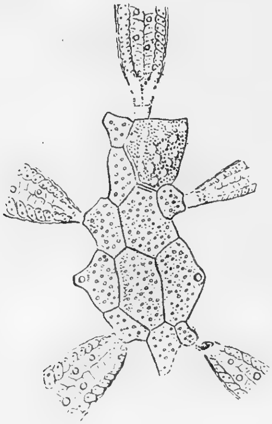
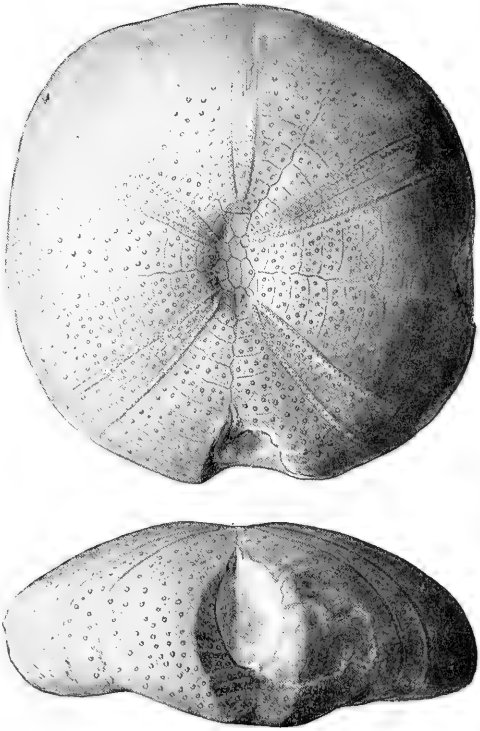


FIG. 1.—Apical disc of specimen shown in Plate XVI. × 3.

Apical disc elongate, slightly depressed, all the plates bearing small granules. Anterior ocular indistinctly shown. Madreporic plate large, in contact with the left anterior genital, which is divided into two parts. Right antero-lateral ocular smaller than the left, and separated from it by a large, nearly hexagonal, complementary plate which touches, in front, the madreporic plate and the left anterior genital plate. Postero-lateral genitals large, separated



Desorella elata (Desor).

Corallian: Upware, near Cambridge. Nat. size.

from the anterior genital plates by the antero-laterals and the anterior complementary plate. Another large complementary plate, which is elongate and hexagonal, separates the postero-lateral genitals. The posterior oculars are small, the left being larger than the right; between them comes the posterior genital, of which the posterior boundaries are indistinctly seen.

Ambulacra not petaloid. The pores of each pair are slightly oblique, the outer being aboral to the inner. The inner pore is rather larger than the outer. On each plate one or more small, sunken tubercles, which are perforate, increnulate, scrobiculate, and well-spaced. Between the tubercles are many granules.

Interambulacra broad, the postero-laterals being rather larger than the antero-laterals. Plates with many tubercles and granules similar to those of the ambulacra.

The specimen was found in the Coralline Oolite of the lower part of the south quarry at Upware, and is now preserved in the Sedgwick Museum, Cambridge. The genus has not hitherto been recorded in England. The types of *Desorella elata* came from the Lower Corallian (Calcaire à chailles) of Yonne.

EXPLANATION OF PLATE XVI.

Desorella elata (Desor). Corallian: Upware, Cambridgeshire. Aboral and posterior views. Natural size.

II. — Note on the Barypoda, a new Order of Ungulate Mammals.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

In a notice published on page 160 of the present volume it was suggested that *Arsinoitherium*, of which a brief description was there given, must be placed in the order Amblypoda, constituting a new family, the Arsinoitheriidæ. Having further considered the evidence available, and having, moreover, had the advantage of some discussion on the subject with Professors H. F. Osborn and W. B. Scott, I have now come to the conclusion that *Arsinoitherium* differs from the Amblypoda in so many points that it seems necessary to refer that remarkable mammal to a new subdivision of the Ungulata of equal value with the Amblypoda and Proboscidea, to both of which a certain degree of relationship may exist. For this new order the name *Barypoda* is proposed, in allusion to the massive character of the limbs in the species at present known. The existence of two orders so marked as the Proboscidea and the Hyracoidea in the Eocene beds of Egypt, and their absence at that period from the rest of the world (with the possible exception of South America), at least make it seem likely that in an area so isolated there were other equally distinct groups which died out before circumstances became favourable to allowing them to pass over to other regions. That *Arsinoitherium* may be the representative of such an order is probable, for its great size and highly specialised character point to its being the closing member of a long line, of which the earlier forms are at present quite unknown, and must be sought in earlier horizons in the Ethiopian region.

The chief characters of the Barypoda are:—Full eutherian dentition without diastemata; molars bilophodont, a character probably produced by the infolding of the ectoloph of increasingly hypselodont teeth. In *Arsinoitherium* the molars are extremely hypselodont. Premolars differ widely from the molars. In the skull the occipital surface is strongly inclined forwards, and there are palatal and nasal horns, the latter of enormous size in *Arsinoitherium.* The orbits are open posteriorly. An alisphenoid canal is present. The brain cavity is relatively much larger than in the Amblypoda.

There is no entepicondylar canal in the humerus, and no third trochanter in the femur.

The fore-foot is much like that of the Proboscidea; thus the metacarpals alternate to the same extent as in *Elephas,* and the scaphoid is closely similar. In correlation with the fact that the radius is much smaller than the ulna, the difference in size being greater than in *Elephas,* the cuneiform is large and seems to have overlapped the magnum, while the scaphoid is relatively small.

The hind-foot differs widely from the Proboscidean type and approaches that of the Amblypoda. The astragalus and calcaneum both bear large fibular facets. The low and broad astragalus articulates distally with the navicular and cuboid, the latter having only a small surface of contact with the calcaneum. There was probably a small tibiale.

The feet were no doubt pentadactyl, the metapodials being short and stout. From the form of the calcaneum it seems probable that the heel sometimes rested on the ground.

The systematic position of the other genus, *Barytherium,* is still doubtful. It is clear that, from the character of its dentition, it cannot come within the limits of the Barypoda as above defined; moreover, as far as can be judged from the distal end of the radius, the carpal structure must have been widely different from both that of the Barypoda and Proboscidea, and was more similar to that of the Dinocerata. The humerus is of a most remarkable form, and its peculiar character indicates that possibly the fore-limb was used for digging or burrowing. For the present it will perhaps be safest to place this genus quite provisionally in a sub-division of the Amblypoda, the Barytheria, equivalent in value to the Dinocerata.

III.—On the Zone of *Marsupites* in the Chalk at Beddington, near Croydon, Surrey.

By George Jennings Hinde, Ph.D., F.R.S.

On hearing that Mr. G. E. Dibley, F.G.S., had exhibited at the June meeting of the Geologists' Association some test-plates of *Marsupites* from the Chalk of a new road near Russell Hill, I made inquiries of him, and he most kindly told me the particular locality where he and others had obtained these fossils. As the place was within an easy walk of my home, I visited it, in company with the younger members of my family, on an evening in June, and found, as Mr. Dibley had told me, that the greater part of the Chalk had been refilled into the sewer-trench, and the residue had been spread over the roadway and was now partly trodden down by the traffic. We patiently broke a number of the remaining blocks of chalk, and, in spite of the fact that Mr. Dibley had already carefully worked at the place, succeeded in finding not only a couple of plates of *Marsupites* with *Echinocorys scutatus*, etc., but also some smaller inconspicuous plates which, when cleaned from the matrix, proved to be test-plates of the unstalked, free-swimming crinoid, *Uintacrinus*, Grinnell. These showed the existence at this place of the lower portion of the *Marsupites*-zone, which has been designated by Dr. Rowe[1] the "Band of *Uintacrinus*."

Since last June another trench for sewerage, more than a mile in length, and from 20 to 25 feet in depth, has been in course of excavation along the northern half of Plough Lane, a road leading from Purley to Beddington, to which I have made repeated visits during the last two months, searching the Chalk exposed throughout, and the subjoined list gives the names of the fossils obtained.

The southern end of the trench is situated at the summit-level of the Chalk ridge between Purley and Beddington, where the new road mentioned above (known as Peak Hill Road) is given off, and it is about 200 yards south of the Keeper's Cottage, shown on the 6 inch Ordnance Map. The summit is about 325 feet above O.D., and from it there is a gentle slope towards the north, in the direction of Beddington as far as where Plough Lane is crossed by the Stafford Road, leading to Croydon, at a level of 193 feet O.D., and at this point the trench stops. The entire area is included in the boundary of Beddington parish.

At the summit-level of the ridge the Chalk is near the surface, being only covered by a few inches of brownish sandy soil, but lower down the northern slope it gradually passes beneath beds of brownish sandy loam, shown in the trench to a depth of 3–4 feet, which represent the lower portion of the Eocene Thanet Sand, and between the sandy loam and the Chalk there is in places a thin layer of the unworn, green-coated flints, known as the Bull's Head bed. The dip of the Chalk from the summit towards the north is probably about the same as that of the general slope of the surface. As far as can be seen, the Chalk in the Plough Lane trench is of the same soft, white character throughout; it contains but a moderate number of black, solid, nodular flints, with a thin white crust, which, I am informed, are principally from one layer, but small nodules are occasionally present elsewhere in the beds.

Fossils are very inequally distributed in this Chalk; in some parts of the section they are fairly common, whilst in others one may split open a number of blocks without finding any. The list given below is by no means complete, for the Microzoa have not been worked out. In determining the various forms I wish to

[1] Proc. Geol. Assoc., vol. xvi (1900), p. 291.

acknowledge the assistance freely given to me by my friend Mr. E. T. Newton, F.R.S., of the Jermyn Street Museum, by Dr. Bather, Mr. R. B. Newton, and Mr. W. D. Lang, of the British Natural History Museum, and by Mr. C. D. Sherborn.

List of Fossils.

Plantæ.

Linear markings resembling the foliage of *Pinus*, Mant. R.[1]

Spongida.

Cephalites longitudinalis, T. Smith. R.
Pharetrospongia Strahani, Sollas. R.
Plinthosella squamosa, v. Zitt. C.
Plocoscyphia convoluta, T. Smith. C.
,, sp. C.
Porosphæra globularis, Phill. C.
,, *nuciformis*, v. Hag. C.
,, *patelliformis*, Hinde. R.

Actinozoa.

Parasmilia centralis, Mant. R.
,, *granulata*, Dunc. R.

Echinoidea.

Cidaris hirudo, Sorig. (spine). R.
,, *perornata*, Forbes (spine). R.
Cyphosoma Koenigi, Mant. (spine). R.
Echinocorys scutatus, Leske.
,, ,, var. *pyramidatus*, Portl. C.
,, ,, var. *striatus*, Lam. R.
Galerites globulus, Desor. R.
Micraster cor-anguinum, Leske. R.

Crinoidea and Asteroidea.

Asteroidea (marginal ossicles). C.
Bourgeticrinus ellipticus, Miller. R.
,, sp. (nipple-shaped). R.
Marsupites testudinarius, Mill. C.
Uintacrinus sp. C.

Annelida.

Serpula ampullacea, Sow. R.
,, *turbinella*, Sow. C.

Crustacea.

Bairdia subdeltoidea, Münst.
Pollicipes glaber, Roem. R.
Scalpellum maximum, Sow. R.

Polyzoa.

Actinopora papyracea, d'Orb.
Berenicea polystoma, Roem.
,, *regularis*, d'Orb., var. *elliptica*, Greg.
Eschara Lamarcki, Hag.
Proboscina radiolitorum, d'Orb.
,, *anomala*, Reuss.
Stomatopora granulata, Milne Ed.
Spinipora Dixoni.

Brachiopoda.

Kingena lima, Defr. R.
Rhynchonella plicatilis, Sow. R.
Terebratulina Rowei, Kitchin. R.
,, *striata*, Dav.

Lamellibranchiata.

Exogyra sp.
Inoceramus Cuvieri, Sow. C.
Ostrea vesicularis, Sow. C.
,, *Wegmanniana*, d'Orb. C.
Pecten cretosus, Defr. R.
Plicatula sigillina, Woodw.
Spondylus latus, Sow. R.
,, *spinosus*, Sow. C.

Gasteropoda.

Hipponyx Dixoni, Desh. R.

Cephalopoda.

Ammonites leptophyllus, Sharpe. R.
Actinocamax granulatus, Blainv.
,, *verus*, Miller. R.

Pisces.

Corax falcatus, Ag.
Enchodus sp.
Lamna ?

Notes on the Fossils.

Plantæ.—The only plant-remains found belong to the species figured by Mantell as resembling the leaves of *Pinus* (Geology of Sussex, 1822, p. 157, pl. ix, figs. 2, 12). I am not aware that they have been properly described and named. They were found at the north end of the road section.

Spongida.—Siliceous sponges are very abundant, and there appears to be a band of the rock filled with their remains. Their skeletons

[1] R. = rare; C. = common.

are now replaced by iron peroxide, and consequently they are in bad preservation. In addition to the species recognized, there are fragments of Tetractinellid, Lithistid, and Hexactinellid forms, but too imperfect even for generic identification. Calcisponges are not so common, but are better preserved. *Porosphæra* is represented by specimens from 2 to 18 mm. in diameter.

Echinoidea.—Echinocorys scutatus, var. *pyramidatus*, is the predominant sea-urchin, and it occurs throughout the section, but more abundantly in association with *Marsupites*. The large depressed or dome-shaped form of *E. scutatus*, the var. *striatus*, is less common. *Micraster cor-anguinum* occurs at both ends of the section, but it is somewhat rare. *Galerites globulus* is rare, and I have only met with it near the south end of the trench. *Galerites albogalerus* (=*conicus*) does not seem to be present in the road section, though it is not uncommon in the Chalk of a road cutting a little further to the south of the present one.

Asteroidea.—The detached marginal ossicles of this group are present in all parts of the section, and they probably belong to several species.

Bourgeticrinus ellipticus.—The cylindrical and barrel-shaped stem-joints are frequent; usually single, but occasionally two are connected together; the heads of this species are rare. The peculiar nipple-shaped heads of another species of *Bourgeticrinus*, figured by Dr. Rowe,[1] but apparently not yet named, are occasionally found. Dr. Rowe states that he has not found this form outside the *Marsupites*-zone.

Marsupites testudinarius.—Detached plates of the test occur in various parts of the road section; they are fairly numerous at the higher south end between the Keeper's House and the end of the trench, and also near the north or Beddington end, below the New Barn Farm, whilst in some of the intermediate portions, where *Uintacrinus* plates are abundant, I have failed to find any of *Marsupites*. No complete specimens have as yet been discovered in this Chalk, but not unfrequently several plates occur in close proximity, as if they had belonged to a single individual. There are notable differences in the size and ornamentation of the plates from different parts of the section; thus, at the south end the plates are large and thick, reaching a maximum of 32 mm. in width, and, as a rule, they are strongly ribbed or striated, whilst those met with at the northern end are relatively thin and not over 14 mm. in width, and their upper surfaces are quite smooth, with occasionally a low fold near the margins. The brachial joints of *Marsupites* are rare, they are considerably larger than those of *Uintacrinus*, and they differ also in form and in the ornamented exterior surface.

Uintacrinus sp.—The irregularly polygonal plates of the test are fairly numerous, more particularly in those parts of the road section between the Keeper's House and the New Barn Farm, where *Marsupites* seems rare or absent. Only single detached plates are

[1] Proc. Geol. Assoc., vol. xvi (1900), p. 297, pl. viii, fig. 6.

found; they range from 4 to 10 mm. in width. The horseshoe-shaped brachial plates or joints are, as one may suppose, more abundant than the test-plates; in some cases several occur in a series as if belonging to the same arm; they range from 2 to 6 mm. in width. Some of these small brachial joints closely resemble those of *U. socialis*, Grinnell, from the Chalk of Kansas, as figured by Dr. Bather,[1] and others correspond as closely with those of *U. Westfalicus*, Schl., from Recklinghausen, in Westphalia, as shown in Schlüter's figures.[2] Whether the forms in our English Chalk belong to either of the above or to a distinct species is, at present, an open question.

Polyzoa.—In addition to the species named in the list, which have been determined by Mr. W. D. Lang, there are several species of Cheilostomata not yet worked out.

Brachiopoda.—This group is very poorly represented in the Beddington section; I have only seen single examples of each of the four species in the list.

Lamellibranchiata.—These are more numerous than the Brachiopods. *Inoceramus* is common in places, and large but imperfect examples occur; small forms of *Ostrea* are distributed generally. *Spondylus spinosus* is not infrequent, and large, well-preserved specimens are met with.

Ammonites leptophyllus is represented by an impression, on a block of chalk, of a portion of the septal sutures of an individual which, in Mr. Crick's opinion, may have been from 2 to 3 feet in diameter, corresponding with those present in the *Marsupites* zone near Margate. It was found at the southern end of the road section near the Keeper's House.

Actinocamax verus.—I only obtained a fragmentary specimen, which was determined by Mr. Crick. It came from near the New Barn Farm, about midway in the road section, where *Uintacrinus* plates are abundant. Two specimens of *A. granulatus* were found by Mr. W. M. Holmes at the higher south end of the trench.

Pisces.—In addition to the teeth named in the list, the Chalk throughout this road section contains great numbers of the scales and bones of small fishes, and one can hardly break up a block without meeting with them, either scattered singly or in small groups of irregularly commingled and compressed bones and scales, without showing any definite outlines of the fish to which they belonged. The fishes were evidently small, and, judging from the number of their remains, they must have swarmed in the sea of the period.

The fossils present in this Plough Lane road cutting prove unmistakably that the Chalk in this part of Beddington belongs to the zone of *Marsupites* and that the *Uintacrinus* band is also well represented. It may also reasonably be inferred that this zone will be found on the same line of strike in South Croydon, where indeed

[1] Proc. Zool. Soc., 1895, pl. liv, figs. 2–13.
[2] Zeitschr. deutsch. geol. Ges., xxx (1878), pl. iv.

its presence has already been anticipated.[1] There appears to be a very close resemblance in the characters of this zone at Beddington and those of the corresponding zone in the coast sections near Margate, so well described by Dr. Rowe.[2] With hardly an exception the same characteristic fossils enumerated by Dr. Rowe and a definite sponge bed are present in both.

Hitherto the highest Chalk in this part of the county has been considered to belong to the zone of *Micraster cor-anguinum*, and in the third volume on the Cretaceous Rocks of Britain, lately issued, it is stated (p. 179) that in the eastern part of Surrey the zone of *Marsupites* is either concealed beneath the Eocene or more probably was removed from the summit of a low anticlinal flexure, formed and eroded before the deposition of the Tertiaries.[3] Professor Barrois included the Purley beds of Caleb Evans in the zone of *Marsupites*, but no specimens of this crinoid have ever been found in them, and it is probable that there is a considerable thickness of Chalk between them and the Chalk of the Beddington ridge in which this fossil abounds.

IV.—The Penzance Earthquake of March 3, 1904.

By Charles Davison, Sc.D., F.G.S.

During the last fifteen years slight earthquakes have occurred in Cornwall on eight occasions, the dates being Oct. 7, 1889; Mar. 26, 1891; May 16 and 17, 1892; Jan. 26, 1896; and Mar. 29, April 1 and 2, 1898. The Pembroke earthquakes of Aug. 18, 1892 (0.24 and 1.40 a.m.), and Nov. 2, 1893, and the Hereford earthquake of Dec. 17, 1896, were also felt in the county. Local earth-shakes, probably connected with mining operations, occur occasionally, as on June 4 and 10, 1902. Under the same heading should perhaps be included the shock of Aug. 27, 1895, near Blisland, which I was led to class as seismic on account of its very elongated, though small, disturbed area.[4]

The Penzance earthquake of March 3, 1904, occurred at about 1.5 p.m.[5] Isoseismal lines of intensities 5 and 4 are represented on the accompanying map, and these show at a glance that the epicentre was submarine. Little more than half of each curve traverses the land, and the form of the remaining portions over the sea-area can only be conjectured from their trend before leaving the land. If, however, the isoseismal 5 be completed, the centre of the curve must be close to a point (indicated by a cross on the map) in lat. 50° 4·2′ N., long. 5° 27·6′ W., or about $3\frac{1}{2}$ miles south of Marazion. This curve is $13\frac{1}{2}$ miles long, and probably 10 miles

[1] Journ. Roy. Micros. Soc., 1904, p. 7.

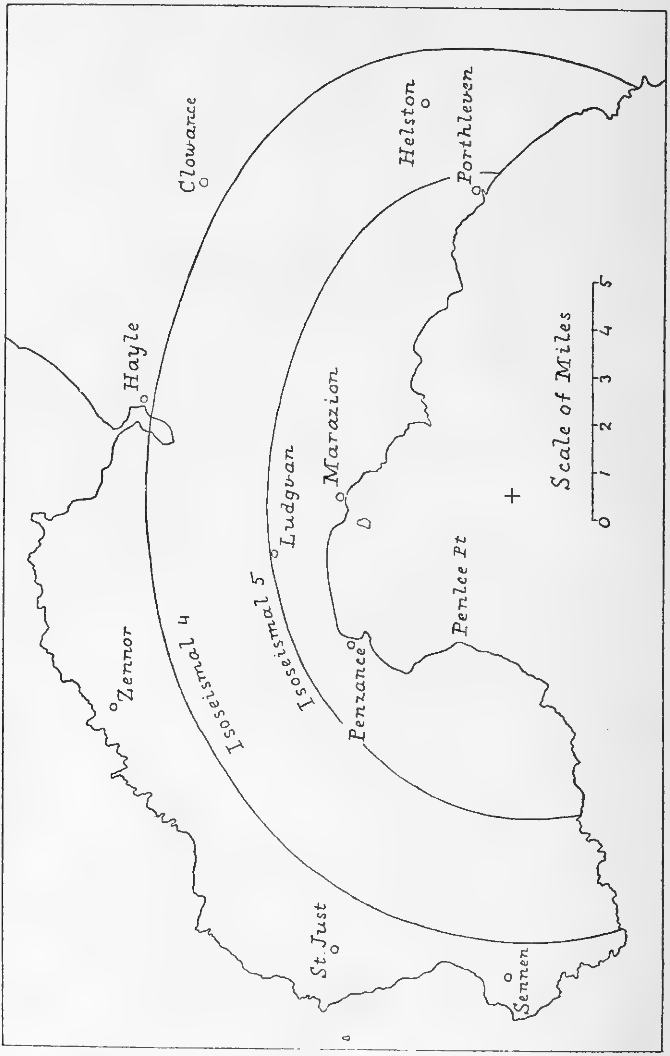
[2] Proc. Geol. Assoc., vol. xvi (1900), pp. 294–301.

[3] Terrain crétacé supérieur de l'Angleterre et de l'Irlande, 1876, p. 139.

[4] Geol. Mag., Dec. IV, Vol. VII (1900), pp. 164–5.

[5] The following account is based on 76 records from 46 places, and 13 negative records from 12 places. The cost of the inquiry was defrayed from a grant received from the Government Research Fund.

wide and 110 square miles in area. The isoseismal 4 is 19 miles long, about $15\frac{1}{2}$ miles wide, and 230 square miles in area, its distance from the preceding isoseismal towards the north being $2\frac{1}{2}$ miles. The longer axes of the isoseismals are directed from



Map of Earthquake-area near Penzance, Cornwall.

a few degrees north of east to a few degrees south of west. The earthquake was also observed at a few places outside the isoseismal 4, the sound being heard at Clowance, Sennen, St. Just-in-Penwith, and Zennor, which are respectively $\frac{1}{2}$, $\frac{3}{4}$, 1, and $1\frac{1}{2}$ miles from the curve, and a slight shock being also felt at Clowance, Sennen, and Zennor.

The shock consisted of a single series of vibrations, which gradually increased in intensity and then faded away, the average of 11 estimates of the duration being about 4 seconds. The sound, as is usual in slight earthquakes, was heard by all the observers. In 18 per cent. of the descriptions it is compared to passing vehicles, in 22 per cent. to thunder, in 2 to wind, in 3 to the fall of a load of stones, in 2 to the fall of a heavy body, in 52 to explosions or the firing of a heavy gun, and in 2 per cent. to miscellaneous sounds. Thus, in 58 per cent. of the records, the type of comparison employed is one of short duration. The beginning of the sound preceded that of the shock in 53 per cent. of the records, coincided with it in 43, and followed it in 4 per cent.; while the end of the sound preceded that of the shock in 2 per cent. of the records, coincided with it in 74, and followed it in 24 per cent. The duration of the sound was greater than that of the shock in 58 per cent. of the records, and equal to it in 42 per cent.

From the above account, it will be seen that the disturbance possesses some resemblance to those which are either wholly or partially artificial in their origin. In particular, the brevity of the sound, as shown by the frequent comparison to explosions of various kinds, is suggestive of heavy gun-firing from a ship about three or four miles south of Marazion. Several correspondents, however, state that no battleships were in the bay on March 3; and I am indebted to the Secretary of the Admiralty for the information that "there is no record of any firing having occurred in that locality on the day in question."

Nor can the disturbance be connected with a fault-slip precipitated by mining operations. For though, as Mr. Clement Reid kindly informs me, there are old workings under the sea near Marazion, Penzance, and Penlee, none of these is in the required position. And, moreover, the isoseismals are farther apart, and the disturbed area larger, than is usually the case with such an origin.

It may therefore be concluded, I think, that the observed phenomena were not due to artificial causes, but rather to a slip, three or four miles in length, along a submarine fault about $3\frac{1}{2}$ miles south of Marazion. In several ways — especially in the small disturbed area, the closeness of the isoseismals, and the brevity of the sound — the Penzance earthquake resembles an after-shock of a moderately strong earthquake, and it is probable that the focus was situated at no great depth. The exact direction of the earthquake-fault is somewhat uncertain, owing to the incompleteness of the isoseismals; but it cannot have deviated widely from that of the lodes in the neighbourhood of Marazion.

In an interesting paper,[1] Mr. Clement Reid has suggested that an

[1] "On the probable occurrence of an Eocene outlier off the Cornish Coast": Quart. Journ. Geol. Soc., vol. lx (1904), pp. 113–117.

Eocene basin may lie under the sea in Mount's Bay and the western part of the English Channel. It is by no means impossible that the last of the series of movements resulting in the formation of the suggested basin was that which caused the recent Penzance earthquake.

V.—Note on two Cephalopods obtained by Lieut.-Col. Skinner, R.A.M.C., from the Valley of the Tochi River on the North-west Frontier of India.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

The valley of the Tochi River is an outlying corner of the British Empire in India forming a portion of Waziristan, the boundary of which was delineated in 1894–5 by an Anglo-Afghan Commission from the Afghan provinces of Khost on the north and Birmul on the west.[1] Mr. F. H. Smith, of the Geological Survey of India, accompanied this Commission as geologist, and his observations "On the Geology of the Tochi Valley" were published in 1895 in the "Records of the Geological Survey of India" (vol. xxxviii, pt. 3, pp. 106–110, pl. iii). On p. 109 he says:—"The range of hills between Idak and Mirán Shah[2] is formed by an anticlinal ridge which approximately strikes north and south, and which is composed of these lower eocene beds. In the core of the anticlinal a considerable thickness of massive dark grey limestone is exposed, in which I could find no fossil remains; the age of this limestone is therefore doubtful, and there is no evidence of any kind to show whether it belongs to the lowest tertiary or upper mesozoic age."

In 1897 the Tochi Valley was visited by an expedition sent there to avenge an assault upon our troops that was made at Maizar in June of that year by the Madda Khel, a section of the tribe of the Darwesh Khel Waziris who inhabit the locality. Major (now Lieut.-Col.) B. M. Skinner, R.A.M.C., who accompanied this expedition, was fortunate enough to obtain from the anticlinal ridge referred to by Mr. Smith, besides several fragments of coral, the two Cephalopods (an Ammonoid and a Belemnite) which form the subject of the present note.

The information accompanying the Ammonoid (No. 213) is as follows:—"Derived: found in the Alveolina limestone at Mirám Shah, E. of Dandi plain"; whilst the locality of the Belemnite (No. 225) is recorded as "E. of Mirám Shah, halfway to Idak." The portion of Mr. Smith's section referring to this locality is reproduced in the accompanying figure, and Lieut.-Col. Skinner has been so good as to indicate on the section the localities of his fossils. The fragments of coral were found at the spot marked *a*; the Ammonoid was obtained from the débris in the neighbourhood of the limestone at *b*; whilst the Belemnite was found *in sitû* at the point marked *d*. At the spot marked *c* Lieut.-Col. Skinner tells me that he observed in

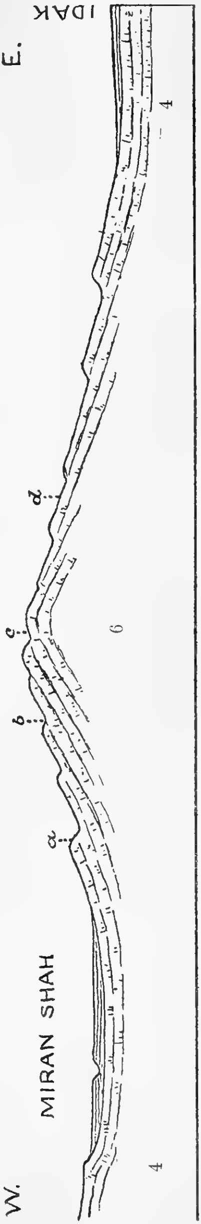
[1] See Major (now Lieut.-Col.) B. M. Skinner, R.A.M.C., "The Valley of the Tochi River," *Science Gossip*, November, 1899, pp. 163–4.
[2] Also spelt Mirám Shah.

the rock a huge branching coral which it was quite impossible for him to extract.

Although the fossils are very fragmentary and difficult satisfactorily to determine, they are of great importance as showing the Mesozoic age of the rocks forming the core of the anticlinal between Mirám Shah and Idak.

The Belemnite (see Text-figure 1, p. 492) is partially imbedded in a light greenish-grey, in places buff-coloured limestone, and its exposed surface has been very much weathered. It was found *in sitû* at a spot which Lieut.-Colonel Skinner describes as "E. of Mirám Shah, halfway to Idak," and which is marked *d* on the section reproduced herewith. The specimen is about 47 mm. long, but has been broken across, and the two parts, 20 and 27 mm. long respectively, have been so dislocated that they are now some 5 or 6 mm. apart. The smaller fragment is part of the alveolar end, a portion of the alveolus being preserved. The exposed surface of the fossil is ventral. The ventral surface of the alveolar portion of the guard appears to have been provided with a median groove, but precisely how far this extended backward cannot be ascertained on account of the eroded state of the fossil; it was probably confined to the alveolar region. The guard, as now preserved, is nearly circular in cross-section, its dorso-ventral and transverse diameters being each about 9 mm.; allowing for the erosion of the ventral surface, the guard seems originally to have been a little compressed and nearly cylindrical or possibly a little fusiform. Unfortunately the posterior part of the guard is wanting. The specimen is also so much eroded that a definite determination is quite impossible.

The fragment of an Ammonoid (see Text-figs. 2*a*–*d*, p. 492) consists of the posterior part of the body-chamber. Lieut.-Col. Skinner's note respecting it is as follows:—"Derived, found in the Alveolina limestone at Mirám Shah, E. of Dandi plain." It was found in the débris in the



Section from Idak to Mirán Shah. 4, 4, Middle and Lower Nummulitic beds; 6, Mesozoic (?) Limestone. (After F. H. Smith, Records Geol. Survey India, vol. xxxviii, pt. 3, 1895, pl. iii.)

neighbourhood of the limestone at the locality marked *b* in the section reproduced herewith. Its greatest length is 44 mm.; it is depressed, subtrapezoidal in cross-section, and has its greatest width near the margin of the periphery; its dorso-ventral diameter (or height of the whorl) is 24·5 mm., its greatest width being 34 mm. including the ribs, or 32 mm. excluding the ribs. Although considerably eroded the specimen appears to be not quite symmetrical, one margin of the periphery being much more angular than the other; consequently on one side the most prominent part of the whorl appears to be close to the peripheral margin, whilst on the other the most prominent part is at about one-third of the height of the whorl from the periphery.

The shell was almost entirely evolute, and was scarcely impressed by the preceding whorl; the sides of the whorl are convex, sloping

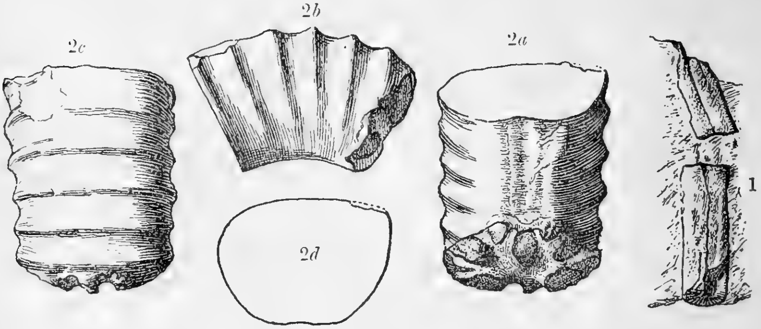


Fig. 1.—Belemnite from Mesozoic rocks (Neocomian?) between Mirám Shah and Idak, Tochi River District, N.W. India. The fissure traversing the specimen longitudinally is of the nature of a crack and not a groove. Drawn from the specimen [register number C. 9296] in the British Museum (Natural History).

Fig. 2.—Ammonoid (*Crioceras*?) from Mesozoic rocks (Neocomian?) between Mirám Shah and Idak, Tochi River District, N.W. India. *a*, peripheral or ventral aspect; *b*, lateral aspect; *c*, dorsal aspect; *d*, transverse section showing asymmetry of the whorl. Drawn from the specimen [register number C. 9297] in the British Museum (Natural History).

gradually from near the margin of the periphery into the umbilicus, the umbilical margin being imperfectly defined. The fragment bears six rather coarse prominent ribs, each about 2 mm. wide, separated by interspaces of about twice their own width. The ribs rise at the inner third of the lateral area, extend rather obliquely forward to the margin of the broad periphery, which they traverse in a straight course without interruption or bifurcation, or apparently without any flattening. The base of the body-chamber is preserved, and, though imperfect, gives the general form of the septal surface and of the suture-line. The septal surface is a little asymmetrical; when the surface is viewed posteriorly the siphonal lobe is seen to be a little to the left of the median line.

The affinities of the fossil are obscure; they seem to be with some forms of the comprehensive 'genus' *Crioceras*, but compared with such Neocomian forms as *Crioceras aegoceras*, v. Koenen,[1] and *C. capricornu* (Roemer),[2] which bear simple prominent ribs, the present specimen has broader, more depressed whorls, and more forwardly-inclined ribs than either of these species. It bears a resemblance to some forms of the Upper Jurassic genus *Simoceras*, but in that genus the transverse section of the whorl is more compressed, whilst the ribs on the peripheral area are strongly curved forward, and the form of its septal surface is different. The last-mentioned character suggests affinity with the Lower Cretaceous forms of *Douvilléiceras* (*D. mammillatum, D. Martinianum*, etc.). On the whole we are inclined to refer the specimen to the 'genus' *Crioceras* with a query.

As the two Cephalopods were not found at the same spot and under the same conditions (the Belemnite being obtained *in sitû*, whilst the Ammonoid was picked up in débris on the surface of the ground), it is quite possible that they are not of the same age geologically, although their lithological character leads one to infer that such is the case. They indicate, however, the existence of Mesozoic rocks, possibly of Neocomian age, in the anticlinal between Mirám Shah and Idak; and now that the existence of fossils in this limestone has been recorded it is to be hoped that at some future time other specimens may be obtained which will enable the exact age of these rocks to be determined. In conclusion, it may be stated that the fossils referred to in this note have been presented to the British Museum (Natural History).

VI.—The Dolomites of Eastern Iowa.

By Nicholas Knight.

THE experimental work of this investigation was done by Grace D. Bradshaw in the chemical laboratory of Cornell College. The purpose was to determine whether the silica exists in a free condition or is in the form of a silicate; also to ascertain whether the iron is in the ferrous condition as carbonate or is in the form of ferric oxide. The rocks abound in many parts of Iowa, and belong to the Niagara formation. The stratified character even in a small section is apparent, and the layers differ somewhat in composition, as shown by the varying amounts of iron visible in different portions. The rocks are used as building stone to manufacture quicklime and in MacAdam paving.

1. To answer the first question as to the condition of the silica six pairs of determinations were made as follows:—

(*a*) A gram of the finely powdered rock was placed in a small beaker and covered with a watch-glass, a small quantity of dilute hydrochloric acid was added, and the carbonates were dissolved by

[1] Abhandl. d. k. Preuss. Geol. Landesanst., etc., Neue Folge, Heft 24 (1902), p. 328, pl. xxxvi.
[2] Ibid., p. 316, pl. xvi, figs. 1–4.

carefully heating to the boiling-point. The insoluble portion, which is the silica, was filtered off, dried in an air-bath, and the weight determined.

(*b*) A gram of the fine powder placed in a porcelain evaporating dish of 100 c.c. capacity was treated with dilute hydrochloric acid and covered with a watch-glass. It was warmed on the water-bath until there was no further evolution of carbon dioxide. The watch-glass was removed, and the dish was kept on the water-bath until crystals began to appear. As the drying continued the substance was constantly stirred with a glass rod, until a fine dry powder resulted. The powder was next moistened with a few drops of concentrated hydrochloric acid and 20 c.c. dilute hydrochloric acid (equal parts concentrated hydrochloric acid and water), and about the same quantity of water was added. The contents of the dish were then filtered and the silica determined.

The results for the two methods were as follows :—

(*a*)		(*b*)
0·78 per cent.	... ...	0·75 per cent.
0·76 ,,	... ...	0·90 ,,
0·81 ,,	... ...	0·85 ,,
0·87 ,,	... ...	0·91 ,,
0·94 ,,	... ...	0·87 ,,
0·94 ,,	... ...	0·73 ,,

The treatment described under (*b*) would decompose a silicate, while the method under (*a*) would not. As the two series of results are fairly concordant, the conclusion is that the silica exists as a fine sand disseminated through the rock. A private communication from W. H. Norton, of the Cornell College department of geology, states that he came to the same conclusion while studying the rock with a petrological microscope. The method described under (*a*) is simpler than (*b*), and the work can be done in a much shorter time. It is therefore to be preferred in the analysis of rock of this kind.

2. The condition of the iron. A gram of the substance was introduced into a flask of 120 c.c. capacity, fitted with a bulb tube and Bunsen valve to prevent oxidation of the iron. It was dissolved in dilute hydrochloric acid. A few drops of the cooled solution were then withdrawn with a capillary tube, placed on a watch-glass, and tested with a crystal of potassium ferricyanide. No suggestion of a blue colour resulted, showing the iron to be in the ferric condition. This increases the value of a rock as a building material, as ferrous carbonate is an unstable substance with a tendency to change to the ferric condition. A complete analysis of the specimen resulted as follows :—

$Ca\,Co_3$	... ...	53·62 per cent.
$Mg\,Co_3$	... ...	44·96
$Si\,O_2$	... ...	0·83
$Al_2\,O_3$	... ...	0·25
$Fe_2\,O_3$	... ...	0·34
		100·00

The specimen is nearly a true dolomite, which contains 54·35 per cent. $Ca\,Co_3$ and 45·65 per cent. $Mg\,Co_3$. This method of analysis was employed:—After removing the silica according to (*a*) a grain or two of pure ammonium chloride is added to the filtrate to prevent the precipitation of magnesium. It is then heated to boiling, and a small excess of ammonia added, which precipitates iron and alumina. They are determined together, and then dissolved in the crucible with warm dilute hydrochloric acid. The solution is treated with caustic potash, which precipitates the iron and dissolves the alumina. The iron is filtered off and discarded, because it cannot be thoroughly washed from the caustic potash. The filtrate is slightly acidified with hydrochloric acid, and the alumina is precipitated with freshly prepared ammonium sulphide. The aluminum sulphide, when heated in a crucible, becomes Al_2O_3. The filtrate from the iron and alumina, containing the calcium and magnesium, was heated to boiling and precipitated with a $\frac{N}{2}$ solution of ammonium oxalate, care being used to avoid much excess of the reagent. The precipitate was allowed to stand eight or twelve hours before filtering. The well-washed precipitate of calcium oxalate, containing also a small quantity of magnesium oxalate, was dissolved in warm, dilute hydrochloric acid, and the solution was made alkaline with ammonia. This precipitates the calcium oxalate, and leaves the magnesium in solution. This with the main portion of the magnesium is precipitated as magnesium-ammonium phosphate, and weighed as magnesium pyrophosphate.

VII.—On the Cause of Compression of the Earth's Crust.[1]

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

I USED to think that the corrugations of the earth's crust were due to compression through the shrinking of the interior. To judge of the sufficiency of this cause the first thing to be done is to seek a measure of the compression, and then to compare the result of the effects of cooling with the actual amount of compression. The most satisfactory measure appears to be the thickness of the layer which the corrugations would form if levelled down. The question then becomes one of *how much*. In 1863 Lord Kelvin (then Sir W. Thomson) formulated a law of secular cooling upon the hypothesis that the interior is solid. Adopting a probable value for the contraction of rocks in cooling, I calculated the thickness of the layer which would be produced by the corrugations resulting, and found it far short of that which the existing inequalities would form if levelled down. Mr. Mellard Reade and Dr. Davison subsequently discovered the existence of a level of no strain within the crust, and this greatly reduces the possible amount of corrugations. The conclusion at which I arrived was that, on the hypothesis of a solid globe, secular contraction through cooling would not account for the corrugations.

Numerous phenomena suggest to the vulcanologist that the substratum is a liquid magma holding water-gas in solution. The free

[1] Read before the British Association, Cambridge, Section C (Geology), Aug., 1904.

yielding of the substratum is also testified by the phenomena of isostacy. I have therefore endeavoured to estimate the amount of corrugations which would be produced by a cooling globe also on this hypothesis. But although they would be slightly greater than in the case of a solid globe, they still fall far short of those actually existing. I therefore argue that the corrugations of the crust are not due to the shrinking of the interior away from the cooled crust, whether we regard the interior as solid or liquid.

If it be asked what my views are upon this vexed question, I may be allowed to say that I have published them fully in my "Physics of the Earth's Crust." In it I have given reasons for believing that the substratum is affected by convection currents, and that these *ascend* beneath the oceans, and flowing horizontally towards and beneath the continents, and descending beneath mountain chains, are the cause of the compression of the crust, and other disturbances, of which we are in search.

Before giving my reasons for believing that upward convection currents exist beneath oceans, it is in the first place necessary to combat the dictum of leading physicists that the interior of the earth is solid. It has been asserted that, unless the earth is extremely rigid, bodily tides would be produced, and that there would be no rise and fall of the water relatively to the land. If the earth was a smooth spheroid covered with a uniformly deep ocean this would no doubt be true. But as matters stand, the tides of short period are affected by local irregularities known as the establishment of the port. If the substratum of the crust is liquid, isostacy requires large protuberances of its underside, which would cause irregularities in the tides in the magma analogous to those in the ocean, and, unless these agree in time, in height, and in place, with the water tides, the latter will not be obscured by them, and may even be augmented.

Of tides of long period the fortnightly is the most important; but I think I have shown in the Appendix to my "Physics of the Earth's Crust" that it had not been proved by fifteen years of observation that any such tide existed,[1] which would be an argument in favour of the liquidity of the interior.

The peculiarities of the transmission of earthquake waves to great distances through the body of the earth have been appealed to, as approving to all, "except some geologists,"[2] that the earth is solid. The disturbance first arrives as a series of minute tremors. These have been considered to be waves of compression. They are soon followed by somewhat larger disturbances, which have been considered to be waves of distortion. Since waves of distortion could not be propagated in a liquid, it is maintained that the earth is hereby proved to be solid. In reply to this argument I have shown that, if a liquid magma holds gas in solution, two types of waves will be propagated through it with different velocities. Tremors will first arrive due to the compressibility of the magma, and subsequently waves caused by the extrusion of gaseous vesicles due

[1] p. 34.

[2] Darwin's "Tides," p. 236.

to the changes of pressure. If my argument is valid, that for solidity loses its force.[1]

I will now give my reasons for thinking that the substratum, if a liquid, is not a still liquid, but is affected by convection currents.

Availing myself of Sir Arthur Rücker's observed values of the melting temperature and specific heat of Rowley rag, I have calculated that, if the substratum of the crust be a still liquid, the thickness of the crust comes out 22 miles, and the corresponding time since it began to solidify about eight million years. This is a much shorter time than geologists would admit. This result proves that the substratum is not a still liquid, and must therefore be affected by convection currents, bringing up heat from below and delaying the thickening of the crust. The existence of convection currents being thus, as I submit, established, I will add my reason for believing that they ascend beneath the oceans.

By a somewhat complicated calculation, which, although criticised by Mr. Blake,[2] has been ably defended by Mr. Brill,[3] I have, I think, proved that the substratum beneath the oceans is less dense than beneath the land. This shows that the upward currents are beneath the oceans. I have at the same time proved that the suboceanic crust does not reach quite so deeply down as the continental crust, and that its upper layer is thin and very dense, from which I infer that it consists of basic lava-flows[4] the oxydation of which would afford the red clay, which covers the bottom of the deeper oceans.

These convection currents, ascending beneath the oceans and then flowing horizontally towards and beneath the continents, till they descend, are in my opinion the cause of the compression of the continental crust.

VIII.—The High-level Plateau Gravels on the North Side of the Tamisian Area, and their connexion with the Tertiary History of Central England.[5]

By Alexander Irving, B.A., D.Sc.

THE author refers to his work in former years among the High-level Plateau Gravels south of the Thames, chiefly in Berks and Surrey, the results of which were given in various papers from ten to twenty years ago.[6] The present note may serve as a supplement to those papers, in which the conclusion was arrived at that the gravels in question were to be regarded as distinctly of riverine origin and, upon the whole, of Pliocene age. Occupying original

[1] Proc. Camb. Phil. Soc., 1904.
[2] Phil. Mag., 1894.
[3] Ibid., 1895.
[4] "Physics of the Earth's Crust," Appendix, p. 8.
[5] A paper read before the British Association, Cambridge, Section C (Geology), August, 1904.
[6] "The Bagshot Strata and their Associated Gravels," Proc. Geol. Assoc., vol. viii (1883); "On the High Level or Plateau Gravels," Quart. Journ. Geol. Soc., vol. xlvi (1890); Lecture at Windsor on "The Geological History of the Thames Valley," *Science Gossip*, May and June, 1891; "On Surface Changes in the London Basin," Geol. Mag., May, 1893.

lines of drainage, they now cap the higher parts of the terrain of the Bagshot country, having preserved those parts from degradation, while the intervening portions have been removed by ordinary agents of denudation to form the present southern upland valley-system of the Thames Basin.

This view, first propounded in 1883, was endorsed by the late Sir Joseph Prestwich, F.R.S., in his papers on the Mundesley and Westleton beds, which were given to the Geological Society in the year 1890. The author is not aware that that view has been seriously combated.[1]

In the present communication the term 'Plateau Gravels' is used in the same sense as in that earlier literature of the subject by the author and other writers. It denotes a series of altogether different age from that denoted by the term as it is used in the Handbook to the Natural History of Cambridgeshire written for the use of members of the British Association at the Cambridge meeting of 1904. They are of pre-Quaternary age, and are overlain by Boulder-clay. They may be regarded as the lower stretches of the series which cap the higher ground of Herts and the adjoining counties, which was doubtless a continuous sloping plateau before the present trough-like valleys, such as those of the Stort and the upper Lea, were incised upon it.[2] The term 'plateau gravel,' therefore, here, as in the case of the other series to the south of the Thames, seems to be appropriate. The gravels themselves repose upon the Tertiary strata of the district. In *structure* and in their relation to the Eocene formations they correspond completely with the high-level plateau-gravels to the south of the Thames, that structure having been minutely described by the author in the papers referred to.[3] But the *composition* of these gravels on the north side is totally different from that of those on the south side of the Thames Valley. There everything points to the derivation of the materials from the once much higher country formed by the Wealden and Kingsclere axes of elevation; here the materials are such as could only have come from the north or north-west. Their most marked characteristic is the abundance of quartzite pebbles, together with quartz, chert, and Lydian stone, from the Bunter of the north and west Midlands. Along with these rolled fragments of Millstone Grit, Coal-measure Sandstone, Carboniferous Limestone, Magnesian Limestone are of less common occurrence, while even pebbles of felstone and gneiss, probably from the Malvern crystallines, may be recognised. All these materials *may* have been derived immediately from the Bunter Sandstone as the author is acquainted with it; and along with these the more durable rocks of the intermediate Jurassic series of the Mercian area are represented, together with Belemnites and Grypheas rolled into pebbles; telling us that the peneplane

[1] This is now generally recognised, yet in a referee's note to the original MS. in 1883 it was pronounced "new to geology and baseless"!

[2] The valley in which Much Hadham lies affords a good example of this trough-like form on a smaller scale.

[3] See especially "Note on the Plateau Gravels, etc.": Q.J.G.S., Nov., 1890.

of the Chalk extension to the north-west, across which these rivers flowed, had been already so deeply furrowed by them that they had even then begun to saw down into the Jurassic rocks. Rolled fragments occur of basic igneous rocks and other crystallines, the origin of which it is not easy to determine, though they may have come from Charnwood or from the igneous intrusions of Warwickshire and Worcestershire. Sarsens and flinty detritus are common enough in the gravels as well as Tertiary flint pebbles.

Not only are these gravels much older than the Boulder-clay (and its equivalents), superimposed upon them, but their relation to the present river-drainage shows that they are older than even the pre-Glacial valleys of erosion in the Chalk, now buried beneath alluvial detritus, which has been proved by a well in the valley of the Stort to a depth of 170 feet; while on the watershed between the Stort and the Cam (also a buried valley) a well-section close to Elsenham Station has proved a depth of 90 feet of drift before the Chalk is reached. We do not know that we have there reached the lowest line of the submerged valley, the original *Thalweg.*

The author regards these plateau gravels as the deposits of Mercian rivers, which flowed through the gaps in the present Chalk range, such as those of Elsenham and Hitchin, towards the ancient arterial Tamisian line of drainage of southern England during the great Miocene elevation of north-western Europe, long before the present escarpment of the Chalk was formed, and therefore before the initiation of the Mercian river-system, as it exists to-day with its convergence towards the Wash and the Humber. In one section at Stansted a fault of five feet throw cuts through the Chalk, the Reading Beds, and the stratified gravels, showing their common participation in later earth-movements, while the Glacial deposits above are unaffected. The author conceives these well-stratified and indurated gravels, splendid examples of which may be seen at Thorley and by the Hallingbury road on the opposite site of the Stort, to be the deposits of a river, at a time when the now buried valleys of the Stort and the Cam in the initiatory stages of their erosion formed perhaps one continuous channel, and before the axial movement took place, which has had much to do with differentiating the present Tamisian and Mercian systems of river-drainage. That movement probably dates from the close of the Miocene period, the corresponding subsidences to the north-west and south-east of the axis of anticlinal flexure being indicated by the ingress of the sea and the consequent Crag deposits in East Anglia on the one side, and by the northerly dip of the strata (with perhaps a true dip to the north-west) as seen in the cliffs at Hunstanton on the other side. This latter subsidence, together with the recession of the Chalk escarpment by denudation, determined probably the present system of drainage towards the Wash in Pliocene times. The nature of the detritus which has buried the ancient Stort Valley is exhibited at the present time in two open gravel-pit sections at Stansted on a magnificent scale, one on either side of the valley, the section in the largest pit showing a vertical face of forty to fifty feet. The data we possess in the well-sections at Elsenham and Bishop's Stortford show a gradient sloping to the north of less than one degree between those two places, a distance of about five miles; the presumed reversal of drainage of the ancient Cam Valley is therefore comparatively a small matter. The present head-waters of the Cam and the Stort have doubtless been determined by later developments in the configuration of the country.[1] The absence of all traces of Tertiary marine deposits north of the Mercian Chalk escarpment furnishes evidence of the continental elevation of north-western Europe during Miocene time, as mapped by Professor Zittel in his work "Aus der Urzeit."[2] But the physiographical agencies of nature were not suspended; and rivers gathering their head-waters from a much higher gathering-ground to the north-west than exists to-day, with contours of the land over the Mercian area furnishing gradients sufficient to keep their middle courses pretty free from detritus, could not fail to do their work in laying down extensive stretches of shingle on the northern slopes of the ancient Thames Valley, as we see it done in modern times by the floods of the Alpine rivers which debouch upon the plains of Bavaria in their course to join the upper Danube.

Taking all the facts together, and taking into account the further fact that observations of them by the present writer for the last ten years and by other observers has failed to detect any signs of glaciation in these stratified gravels, even on the rolled sarsen blocks included in them, it seems impossible to regard them by any stretch of scientific imagination as 'interglacial.' It will be seen that the author's work has proceeded on lines parallel with that of Dr. A. E. Salter and Mr. Osborne White, and leads to similar results.[3]

The differential earth-movements, which culminated in the Miocene continental elevation, may be traced back even to Eocene time by the abundant evidence that we have of the attenuation, as we work northwards, of the Middle and Lower Bagshot strata. High-level stratified gravels of a type differing from those described here are found, as we get away from the ancient transverse lines of drainage, composed chiefly of redistributed pebbles and sand of the Bagshot beds, of the quondam extension of which northwards we have evidence in a considerable outlier near Sudbury in Suffolk; but with these the present communication is not intended to deal.

This short paper suggested itself as an addendum to the admirable lecture by Dr. J. E. Marr, F.R.S., on the Geology of Cambridgeshire at the meeting of the British Association at Cambridge, dealing, as it does, with a district only a few miles removed from the county boundary, physiographical relations being more important to geologists than such artificial limitations.

[1] Fuller details are given by the present writer in a paper read before the Geologists' Association in 1897 and published in its Proceedings, vol. xv, Feb., 1898.

[2] Published by R. Oldenbourg, of Munich.

[3] See Proc. Geol. Assoc., vol. xiv, Aug., 1896; vol. xv, Aug., 1897.

IX.—On Basic Patches in the Mount Sorrel Granite.

By R. H. Rastall, B.A., F.G.S.

During a visit to Mount Sorrel at the end of last year I collected a number of specimens of the dark-coloured patches which are so common in the granite. I have had about a dozen of these sliced, and an examination of them has yielded some results which seem worthy of a brief description.

These dark patches vary a good deal in character, and may be divided into three fairly well-defined types, as follows :—

(1) Small black or grey, generally angular patches, without porphyritic felspars.

(2) Somewhat larger and usually ovoid patches of a brown colour, generally enclosing felspars of porphyritic habit.

(3) Rather large black bodies, distinctly banded and often penetrated by parallel veins of granite, in the manner usually described as *lit-par-lit* injection. These have an obvious outward resemblance to blocks of banded or bedded rock.

Corresponding to this macroscopic classification are distinct differences in the microscopic structure, and the special character of each type may be shortly described.

Type 1. The patches of this class consist essentially of felspar and hornblende with only a little interstitial quartz. The felspar is usually a plagioclase, in rather narrow lath-shaped sections, of the habit usual in basic intrusive rocks. The hornblende also occurs in small prisms, and is often chloritised; in places it has a distinctly ophitic character. Near the centre of the patch these two minerals, with a very little quartz, make up the whole mass, but towards the outside the crystals become more widely separated and are enclosed in poecilitic fashion in large plates of orthoclase or perthite. These are often continuous with the felspars of the normal granite. It is very noticeable that in such patches the minerals are often much decomposed, forming 'saussurite' chlorite, epidote, and other secondary products, while the normal granite surrounding them is very fresh.

Type 2. Brown patches with large pink felspars. The structure here is very similar to that just described, but more quartz is present; the quartz is interstitial, and in parts has a sort of pseudogranophyric appearance. The large felspars are often much rounded and also show internal zones of corrosion.

In both the black and the brown patches there are often to be seen large crystals of sphene of a very peculiar habit. The sphene is moulded on crystals of felspar, etc., in an interstitial manner, and in a slice numerous disconnected patches extinguish simultaneously over a large area. Sphene of this kind must almost of necessity be of secondary origin.

Another noteworthy point is the almost total absence of biotite in the dark patches, although it is more abundant than hornblende in the normal rock.

This part of the subject may be summed up by saying that both the dark grey and brown patches strongly resemble in their microscopic structure certain altered rocks of the kind commonly described as Diabase, and if taken alone they would be most accurately described as epidiorite.

I have only one slice of the banded type of inclusion, and this differs entirely from those above described. It consists of an aggregate of flakes of strongly pleochroic brown biotite and grains of magnetite, enclosed in poecilitic fashion in large plates of felspar, which at the margin are continuous with the felspars of the normal granite. These plates are of variable character—orthoclase, microcline, or more commonly plagioclase.

This is obviously something very different from the cases before described, and I am inclined to regard it as an altered slate fragment caught up during intrusion, and metamorphosed by the granite.

The foregoing brief descriptions show that these dark patches in all cases possess some of the characters of a metamorphic rock, and it is even possible to form an opinion as to what the original rock may have been. The most promising case is what has been spoken of above as the 'diabase' type. In these the absence of biotite is sufficient to show that they are not mere centres of concentration of the basic molecules of the magma, as they do not consist of the same minerals as the rest of the rock in different proportions. The abundance of secondary sphene is also suggestive.

I therefore conclude that the dark patches in the Mount Sorrel granite are, in all cases yet examined, much altered fragments of other rocks caught up by the magma during intrusion, and I suggest that it is possible to discriminate to a slight extent between those of igneous and of sedimentary origin.

X.—Recent Coast Erosion in Suffolk: Dunwich to Covehithe.

By John Spiller, F.C.S.[1]

THIS communication brings up to date the record of losses on the Suffolk coast, and continues the report presented at the Ipswich Meeting, 1895, of which details were published in the Geological Magazine for January, 1896. Since that time scarcely a year has passed without the winter gales and high tides doing mischief at one or more points of the coast embraced within the above-mentioned limits; but whilst Lowestoft and Pakefield, Covehithe and Easton have all suffered very considerably, the cliffs at Dunwich remained until quite recently almost unaffected.

The losses may be summed up as follows:—

Dunwich.

All Saints Church ruins and graveyard.—The 43 feet of land

[1] Read before the British Association, Cambridge, Section C (Geology), Aug., 1904.

reported by Mr. Whitaker, September, 1880,[1] became 25 feet by the Director's (Dr. Teall's) measurement in August, 1902. Now all gone, and about 6 feet of the northern buttress of the church dropped into the sea. Total loss, 31 feet in two years.

Footpath at Temple Hill.—At same date Mr. Whitaker says, "40 yards outside the wood." The Director in 1902 made it 38 yards, equal to 114 feet. It has now diminished to 59 feet. Actual loss, therefore, 55 feet in two years.

The cliffs extending away north and south have lost more than this except at Misner. The lifeboat at the Coastguard Station cannot be used at present, for much of the shingle beach is gone and the boathouse left perched on a terrace. Ordinary tides reach the foot of the cliffs and further losses may be expected.

Walberswick.

The high shingle beach is cut back all the way from Dunwich to the mouth of the river Blyth.

Southwold.

A good result has followed the lengthening of the old North Pier at the Harbour by 60 feet, a considerable quantity of sand and shingle having been thrown up; but the benefit of this extension does not reach to the Lifeboat House, which is practically useless and barricaded for further protection. It has been suggested that an additional 50 feet might be built on to the pier, and that the old jetty near the centre cliff should be reconstructed with perhaps an intermediate strong groyne. The timber breastwork in front of the town has stood well since it has been continued to Buss Creek and strengthened at critical points by double piling. The new pier, 880 feet long, erected by the Coast Development Company at the North Cliff has acted like a groyne, and vastly increased the width of beach on both sides of it, so that the bathing station threatened with destruction in 1895 is better than ever.

Easton.

The low land extending from Buss Creek to the southern slope of Easton Cliff remains as before protected by a huge bank of shingle, but from this point onward to the Broad great losses have occurred. The site of the gun battery is buried out at sea, with the powder magazine behind it now left in ruins on the shore 50 feet outside the present edge of cliff. The rifle range has been shortened by 100 yards and a new butt constructed, so that the total loss may be estimated at 350 feet since 1895. The effect of this demolition is to bring Covehithe Ness prominently into view, whereas it was formerly almost invisible from Southwold. Another necessary consequence is that the coastline, straight in the Ordnance Map, has once more become curved inwards, corresponding with

[1] See Memoir of the Geological Survey, "Southwold and the Suffolk Coast," by W. Whitaker, F.R.S., p. 48.

the original Sole Bay. The seam of shelly crag at the foot of Easton High Cliff was uncovered a year ago for the length of 40 yards, but is now entirely hidden by masses fallen from the cliff. The measures of loss (nine years) are as follows:—

Easton Cliff, southern end	350 feet.
Roadway, Easton Bavents	163 ,,
Easton High Cliff	77 ,,

Covehithe.

Beyond Easton Broad the cliffs leading to Covehithe are constantly presenting new faces with bright yellow and pink colouring, suggestive of Alum Bay. The losses would probably have been greater but for ledges of hard sand rock projecting some 10 to 12 feet, and acting as benches for the support of the upper strata. At Covehithe roadway, starting from the hedge and cliff barrier, frequent measurements have been taken since 1895, showing gradual diminution in length from 62 yards to a remnant of 19 yards. Total loss in nine years = 129 feet.[1]

XI.—The Glaciation of Holyhead Mountain.

By Edward Greenly, F.G.S.[2]

The bare and rocky hill known as Holyhead Mountain is of considerable interest in connection with recent geological events, standing as it does some thirty miles out from the highlands of Carnarvonshire into the Irish Sea Basin; and in such remarkable isolation, for it is much the highest of the five hills which rise above the general level of the platform of Anglesey.

Its height is only 721 feet, but so strongly featured is it, especially towards the west, that one feels the term 'mountain' to be no misnomer, and can hardly believe it to be really lower than many of our smooth wolds and downs of Oolite and Chalk. Being composed, moreover, of white quartzite (or more properly of quartzite-schist), and being so bare of vegetation, it recalls much more vividly certain types of scenery in the Scottish Highlands than anything in those Welsh mountains that one sees from its sides. Towards the east it slopes at a moderate angle, but a little west of the summit it is traversed by a very strong feature, due to a fault, running nearly north and south, along which is a line of great crags, facing west, and prolonged northwards into the still greater sea cliffs towards the North Stack. Beyond this the land still remains high, but is smoother in outline, a somewhat softer series of rocks extending from the fault to the South Stack, where the high moors end off in great cliffs above the sea.

[1] The author's communication was illustrated by maps and photographs, and a discussion followed as to the best means of artificial protection.

[2] Read before the British Association, Cambridge, Section C (Geology), Aug., 1904.

The whole mountain is strongly rubbed and *moutonnée* on the north-east side, every boss having the characteristic outline. (The outline of the whole mass, indeed, is like that of a gigantic *roche moutonnée.*) On many of these surfaces, which are often polished and shine in the sun, the hard and enduring quartzite still retains fine striæ, while towards sunset on a summer's evening they can be detected almost everywhere. The rocks of the South Stack series have not retained them so well. The general direction is N.E.–S.W., with local variations and deflections ranging from S. 35° W. to W. 40° S. A more marked deflection is S. 10° W. near the flag-staff above the South Stack. On the South Stack itself they run S.S.W., fanning out to south-west on the slope of the boss. Along the southern slopes of the mountain they tend to west of south-west.

Striæ cross the summit itself running S. 40° W. The ridge at the summit and towards the North Stack falls steeply westward for 50 or 100 feet before breaking into the crag and sea-cliff alluded to above, and at the brow of this vertical cliff the rocks are still polished and traversed by striæ running in the usual N.E.–S.W. direction, in spite of being under the lee of some 50 or 100 feet of steep rock.

Undercut furrows have not been observed on the mountain itself, but it may be worth while to note that they occur at Ffynnon Gorlas, on the lower ground at its eastern foot, where, also, a surface facing south-west and overhanging, as much as 40°, and in one place 60°, from vertical, is rubbed and smoothed.

The mountain proper (excluding the South Stack moors) is very bare of drift, but a little till occurs in the hollows, with débris chiefly from the eastward so far as yet recognized. Many large boulders of the quartzite occur on the South Stack moors.

At the summit are many small fragments of the well-known green mica-schists of the neighbourhood of the town, with other erratics. These schists do not occur *in sitû* at a greater elevation than about 220 feet; and in the direction from which the striæ indicate ice-movement, not more than 100 feet. The fragments have therefore been lifted 500 feet at least, and almost certainly 600 feet, during their journey.

Although it has long appeared to me that we have much to learn from research in Arctic and Antarctic lands, and cannot hope yet to be able to explain many of the glacial phenomena of the past, yet a group of facts like these of Holyhead seem to be more easily explained by the passage of land-ice than by any other hypothesis.

The general direction of glaciation, it may be observed, is parallel to that of the mainland of Anglesey so far as I have yet examined it.

In conclusion, there are some banks and mounds on both sides of the mountain, the most marked being on the south-west side, which have much of the appearance of moraines; and are, moreover, so far as I can make out, composed almost exclusively of quartzite débris. It would be interesting if, in spite of the comparatively slight elevation, one or two small local glaciers had lingered, or perhaps for a short time formed, upon this exposed and lonely hill.

NOTICES OF MEMOIRS, ETC.

I. — British Association for the Advancement of Science. Seventy-Fourth Annual Meeting, held at Cambridge, August 18–24th, 1904.

List of Papers read in Section C, Geology.

Aubrey Strahan, F.R.S., President.

President's Address. (See p. 449.)

Dr. J. E. Marr, F.R.S.—The Geology of Cambridgeshire. (See p. 508.)

F. W. Harmer.—The Great Eastern Glacier. (See p. 509.)

W. Whitaker, F.R.S.—On a Great Depth of Drift in the Valley of the Stour, Suffolk. (See p. 511.)

W. Whitaker, F.R.S.—Some Cambridgeshire Wells. (See p. 511.)

H. B. Woodward, F.R.S.—Note on a small Anticline in the Great Oolite Series, north of Bedford. (See p. 439.)

J. Spiller.—Recent Coast Erosion in Suffolk: Dunwich to Covehithe. (See p. 502.)

J. W. Stather.—Report of the Committee on the Drift Deposits at Kirmington, Lincolnshire. (See p. 512.)

Professor W. J. Sollas, F.R.S.—On the Structure of the Silurian Ophiurid *Lapworthura Miltoni.*

Dr. B. N. Peach, F.R.S., and *Dr. J. Horne, F.R.S.*—The Base-line of the Carboniferous System round Edinburgh.

Dr. R. H. Traquair, F.R.S.—Note on the Fish-remains recently collected by the Geological Survey of Scotland at Salisbury Crags, Craigmillar, Clubbiedean Reservoir, and Torduff Reservoir, in the Edinburgh District.

Dr. R. H. Traquair, F.R.S.—On the Fauna of the Upper Old Red Sandstone of the Moray Firth Area.

G. W. Lamplugh.—Note on Lower Cretaceous Phosphatic Beds and their Fauna.

G. W. Lamplugh.—Marine Fossils from Ironstone of Shotover Hill.

E. A. Newell Arber.—On the Fossil Plants of the Upper Culm Measures of Devon.

E. A. Newell Arber.—On derived Plant-petrifactions from Devonshire.

Professor H. G. Seeley, F.R.S.—On Fossil Footprints of Reptiles from the Stormberg Beds of the Karroo of Cape Colony.

Dr. J. E. Marr, F.R.S.—Report of the Committee on Life-Zones in the Carboniferous Rocks.

J. Lomas.—Report of the Committee on the Fauna and Flora of the Trias.

Discussion on the Nature and Origin of Earth Movements, opened by the President, Dr. J. Horne, F.R.S., Professor W. J. Sollas, F.R.S., and Mr. J. J. H. Teall, F.R.S.

Professor P. F. Kendall.—Evidence in the Secondary Rocks of persistent movement in the Charnian Range.

Rev. W. Lower Carter.—River Capture in the Don System.

E. Greenly.—The Glaciation of Holyhead Mountain. (See p. 504.)

Rev. O. Fisher.—On the Elephant-trench at Dewlish, Dorset.

Professor P. F. Kendall.—Report of the Committee on Erratic Blocks.

Professor H. Bäckström.—On the Origin of the Great Iron Ore Deposits of Lappland.

A. Harker, F.R.S.—Exhibition of specimens of Tertiary Plutonic Rocks (including Gneisses) from the Isle of Rum.

E. Greenly.—The Lava-domes of the Eifel.

Professor W. W. Watts, F.R.S.—Report of the Committee on Geological Photographs.

Professor H. A. Miers, F.R.S. — Concretions as the Result of Crystallisation.

R. H. Rastall.—Basic Patches in Mount Sorrel Granite. (See p. 501.)

L. J. Spencer.—On the different modifications of Zircon.

R. H. Solly.—A preliminary description of three new Minerals and some curious Crystals of Blende from the Lengenbach Quarry, Binnenthal.

Professor K. Busz.—On the Granite from Gready, near Luxullian in Cornwall, and on some Contact Rocks.

A. W. Dwerryhouse.—Report of the Committee on Underground Waters of North-West Yorkshire.

Professor P. F. Kendall.—Exhibition of a Model of the Cleveland Area, showing Glacier-lakes.

Rev. W. Lower Carter.—On the Glaciation of the Don and Dearne Valleys.

H. N. Davies.—On the Discovery of Human Remains under Stalagmite in Gough's Cave, Cheddar, Somerset.

Dr. Scharff and *G. W. Lamplugh.*—Report of the Committee to Explore Irish Caves.

J. Parkinson.—The Geology of the Oban Hills, Southern Nigeria.

A. W. Gibb.—On the occurrence of Pebbles of White Chalk in Aberdeenshire Clay.

W. G. Fearnsides and *R. H. Rastall.* — On Boulders from the Cambridge District collected by the Sedgwick Club.

Rev. Dr. Irving.—On Stratified High-level Gravels and their Relation to the Boulder-clay. (See p. 497.)

J. N. Shoolbred.—Tidal Action in the Mersey in Recent Years.

Rev. O. Fisher.—The Cause of Compression of the Earth's Crust. (See p. 495.)

Papers bearing on Geology read in other Sections :—

Section D.—Zoology.

Professor W. B. Scott (Princeton, U.S.A.).—The Hoofed Animals of the Santa Cruz Beds of Patagonia.

Dr. C. W. Andrews. — Egyptian Eocene Vertebrates and their Relationships, particularly with regard to the Geographical Distribution of Allied Forms.

Professor H. F. Osborn (Columbia University, New York).—The Evolution of the Horse.

Section E.—Geography.

President's Address (D.W. Freshfield).—On Mountains and Mankind.

Moritz von Déchy.—The Glaciers of the Caucasus.

R. T. Günther.—Changes of Level on the Italian Coasts.
R. H. Yapp.—Vegetation features of the Fen District.
H. Y. Oldham.—Changes in the Fen District.
Dr. Vaughan Cornish.—Report of Committee on Terrestrial Surface Waves.
Dr. Tempest Anderson.—The Lipari Islands and their Volcanoes.
A. W. Andrews.—A Geographical Object-lesson : Passes of the Alps.

Sub-Section of Anthropography.

Professor A. Macalister, F.R.S., Vice-President, in the Chair.

Dr. Valdemar Schmidt. — The Latest Discoveries in Prehistoric Science in Denmark.
Miss Nina F. Layard.—Further Excavations on a Palæolithic site at Ipswich.
Report.—The Lake-Village at Glastonbury.

Section K.—Botany.

Francis Darwin, M.A., M.B., F.R.S., President.

Dr. D. H. Scott, F.R.S.—A New Type of Sphenophyllaceous Cone from the Lower Coal-measures.
Dr. D. H. Scott, F.R.S., and *E. A. Newell Arber.*—On some New Lagenostomas.
E. A. Newell Arber.—A new feature in the Morphology of the Fern-like fossil *Glossopteris.*
Francis J. Lewis.—Interglacial and Post-Glacial Plant Remains from the Peat of England and Scotland.
Dr. D. H. Scott, F.R.S.—Semi-popular Address on a New Aspect of the Carboniferous Flora.

II. — The Geology of Cambridgeshire. By J. E. Marr, Sc.D., F.R.S., Pres. Geol. Soc.[1]

THE main physical features of the county are the Chalk uplands of the south-eastern and southern part, the curious plateau on the west, the Cam Valley between them, and the fenland of the north.

Of Jurassic rocks, the Oxford Clay is not well exposed save near Whittlesea. The Corallian rocks are of considerable interest. Two types occur—the Ampthill Clay facies of the western outcrop and the Calcareous facies of the Upware Inlier. The Elsworth rock forms the base of the deposits of each of these types, and its relationship to the members of the Calcareous facies is a subject still under discussion. The Upper and Lower Kimeridge Clay are found at Ely and in the neighbourhood of that city.

Of Cretaceous rocks the Lower Greensand is well seen near Gamlingay. The old phosphate workings of Wicken are now closed. The Gault is seen in many exposures. Most of the sections exhibit Lower Gault, but Mr. Fearnsides has recently detected the Upper Gault in the Barnwell brick-pit. The basal member of the Chalk,

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

the well-known Cambridge Greensand phosphatic seam, lies unconformably upon the Gault. It is succeeded by various divisions of the Chalk up to the zone of *Micraster*.

The glacial deposits consist chiefly of the Chalky Boulder-clay; the great boulder at Ely is also of interest.

The Pleistocene gravels include the plateau gravels on the Chalk hills and the well-known mammaliferous gravels forming terraces on the valley-sides. The March marine gravels are usually correlated with the gravels of one of these terraces.

Alluvium is found on the valley-bottoms, and in the fenland peat occurs with intercalated patches of *Scrobicularia* clay. The peat contains the fauna of Neolithic and later times.

III.—The Great Eastern Glacier. By F. W. Harmer, F.G.S.[1]

THIS name is proposed for the great ice-stream the moraine of which, the Chalky Boulder-clay, covers an area of more than 5,000 square miles in the east of England, frequently attaining a thickness of more than 100 feet.

As far back as 1858, Trimmer, a pioneer in glacial investigation, pointed out that the county of Norfolk had been twice invaded by ice, first from the North Sea and then from the west, the resulting detritus in the one case being characterised by igneous blocks, some of them of Scandinavian origin; and in the other by a predominance of Jurassic material. The first invasion is represented by the Cromer Till and the Contorted Drift of the Norfolk coast; the second, by the Chalky Boulder-clay, the subject of the present paper, which does not occur in north-east Norfolk.

The region covered by the latter deposit, which extends over a great part of the eastern counties of England, has a palmate outline, its lobes, which radiate from the great depression of the Lincolnshire and Cambridgeshire Fens, being of unequal length. The latter region was not only the centre whence the Chalky Boulder-clay of the southern part of the area was distributed, but also the quarry out of which was excavated most of the enormous mass of Jurassic material of which the matrix of this deposit is so largely composed.

The present physiographical features of the east of England resemble, more or less, those which obtained in Glacial times, the Drift deposits not only covering the plateaux between the valleys in which the rivers of the district now run, but descending into them, sometimes to below sea-level. Hence by the study of the existing contours, aided by that of well-borings, it is possible to obtain a general idea of the pre-Glacial topography by which the movements of the ice must have been determined or influenced.

Although the erratics of the Chalky Boulder-clay are more or less of a similar character over a wide area, indicating that it was distributed from a common centre, the predominant character of its

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

detritus varies in different districts, in accordance with that of the strata over which the ice had moved. The matrix of the Boulder-clay of South Norfolk and North Suffolk, for example, has been largely derived from the Kimmeridge Clay. Over this region, which formed in Glacial times a shallow trough running east and west, corresponding with the present depression of the basins of the Little Ouse and the Waveney, as well as with the gap in the Chalk escarpment between Swaffham and Newmarket, the ice evidently poured in great volume, planing down the surface of the Chalk and carrying its Kimmeridgian material fifty miles to the east from its original source in the Fen basin. On the other hand, although the Fen ice was sufficiently thick to enable it to overflow the Chalk hills between Newmarket and Royston, it only travelled thence to the south-east for about half that distance. In this region the Boulder-clay is chalky near the escarpment, while beyond the outcrop of the London Clay it is mainly composed of detritus from that formation.

Along the basin of the Ouse, where its matrix is largely Oxfordian, the ice to which it was due advanced much further, to Buckingham and beyond, as it also did along that of the Nene, in the direction of Northampton, where Liassic débris is common. On the contrary, the high land near the head waters of the Welland obstructed the ice-flow, so that but little Boulder-clay seems to have found its way into the area comprised in Sheet 53 of the Ordnance map. The greater part of Sheet 63, however, is covered by it, and it there reaches an elevation of 730 feet above the sea-level. Much of the Boulder-clay of this region, in the author's opinion, was due to the ice-stream of the Trent Valley, having been piled up upon the high land to the east of Leicester by the pressure of ice descending from the Pennines.

It seems probable that the whole of the low-lying region between the Lincolnshire Wolds and the Pennines was filled with ice during the period of maximum glaciation. It is not physically possible that any considerable thickness of ice could have existed on one side only of the Lincolnshire ridge, which does not often exceed an elevation of about 200 feet above the lower ground adjoining it.

The author hopes to make the ultimate source of the Chalky Boulder-clay ice the subject of a future paper. The prevalence of Carboniferous débris in the East Anglian region seems to indicate, however, that a part of it at least was of Pennine origin; another part may have been due to an overflow from the North Sea across the lower part of the Chalk Wolds, and the ice may also have been reinforced by the abundant precipitation to which this district was subject during the Glacial period; the moisture-bearing cyclonic disturbances from the Atlantic, to which the enormous accumulation of ice in the Baltic region was due, must have passed near the eastern counties of England. There is no evidence to show that any considerable amount of ice entered East Anglia through the Wash gap during the Chalky Boulder-clay period, all the facts known to the author appearing to point in an opposite direction.

IV.—On a Great Depth of Drift in the Valley of the Stour. By W. Whitaker, F.R.S.[1]

SEVERAL cases of great irregularities in the thickness of the Drift have been shown by borings in Suffolk, and the existence of deep channels filled with Drift has been practically proved, as also in the neighbouring counties of Essex and Norfolk. In some cases these channels cannot be shown on the map, the Glacial Drift being hidden by deposits of later age, and this is markedly the case in the upper part of the valley of the Cam, where at one place (Newport) the Drift has been pierced to the depth of 340 feet without reaching the bottom.

In Suffolk the greatest amount of Drift recorded is at Brettenham Park, where apparently a thickness of 312 feet has been found. But this and all other records in East Anglia are now put into the shade by the result of a boring near Glemsford railway station. This is at a low level in the valley of the Stour, in the tract formed by the sand and gravel that crop out from beneath the Boulder-clay of the higher ground. Here one would have expected, perhaps, some 50 feet of Drift, but certainly not more than 100. No less than 477 feet have been passed through before reaching the Chalk.

The gravel and sand that form the surface reached to a depth of 51 feet, as might have been expected; but then the unexpected occurred, no less than 228 feet of Boulder-clay (partly sandy) having been found, with a mass of sand and clayey sand beneath.

We seem here, then, again to have evidence of a very deep Drift-filled channel. A well in the village, at a higher level, has reached Chalk after passing through 120 feet of Drift; so the channel does not reach far northward, nor does it reach to Foxearth, in Essex, about a mile to the south, where there is a still less thickness of Drift. As to its direction or extent, however, we can say little as yet.

One may add that a boring (? unfinished) in Euston Park has proved over 150 feet of Drift, at a spot where no Drift is shown on the map. This may be simply a huge pipe.

V.—Some Cambridgeshire Wells. By W. Whitaker, F.R.S.[1]

SINCE the publication of the latest Geological Survey memoir dealing with the county further records of nineteen additional well-sections at sixteen places have been obtained.

These vary in depth from 40 to 284 feet, and pass through various formations from Drift to Lower Greensand. None have any special interest; but the whole forms a useful addition to our knowledge of the geology and water-supply of the county.

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

VI.—Report of the Committee to investigate the Fossiliferous Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire. Chairman, Mr. G. W. Lamplugh; Secretary, Mr. J. W. Stather.[1]

It has only been found possible during the present year to complete the investigation of the deposits at Kirmington and Great Limber, but it is hoped in the future to extend operations to Bielbecks and several other sections that require further elucidation.

Kirmington Section.

The work on this important section, which was begun last year, has now been carried to a successful conclusion; and the results show that in some respects this section has no known parallel in English drift sections. It will be remembered that, as described in last year's report, a brickyard is worked at this place in a mass of warp or clay containing estuarine shells, with a fresh-water bed at its base, and that this deposit is overlain by a bed of coarse flinty shingle, above which in one part of the pit there is found a few feet of red stony clay believed to be a boulder-clay. The boring last year proved the presence of a glacial clay at some depth beneath the warp. The chief object of our investigation has been to discover the relationship of the fossiliferous warp to the Glacial Series, and to carry the boring through the superficial deposits to the chalk, which was not reached last year.

During June of the present year a new boring was carried out under the personal supervision of the Chairman and Secretary, with the assistance of Mr. G. W. B. Macturk. Mr. Villiers, well engineer, of Beverley, undertook to put down the boring, and the Committee desire to express their indebtedness to him for the ready manner in which, at considerable personal inconvenience, he met their wishes as to the time and conditions of the work.

In order to secure a section in another part of the pit, the site of the new boring was fixed at a point 80 yards north-east of last year's boring. Although at the spot chosen the warp used for brickmaking had been excavated to a depth of 5 feet below the level of its base at the former site, this material was passed through in the new boring to a further depth of 3 feet, so that its base is here 8 feet below its position in the former boring. The total depth attained by the new boring, combined with the height of the open section, was 96 feet, or 41 feet lower than was reached last year. The surface of the chalk lay much deeper than was anticipated, and the borings seem to prove that the surface features of the locality are not due to the presence of chalk, as hitherto supposed, but that the rising ground has been formed by the erosion of a thick and complex mass of drift.

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

The diameter of the second boring was at first 4 inches, narrowing to 3 inches at a depth of 15 feet. It was found necessary to line the boring with the tubes throughout.

The section seen in the brickyard and proved in the borehole was as follows :—

	ft.	in.
Surface soil (at 95 feet above O.D.)	1	0
Clay with foreign stones (see NOTE A)	4	0
Well-worn shingle, principally of battered flints	8	0
Laminated warp with estuarine shells, and at its base a thin seam of peat associated with a sandy warp containing fresh-water shells in one part of the pit (see NOTE B)	18	6
Clean yellow sand, with pebbles of chalk and flint	4	9
Red clay passing downwards into tough reddish-brown clay ...	7	6
Purple clay, streaked with silt and loam, passing downwards into tough purple clay with small stones, including some erratics (see NOTE C)	10	6
Stoneless purple clay	5	0
Stoneless yellow clay	6	0
Flinty gravel	4	6
Yellow clay and loam with small drift pebbles	5	0
Yellow sand, full of well-rounded quartz grains and specks of chalk	8	0
Yellow sand and laminated clay	4	0
Tough compact bluish-grey or lead-coloured clay, with a few small foreign pebbles (see NOTE D)	5	3
Tough yellow clay streaked with chalk	1	0
Solid chalk and flint	3	0
Total	96	0

NOTE A.—Among the erratic stones which this clay contains the following were identified: basalt, porphyrites, rhomb-porphyry, grits, etc.

NOTE B.—Mr. Clement Reid records from this bed *Scrobicularia piperata*, *Rissoa ulvæ*, *Tellina balthica*, *Cardium edule*, *Mactra subtruncata*, *Mytilus edulis*, and abundant Foraminifera (see Mem. Geol. Survey, Holderness, p. 58).

NOTE C.—In general appearance this clay resembles the Purple Clay of Holderness. Among the pebbles washed out of 30 lb. of the clay brought up by the augre, chalk and flint greatly predominate, but the following rocks were also represented: red chalk, black flint, Spilsby sandstone, ferruginous pebbles, quartz, basalt, and porphyrites, besides many undeterminable small pebbles.

NOTE D.—This clay is hard and tough, and very different from A and C both in texture and colour. It resembles in colour the Basement Clay of Holderness. The pebbles are smaller in size than in C, and there is a still higher proportion of chalk and flint. Among the erratic pebbles the following are recognizable: basalt, porphyrite, sandstone, black flint, grit, quartz, etc.

Mr. Reid has examined the plant remains obtained by the Committee from the band at the base of the warp, and reports as follows :—"The plant remains obtained by Mr. Stather from the peaty warp belong to the following species :—

Ranunculus sceleratus, Linn.
Eupatorium cannabinum, Linn.
Aster Tripolium, Linn.
Lapsana communis, Linn.
Mentha aquatica, Linn.
Labiate (much crushed)
Atriplex?
Zannichellia pedunculata, Reichb.
Scirpus setaceus, Linn.
,, *maritimus*, Linn.
,, sp.
Carex incurva, Lightf.

"The list is a small one, but it indicates estuarine conditions, and suggests a sub-arctic climate. With one exception the plants are still to be found in the neighbourhood of the Humber; but one of them, *Carex incurva*, is a sea-coast sedge not now ranging south of Holy Isle.

"A striking peculiarity of the deposit is the abundant remains of the estuarine sedge, *Scirpus maritimus*, a plant which, growing out of a few inches of water, tends to form a thick belt through which few drifted seeds would find their way. In view of the abundance of this sedge in the bed now examined and of the like-growing reed, *Phragmites communis*, in the deposit which I searched some years ago, the small number of other plants yet detected is not surprising. Land plants are only represented by two fruits of *Lapsana*, perhaps brought by birds. These fruits of *Lapsana*, as well as those of the sea-aster, are considerably smaller than my recent specimens, but I have not yet had an opportunity of comparing them with fruits of the same species near their northern limit."

From the fresh-water shell-bed associated with the peat, Mr. E. T. Newton has determined *Planorbis spirorbis*, *Bithynia tentaculata*, with probably *Candona* (an Entomostracan).

Great Limber Section.

A boring was also put down under the supervision of Mr. G. W. B. Macturk, who kindly undertook to aid the Committee in this manner, at the Great Limber brickyard, three miles south-east of Kirmington, where there is a further development of warp and sand, believed by Mr. C. Reid to be of the same age as the Kirmington deposit, though no fossils have been found in it. The section seen in the brickyard and proved in the boring was as follows :—

	ft.	in.
Surface soil and clay with stones (at 110 feet above O.D.)	4	0
Loamy sand contorted and mixed with warp	4	0
Laminated blue warp with sandy streaks	10	0
Pan	1	3
Current-bedded sand	4	9
Sharp sand	8	0
Flint, sand, and rounded chalk pebbles	5	0
Solid chalk with flints	1	0
Total	38	0

In comparing this section with the one at Kirmington it should be noted, (1) that no shells have been found in the laminated warp at Limber; (2) that the warp does not rest on glacial clays; and (3) that the base of the Limber warp is 92 feet above O.D., or 28 feet higher than that of Kirmington.

It would be premature to discuss the problems raised by these interesting sections until the work of the Committee has been carried further. For the present, therefore, we desire only to record the data thus far obtained.

The thanks of the Committee are due to Mr. W. H. Crofts and Mr. G. W. B. Macturk for practical help in many ways; also to the Earl of Yarborough (landlord), E. P. Hankey, Esq. (agent), and the occupiers of the brickyards—Mr. Hervey and Mr. John Housan—for permission to put down the borings.

VII.—Geology and Agriculture. By F. J. Bennett, F.G.S.

[Abridged from article contributed to the *Land Agents' Record* (August 20th, 1904) on the uses to which Ordnance Maps might be put for Estate Records.]

MUCH valuable information is lost, both to the landowner and farmer, to say nothing of the geologist, for want of recording it at the time. How often is land drained and no record made of the soil turned out, and the courses of the drains not laid down on the estate maps? Post-holes and excavations of all kinds are made and no record kept at the time. And yet how easy to put all these down on the map itself, a record for all future time, and constantly under the eye of the owner and occupier. The map itself, the back as well as the front, is most obviously the proper place for these notes. Yet how very few persons use these maps in this way.

Scotch farmers seem to succeed in England where our farmers cannot, and why is this? One great reason is that they are far more systematic than ours are, and they record the results of each field year by year.

Let us take the case of a person purchasing an estate. To a large extent he would, in a usual way, be very much in the dark as to the real nature of the property he had purchased. He would, of course, have all the information the seller could afford him, and that would vary very much according to the way in which the estate had been managed. He might be able to obtain 1 in. or even 6 in. maps of the Geological Survey, both Solid and Drift, with, in many cases, the accompanying memoirs; and, according as he was able to understand them, they would give him much or little information. Yet to most this would be of a superficial or vague nature on many points, and perhaps could not give the details most useful to him. But if he had followed the plan adopted, I believe, in the best estate offices, the 25 in. Ordnance maps would have been used, and on these maps all the divisions of the fields would have been marked at the time the survey was made, and the estate maps would, no doubt, have been brought up to date by marking on them any alteration subsequently made. There would, no doubt, be a schedule of the amount of arable and pasture and woodland, with the kind of trees, water, and roads, and there might be a rough division of the soil into heavy and light.

Soil.—Now, let us suppose that the late owner had made these maps in the way this paper suggests. Say, that on each field division be noted the nature of the soil and subsoil, whether clay, sand, loam, gravel, chalk, etc., and the qualifying character of these. Of course difficulties would arise as to how this information could be obtained. Here, then, I would suggest that a visit should be paid to the Geological Survey Office to ascertain what information was available. As a very useful preliminary to this visit, trial holes, or trenches preferably, could be dug, especially in the pasture lands, so that the subsoil could be exposed. In this way a kind of soil map could be made and recorded on the map or schedule accompanying it. Field names should also be noted, with their oldest and latest ways of spelling these, with the dates.

Wells.—These should be all marked on the map, whether in use or not, and all measured, and their total depth given, and that of the water and the variation of this, and, where possible, a record of the soils and subsoils met with when this well was sunk and the name of the sinker.

Springs.—All these should be marked, and their variations and highest point in any special year, going as far back as possible.

Quarries.—All these should be noted, and characters recorded on the map.

Pits.—Where old pits exist, often, of course, grown over, it will be found of the utmost importance, where all record has been lost, that they should be cleared and their true character ascertained.

Drains.—Now, perhaps, the most important detail has been left to the last. I am informed that, in most cases, where land has been drained the courses of the drains have not been laid down on the estate maps, so that very often much of the money thus expended has, for practical purposes in after years, been lost, and where the drains have ceased to work much time and expense have been incurred, sometimes to no purpose, in seeking the outlets, etc. All this would have been avoided had their courses been laid down on the maps. To record the nature of the soil dug out, when drains are being made, is of the utmost importance to the agriculturist and geologist, and this should be especially noted on the map. As the Government indirectly lends large sums of money for land drainage I would suggest that the Government stipulate in the future that the courses of all land drains should be laid down on the estate maps, and the nature of the soil recorded, and that a copy and tracing of the drains be deposited with the Government Department.

I would here suggest a further use of these 25 in. maps for the recording on them by farmers of certain agricultural notes relating to crops, etc.

On each of the field divisions year by year, and in one line if possible (so that the records of several successive years might be placed on the same division for reference, especially if contractions were used), should be noted the amount of seed sown, the kind and quantity of manure used, and the weather at the time; also the result of the crop, such as weight of grain, length of straw, etc., and the same with other crops. If the results of seven years were thus recorded they could be taken in at a glance and the reason often seen for success in one year and failure in another, and the varying results where different manures had been used could also be noted in a field-book. The different kinds of trees and their growth in relation to the soil should be noted both by farmers and landowners. Many farmers, no doubt, would object to all this as an additional and useless labour on their part; but I would suggest that such information would be of the utmost value to the incoming farmer, and would, of course, be the private property of the late occupier. The incoming tenant should be very glad to pay a very substantial sum for this accumulated information, as, without this, he might have to spend years and lose much valuable time and money in finding it out. Thus the late occupier would find that he had not only been getting together much valuable information for himself, but information of such a nature that the incoming tenant would be glad to buy it.

VIII.—Brief Notices.

1. The Yorkshire Philosophical Society.—The Annual Report of this Society for 1903 is a trifle more bulky than usual, separate copies of Dr. Anderson's paper on the West Indian Eruption, which was published by the Royal Geographical Society, together with the 12 plates and map which accompanied the original paper, being inserted.

2. Cambrian of Portugal. — A fine series of fossils from the calcareous schists of Alemtejo is described by J. F. Nery Delgado (see Comm. Serv. Geol. Portugal, 1904, 6 pls.). Delgado considers the fauna nearly allied to that of *Olenellus*, and that it is more ancient than the Cambrian fauna of Spain, which certainly belongs to the zone of *Paradoxides*. The fauna contains *Paradoxides*, *Olenopsis*, *Hicksia*, *Microdiscus*, *Metadoxides*, and *Olenellus* among the Trilobites, *Lingulella*, *Obolella*, *Acrothele*, *Hyolithes*, and many Lamellibranchs. The plates contain photographic figures and are excellently produced.

3. Reclassification of the Reptilia. — Professor Osborn has printed in the *American Naturalist* for February, 1904, his paper on the reclassification of the Reptilia, read before the Society of Vertebrate Palæontologists at Philadelphia in December, 1903. He arrives at the following conclusions:—

The birds probably originated from a group of Diaptosauria identical with or closely related to that which gave rise to the Dinosauria. It is not true that birds have descended from Dinosaurs, but there is very strong evidence that birds and Dinosaurs are descended from a common stock.

There is no question that the mammals are affiliated with the subclass Synapsida rather than with the Diapsida; both in skull and shoulder-girdle structure and in the phalangeal formula they are Synapsidan. As to their nearer relationships they appear to be rather with the superorder Anomodontia and with the order Cynodontia or Theriodontia. The divergence of the mammal stem from these typical reptiles will probably be found to have occurred in the Permian or Trias of South Africa.

4. Geology of Tunis.—Under the title "Etude géologique de la Tunisie centrale," Dr. L. Pervinquière has written a detailed monograph around a really magnificent map of the country, geologically coloured. The formations dealt with range from the Pleistocene to the Trias, the fossils themselves being referable to the Lias, Oxfordian, Portlandian, Neocomian, Aptian, Arbian, Cenomanian,

Turonian, Senonian, Eocene, Oligocene, Miocene, and Pliocene. The country seems remarkable for the isolated Triassic hills which stand up boldly from the surrounding country. A list of previous works on Tunis is given, and M. Pervinquière deserves our thanks for a valuable addition to African geology. The book is issued from Paris (Direction Générale des Travaux Publics), 1903. Price 15 frs.

5. *Merycodus.*—A fine and perfect skeleton of the hypsodont group of ruminants has been described and figured by W. D. Matthew (in the Bull. Amer. Mus. N.H., xx, 1904). This is *Merycodus osborni*, a form related to the antelopes, but with branching, deciduous antlers like those of the deer. The specimen came from the Middle Miocene (Pawnee Creek Beds) of north-eastern Colorado, and was found by Mr. Barnum Brown, of the American Museum Expedition of 1901. The paper sketches the other known species of the genus as well as species of the genera *Blastomeryx, Lapromeryx,* and *Palæomeryx.*

6. The Mines of Hualgayoc, Peru.—Situated in a volcanic region, in which the sedimentary rocks seem to be of Cretaceous age from their fossil contents, the mines of Hualgayoc yield an abundance of minerals. Those chiefly worked are lead and copper, and this paper (published in the Bol. Cuerpo Ingen. Minas Peru, No. 6, 1904), by F. Malaga Santolalla, is mainly devoted to them. Hualgayoc is a province of Peru, and the author prefaces his description of the mines with a sketch of the geography, history, and geology of the area. The paper is well illustrated and has a topographical map.

7. Tertiary Fauna of Florida.—Dr. W. H. Dall has recently published in the Transactions of the Wagner Free Institute of Science the concluding part of his "Contributions to the Tertiary Fauna of Florida." This consists of the molluscan fauna of the Silex beds of Tampa and the Pliocene beds of the Caloosahatchie river, and includes in many cases a complete revision of the generic groups treated of and their American Tertiary species. This part vi runs from p. 1219 to p. 1654, pls. xlviii–lx, and with an index brings a laborious and valuable work to a successful conclusion.

8. North Polar Expedition, 1893–96.—Messrs. Longmans & Co. have published vol. iv of the scientific results of this expedition, edited by Dr. Fridtjof Nansen. The volume before us contains Dr. Johan Kieer's paper in the Lower Silurian at Khabarora. The age of the beds appears to be of the Scandinavian Esthonian type, and praise is due to Dr. Kieer and Dr. Brögger for successfully dealing with such unpromising material. Dr. Nansen contributes to this volume his "Bathymetrical features of the North Polar seas, with a discussion of the continental shelves and previous oscillations of the shore-line," illustrated by maps and plates.[1]

9. Relief Map of North America.—Although dated as long ago as 1901, it may be worth while to call attention to a publication of the Geological Survey of Canada entitled "Altitudes in the Dominion

[1] See Professor Hall's Review in our August Number, p. 422.—Ed. Geol. Mag.

of Canada, with a Relief Map of North America." This is on a scale of 200 miles to an inch, and shows elevations at 100, 1000, 5000, 10,000, and above 10,000 feet, and does not seem to be generally known.

10. Primitive Fossil Fishes.—M. Ad. Kemna contributes to the Bull. Soc. Belge Géol., xvii, 1903 (1904), a general review of recent discoveries in fossil fishes of the earliest period. The writer bases his review on the papers of Dr. Traquair and Dr. Smith Woodward, and after pointing out the importance of the more ancient fishes, refers to their zoological position, and sketches in some detail the families Heterostracidæ, Osteostracidæ, and Anaspidæ.

11. Excursions in Belgium.—M. Rutot has provided a full report of the excursion of the Belgian Society of Geology, Palæontology, and Hydrology to Hainaut and the environs of Brussels in 1902. It is published in the Bulletin, xvii (5), 1904. The district traversed was from Erguelinnes to Leval-Trahegnies, Mons, Vaulx lez-Tournai, Blaton and Hautrage, Brussels and environs; and the jaded British geologist might do worse than spend his four days over this ground. The geology covers the Landenian, Bruxellian, Ypresian, and Montian, and fossils are abundant.

12. Oligocene of Poland.—M. K. Wójcik has found in a small valley in Kruhel Maly, near Przemysl, on the northern border of the Middle Carpathians, a dark clay or sandy clay-bed with Mollusca and Foraminifera. Of the forms found 46 out of 60 belong to the Lower Oligocene of North Germany, as described by Von Koenen, and 8 of the 14 remaining species are found in the Vicentinian beds described by Fuchs and Oppenheim. The whole fauna is comparable to that of the *Clavulina szaboi* beds of Von Hantken. Accompanying the paper, which appears in the Bull. intern. Ac. Sci. Cracovie, 1893, No. 10, are two plates of shells and Foraminifera.

13. Minerals of Colombia.—A new journal has reached us from the Republic of Colombia, "Trabajos de la Oficina de Historia Natural," Bogata, 1904. This tract of 27 pages contains an account of the alkaline and earthy minerals of Colombia, by Ricardo Lleras Codazzi, chief of the section of Mineralogy and Geology.

14. Cinnabar from Peru.—Augusto F. Umlauff publishes in the seventh "Boletin del Cuerpo Ingenìeros de Minas del Peru" a long account of the Huan Cavelica mercury deposits, with map and sections. The ore seems to occur indiscriminately throughout the mass, as at Santa Barbara it is described and figured as occurring in Andesites, Amphibolites, Basalts, Sandstones, Limestones with Cretaceous mollusca, and Conglomerates. No description of the fossils is given; it being merely stated "molluscs and others very abundant."

15. 'Exotic Blocks' of the Himalayas.—In the Comptes Rendus of the Ninth Congress of Geologists held at Vienna in 1903, just published, we find Dr. C. L. Griesbach's note on the 'exotic blocks' of the Himalayas. These are masses of limestones of Nummulitic

age, often converted into marble, which rest, and in some cases are enclosed in, igneous rocks. They occur in the Tibetan area. These blocks would appear to be the result of the action of huge igneous flows, which, passing through the dislocated rocks, tore off and bore to the surface masses of rudimentary rock, together with other loose masses, the result of the dislocating and faulting itself. Dr. Griesbach thinks that all this was part of the general Himalayan upheaval, which falls into the period after the deposition of the Upper Cretaceous system and prior to the deposition of the younger Tertiaries, and fits into the period during which the great flows of Dekkan Trap took place in India.

16. Bradford Glacial Lakes.—The Bradford Scientific Association have started a new quarterly called the *Bradford Scientific Journal* (No. 1, July 1904), and the opening paper deals with "The Glacial Lakes of the Bradford District," by J. E. Wilson. The author gives a map, and states that a note of his conclusions appeared in the Report of the British Association for 1900.

17. Persimmon Creek Meteorite.—This iron came from North Carolina in 1893, and is now in the U.S. National Museum. It is described in the Proc. U.S. Nat. Mus., xxvii (1904), by Wirt Tassin, as "a more or less continuous matrix of iron containing troilite, schreibersite, and carbon." Its present weight is 9 lb. 6 oz., but a fragment weighing about 1 lb. 13 oz. has been broken off.

18. Museums.—It may be well to call attention to the Vorberichte für die xii Konferenz (Centralstelle für Arbeiter - Wohlfahrtseinrichtungen), 1903, in Mannheim, which contains Gill Parker's account of the Ruskin Museum and Lehmann's account of the Altona Museum, among other papers.

19. Fresh Fossil Egg.—Messrs. W. C. Morgan and M. C. Tallman described in Bull. Geol. Univ. Calif. Publications (iii, 1904) an egg from a pebble in a placer deposit on the Gila river in Arizona. The egg formed the centre of a rounded mass of hard calcareous rock, which was removed so as to allow of an examination of a fresh surface of the shell. The authors say that the egg corresponds fairly well to the type of egg laid by a cormorant, and with that and some photographic illustrations we must content ourselves.

20. Erratic Blocks.—Special attention should be called to the Eighth Report of the Committee on the Erratic Blocks of the British Isles (Rep. Brit. Assoc. for 1903, 1904), as in it the Secretary, Professor Percy F. Kendall, has drawn up a summary of the records accumulated during the past thirty-two years from England, Wales, the Isle of Man, and Scotland.

21. The "Records of the Geological Survey of India," established in 1868, published hitherto in yearly volumes until 1897, when it was amalgamated with the "Memoirs." With a view to the rapid publication of short papers and notes on Indian geology, it is now being continued again as before. Private workers are invited to contribute. The current number (vol. xxxi, pt. 1, 1904) contains

papers of economic importance; on an occurrence of copper ore in the Darjiling district, and on coal deposits in Punjab and Assam. Various mineralogical notes and technical assays are appended.

22. *Stylonurus* in the Baltic Silurian.—The genus *Stylonurus* has not hitherto been recorded from the Baltic region, but Dr. F. Schmidt, in examining a specimen collected from the uppermost Silurian of Rotziküll on the Island of Oesel, has come to the conclusion that it represents a fragment of this Merostomatous Arthropod. He bases this conclusion on the general form of the body, which tapers somewhat rapidly backwards, the shape of the four-jointed limb fragment with terminal spines, and the ornament of the body-segments. At the same time the species, which he names *Stylonurus* (?) *Simonsoni*, after the collector, may belong to some hitherto undescribed genus. The specimen presents some interesting features, especially two grooves on the dorsal side of the carapace, giving it a somewhat trilobed appearance. Portions of the underside of the head-shield are preserved, including a complete metastoma, a structure hitherto unknown in *Stylonurus*; it is distinguished by its pyriform outline. Dr. Schmidt's paper, which appeared in the *Bulletin* of the Imperial Academy of Sciences of St. Petersburg for March, 1904, is illustrated by a plate.

23. A large *Prestwichia*.—Among the papers of the late Professor C. E. Beecher was found a manuscript which has been printed in the Amer. Journ. Sci., July, 1904. This manuscript describes (and figures) a cephalothorax of *Prestwichia signata*, sp.n., from the Fort Riley Limestone of the Lower Permian, three miles west of Stockdale, Kansas. The specimen has a length of 45 mm., and is of especial interest as coming from a higher horizon than any other American species yet known.

REVIEWS.

The History of the Collections contained in the Natural History Departments of the British Museum. Vol. I: The Libraries—The Department of Botany—The Department of Geology—The Department of Minerals. 8vo; pp. xviii and 442. (London: printed by order of the Trustees of the British Museum. Sold by Dulau & Co., 37, Soho Square, W., and others. 1904. Price 15*s*.)

This volume contains the history of the libraries and of the collections in the Departments of Botany, Geology, and Minerals. A second volume (not yet issued) will contain the history of the collections in the Department of Zoology.

"The possibility of producing such a history as the present is," says the Director in his Preface, "a remarkable evidence of the care and efficiency with which the records of the Museum have been kept during the past century. The value of the book to workers in the various branches of Natural History will be very great. It not only furnishes an interesting record of the names of hundreds who have contributed to build up our science during the nineteenth century, but it will prove to be of assistance to investigators who are anxious to discover the present depository of specimens or collections referred to in old publications and to compare them with later examples. It will also furnish to a very large number of persons, who at present are not informed on the subject, a correct idea of the variety, extent, and importance of the immense series of collected specimens which are here carefully guarded and kept in orderly arrangement, 'not only' (according to the terms of Sir Hans Sloane's will) 'for the inspection and entertainment of the learned and curious, but for the general use and benefit of the public to all posterity.'

"Mr. B. B. Woodward has written the history of the libraries; Mr. George Murray, assisted by Mr. Britten, that of the Department of Botany; Dr. Arthur Smith Woodward, with valuable help from the late Keeper, Dr. Henry Woodward, and from the present Assistant Keeper, Dr. Bather, that of the Department of Geology; and Mr. Fletcher, that of the Department of Minerals."

The actual foundation of the British Museum dates from the year 1753, when an Act of Parliament was passed "for the purchase of the Museum or Collection of Sir Hans Sloane, and of the Harleian Collection of Manuscripts, and for providing one general repository for the better reception and more convenient use of the said Collections and of the Cottonian Library and the additions thereto."

The collection of Sir Hans Sloane contained in his residence, The Manor House, Chelsea, consisted of "books, drawings, manuscripts, prints, medals and coins, ancient and modern antiquities, seals, cameos and intaglios, precious stones, agates, jaspers, vessels of agate and jasper, crystals, mathematical instruments, pictures, and other things," which last included numerous zoological and geological specimens and an extensive herbarium of dried plants preserved in 310 large folio volumes.

The Cotton Manuscripts were already the property of the nation, having been acquired by gift in 1700. The Harleian Collection was obtained by purchase at the same time as the Sloane Collection, and the three were brought together under the designation of "the British Museum," placed under the care of a body of Trustees, and lodged in Montagu House, Bloomsbury, purchased for their reception in 1754.

Admission to visit the Museum was limited by ticket, issued only on application in writing, and to not more than ten persons for each of three hours in the day; the hours were subsequently extended, but it was not until the year 1810 that the Museum was accessible to the general public for three days in the week from 10 o'clock to 4. The present daily opening, with longer hours in Summer, dates only from 1879. The collections soon outgrew the limits of the original Montagu House and also its successor, the present classical building, completed in 1845. The erection of the magnificent reading-room in 1857 disposed for a time of the difficulty of finding accommodation for the ever-growing library, but the keepers of the other departments continued urgent in their demands for more space; and after much discussion of rival plans for keeping the collections together and obtaining the needful extension of room by acquiring the property immediately around the old Museum, or for severing the collections and removing a portion to another building on a fresh site, the latter course was finally decided upon. In 1863 the House of Commons sanctioned the purchase of part of the site of the International Exhibition of 1862, in Cromwell Road, South Kensington, with a view to appropriating it to the purpose of a Museum of Natural History.

The considerations of the various plans for the new buildings occupied a long period of time, Mr. Alfred Waterhouse, the architect, finally obtaining for his design the approval of the Trustees in 1871. The present building was commenced in 1873, and was handed over to the Trustees completed, but without internal fittings, in June, 1880. The great labour of removing the collections to the new building was commenced, and a part of the Departments of Geology and Mineralogy were opened to the public on April 18th, 1881.

The history of the growth of the great collections in the British Museum runs parallel to the growth of natural knowledge, as exemplified by the establishment of the various learned Societies which have been founded for its promotion. Thus, in 1756 the National Museum consisted of three departments only, (1) Printed Books, (2) Manuscripts, (3) Natural History; strange to say, this last department included antiquities, coins, and medals! In 1807 the last-named department was divided into the Department of Natural History and Modern Curiosities and of the Department of Antiquities and Coins.

In 1827 Robert Brown was appointed Keeper of Sir Joseph Banks' Botanical Collection, and by adding to this the Sloane herbarium and other dried plants a separate Department of Botany was formed. In 1837 the Mineralogical and Geological branch, under Mr. C. König, Keeper, and the Zoological branch, under Mr. J. G. Children, were created. The last subdivision occurred in 1857, when Mineralogy and Geology were split up into two departments, and the four departments so formed have remained intact to the present time.

Originally, the Royal Society, which was founded in 1660,[1] *represented all the Natural Sciences* till 1788, when the Botanists seceded, with others, and formed the Linnean Society. The Geologists made another separate Society in 1807, and the Astronomers in 1821. The Zoological Society commenced its existence in 1826. The Chemists founded a separate Society in 1841. Many others might be named, as the Entomological Society founded in 1833, while the Mineralogical and Malacological Societies have a still more recent origin. But the swing of the pendulum of time seems now changing in favour of reunion, or perhaps of reorganisation; and

[1] The Antiquaries formed a Society in 1572, were dissolved in 1604, reconstituted in 1717, and obtained their charter in 1751.

one would not be surprised to learn that Zoology and Palæontology in the Natural History Museum had been recombined together as representing Animal Biology; in fact, the late Director, Sir William Flower, and the present Director, Professor Ray Lankester, have both strenuously aimed at bringing the recent and extinct forms of animal life together into one series. It is remarkable that notwithstanding the various attempts to change the existing order of things (as e.g. that of the Kew authorities to absorb the Botanical Department into the Kew Herbarium, and the plan suggested by Professor Maskelyne, many years ago, to transfer the Mineral Collections to the Royal College of Chemistry, or to the Royal School of Mines), they all failed, and these departments still remain firmly united to the Natural History Museum, and the Geological Department still enjoys a separate and distinct existence.

It would be impossible in a brief notice like the present to give an adequate notion of the amount of labour bestowed in working up the historical records of the Museum in the past 150 years, presented to us in this interesting volume, bringing out as it does, in an orderly and succinct form, the story of the three great Departments and of the Libraries attached to them; but to any person interested in the progress of Natural History in this country this book will afford the greatest pleasure, not only to read, but to possess, as a most valuable work of reference for all time.

CORRESPONDENCE.

ICE-ACTION ON WINDERMERE.

Sir,—As one of the party that visited the cliffs in the neighbourhood of Cromer in connection with the recent meeting of the British Association, I was greatly interested, as we all were, with what we saw and with the able exposition given by Mr. Clement Reid; and it occurred to me that what I have observed of ice-action on a small scale when Windermere, in 1895, was completely frozen over might be of some interest to students of ice-action on a far grander scale in past ages, of which we see traces in the present day. I was encouraged in this view by some of the members of Section C to whom I mentioned what I had seen. I will simply state the facts without attempting to found any theory upon them.

During the Winter in question Windermere was frozen throughout its entire extent, the ice attaining a thickness in many places of seven to eight inches or more. Wherever there was a considerable expanse of water, as for instance between Thompson Holme and the northern shore of Miller Ground Bay, a distance of about two miles, the expansion which takes place in freezing forced the ice up on the shore wherever the slope was sufficiently gentle to permit of this. The striation produced by this glaciation was clearly to be seen below the ice where the bottom was chiefly composed of clay. Where the shore was composed of loose shingle the ice in its progress ploughed its way through it, raising a bank of from one to two feet in height. Where the shore presented miniature cliffs of clay capped by turf, the soil was turned over by the ice as by a ploughshare. Along the greater part of the shore-line, but especially where the shore was steep or rocky, the pressure forced the ice up into hummocky fragments. Great cracks, the edges of which were similarly thrown into hummocks, extended right across the lake at two points between Bowness and Ambleside. When the thaw set in and the ice contracted, the position of these two loci of compression was marked by wide lanes of open water, while the ice on either side was still strong enough to bear the weight of a man. Other more local evidences of compression were seen in funnel-like depressions in the ice, in some cases with a dangerous hole in the centre, though the ice surrounding the hole was so strong that a man was able without risk to reach the hat of a skater who had fallen through. Evidences of the motion of the ice in the direction of the greatest pressure was also to be seen in bent and broken piles and landing-stages. These phenomena were not to be seen where from any cause the ice did not attain to any great thickness, as, for instance, at the mouth of Troutbeck, where the flow of the river checked the formation of the ice.

Scarcely less remarkable than the effects of the ice-action themselves was the short time that it took for denudation to remove all traces of them.

These are the facts that I observed; and I think they may be worth putting on record, especially because the opportunities of observing them are so rare, Windermere being seldom frozen over more than three or four times in a century. GEO. CREWDSON.

ST. MARY'S VICARAGE, WINDERMERE.
September 1st, 1904.

THE DISCOVERY OF MARSUPITES IN THE CHALK OF THE CROYDON AREA.

SIR,—Some few weeks ago I received a letter from Messrs. Wright & Polkinghorne (of the Battersea Field Club and Geologists' Association) to the effect that while cycling from Purley to Beddington they observed some chalk that had been thrown out while laying the sewer in one of the new roads at the top of Russell Hill.

Upon examining the chalk they were rewarded by finding plates of Marsupites. The following Thursday evening I accompanied Mr. Wright to the spot, when we found that the chalk had been put back; however, after a diligent search among the blocks on the surface, we succeeded in obtaining five or six plates, two of which were embedded in flint nodules.

The nipple-headed form of *Bourgueticrinus* and the pyramidated form of *Echinocorys vulgaris,* both characteristic fossils of the Marsupite zone, were also obtained.

The chalk is of a very soft nature, quite different to that of the other zones in the district. I spent four hours the following Saturday at excavations at a lower horizon in the hope of finding *Uintacrinus,* but without success. I am bound to admit that the appearance of this zone at this spot is quite a surprise, for, standing at Russell Hill one turns to the left, where at the Haling Pit the bottom beds of the *M. coranguinum* beds are exposed; while immediately facing us at the Purley Junction pits (now ceased to be worked) we have the *M. cortestudinarium* zone; the dip, as revealed by the successive zones to the Chalk escarpment, being to the north and disappearing under the Tertiaries at South Croydon.

One can only account for this zone by a fold in the Chalk, as we have at Beddington, a little further south-west, the upper part of the *M. coranguinum* beds exposed which are at a lower level, according to ordnance datum, than Russell Hill.

Subsequent discoveries will be watched with interest by all workers in Chalk geology. G. E. Dibley.

7, Champion Crescent, Lower Sydenham, S.E.
August 29*th*, 1904.

EQUIVALENTS OF THE LOWER CULM.

Sir,—Mr. Jukes-Browne has pointed out to me that in my paper on the Homotaxial Equivalents of the Lower Culm I have left it uncertain what remains in North Devon as the representative of the Lower Carboniferous series, and that I might be understood to mean that there is absolutely no representative of the Carboniferous Limestone in that area. He also reminds me that Salter in 1863 mentioned the existence of soft fossiliferous shales containing Carboniferous fossils above the Pilton Beds to the north of Barnstaple, which I noted as passage beds (p. 397). He further suggests that my table of comparative succession (p. 401) might be amplified thus:—

Devonshire.	South-West Ireland.	
Lower Culm	*Posidonomya* beds.	
Fremington Beds	Carboniferous shales }	
Soft shales }	Carboniferous slate }	
Pilton Beds }	Carboniferous, lower part }	Upper
Baggy Beds	Coomhola Beds }	Devonian.

I am quite prepared to admit the possibility that the Lower Carboniferous series is represented in North Devon and in South-West Ireland, but at present I am not sufficiently conversant with the palæontology of the Pilton Beds to discuss the question. For its settlement, moreover, some further field-work would be required.

Wheelton Hind.

Stoke-on-Trent.
September 13*th*, 1904.

MISCELLANEOUS.

Eoliths: a Chance for Collectors!—We have learnt from Mr. Benjamin Harrison, of Ightham, that, with the kind permission of Sir Mark Collett, the present owner of the property, he has recently opened a fine section in the Eolithic Drift on Terrys Lodge crest. Mr. Harrison hopes that anyone desirous of studying this drift for themselves will take advantage of this opportunity.

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THE

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"THE GEOLOGIST."

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HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

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NOVEMBER, 1904.

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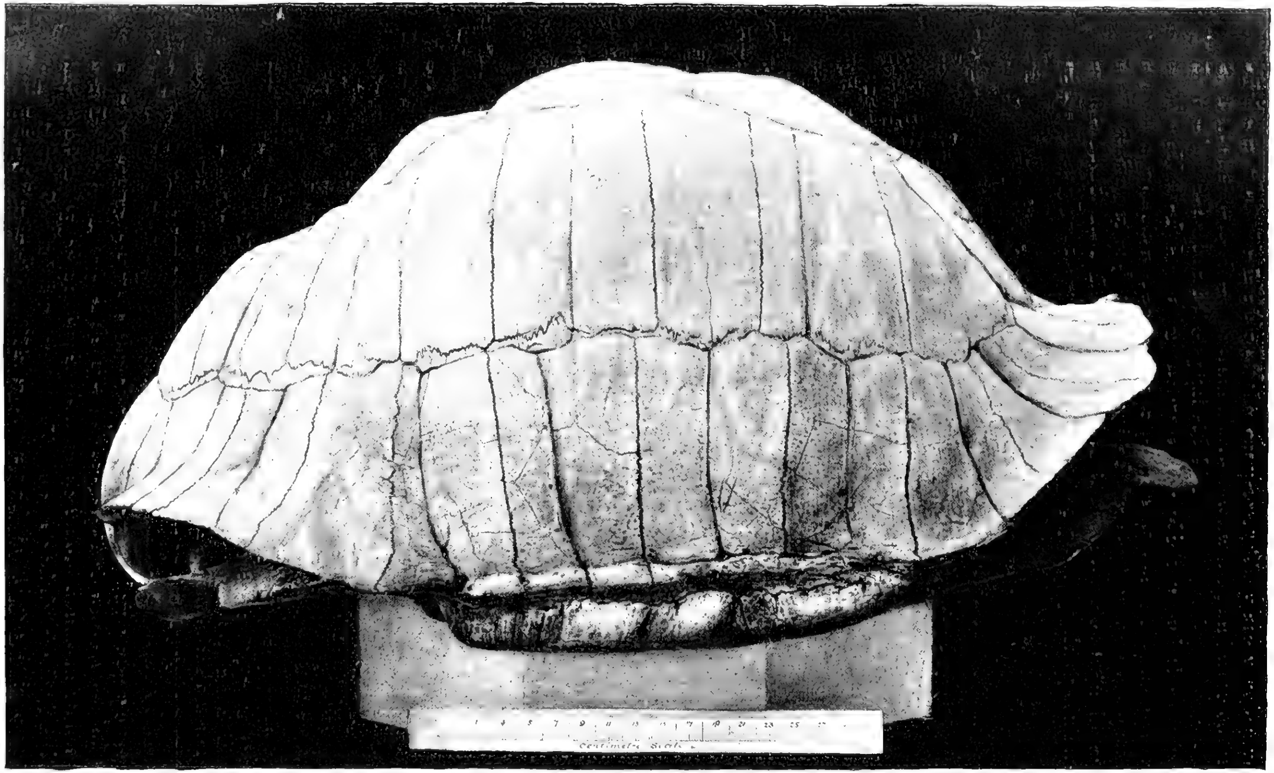

Shell of *Testudo Ammon*, Andrews; Upper Eocene, Fayûm, Egypt.

(About one-sixth natural size.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. I.

No. XI.—NOVEMBER, 1904.

ORIGINAL ARTICLES.

I.—Note on the Gigantic Land Tortoise (*Testudo Ammon*, Andrews), from the Upper Eocene of Egypt.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

(PLATE XVII.)

In the course of his excavations in the Upper Eocene beds of the Fayûm during the early part of 1902, Mr. H. J. L. Beadnell unearthed a remarkably fine shell of a very large species of *Testudo*. A brief description of this specimen [1] was afterwards published in Cairo by the present writer, and it was made the type of a new species, *Testudo Ammon*. At the same time Mr. Beadnell gave a short account of the beds in which it was found, and of the methods employed by him for its preservation and transport to the Museum in Cairo.

Owing to the fact that when the original description was drawn up the shell was still imperfectly freed from matrix, some mistakes were made, the most important being the statement that there was no epidermal nuchal shield. It can now be seen that this was present, though it happens that in the type-specimen it is smaller and less distinctly marked than in other shells since found, including several specimens in Cairo and two in the British Museum.

Plate XVII is a side view of the type-specimen, and the diagram in the text (p. 528) shows the structure of the carapace in this species. Seen from above, the shell is somewhat quadrate in outline, owing to the prominence of the slightly everted antero-lateral and postero-lateral portions of the border. The carapace is strongly arched, and the vertebral shields form prominent bosses, separated from one another and from the costals by deep depressions; the costals themselves are also somewhat convex. The anterior border of the carapace is slightly emarginate, and there was an epidermal nuchal shield. There are seven neural bones and three pygals; the latter form a protective covering for the tail and project below the level

[1] "A Preliminary Notice of a Land Tortoise from the Upper Eocene of the Fayûm, Egypt," by C. W. Andrews and H. J. L. Beadnell, Survey Department, Cairo, 1903.

of the rest of the border of the carapace. They are very convex, both from side to side and from above downwards, and were covered by the last neural and the pygal shields.

The sides of the bridge between the plastron and the carapace are greatly thickened and form a prominent border. The plastron itself is larger, and the openings of the shell were consequently smaller, and the soft parts therefore better protected than in most of the later gigantic species of the genus; possibly this peculiarity

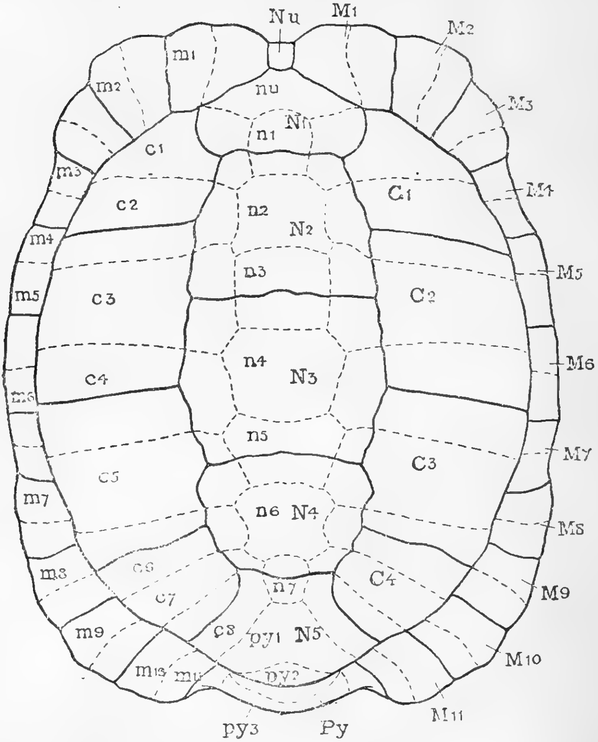

Diagram of carapace of *Testudo Ammon*. *C* 1–4, costal shields; *M* 1–11, marginal shields; *N* 1–4, neural shields; *Nu*, nuchal shield; *Py*, pygal shield. *c* 1–8, costal bones; *m* 1–11, marginal bones; *n* 1–7, neural bones; *nu*, nuchal bone; *py* 1–3, pygal bones. The outlines of the bones of the carapace are marked in dotted lines, those of the epidermal shields in black lines.

may be connected with the circumstance that large and powerful carnivores coexisted with the present species, while most of the more recent types are or were inhabitants of islands in which no such powerful enemies are found. In some of the earlier Tertiary species of Europe (e.g. *Testudo gigas* of the Upper Oligocene of France) the plastron is likewise large, possibly for a similar reason.

In the type and in several other specimens the epiplastral region is produced forwards so as to project considerably beyond the anterior border of the carapace; this epiplastral prominence, like the deep concavity of the middle portion of the plastron, is probably a male character. In the Museum at Cairo there is a beautifully preserved shell of which the carapace differs very slightly from that of the type (e.g. in the smaller degree of convexity of the vertebral shields), while the plastron is very dissimilar. In the first place it is only slightly concave, then the epiplastral region, though prominent, is not produced forward in the same way, and lastly the portion of the xiphiplastrals covered by the anal shields is much narrower, so that the posterior emargination of the plastron is narrower and its angle more acute; this specimen may be regarded as probably the female form of the present species.

The dimensions of the type-specimen (Plate XVII) are:—

Length of the carapace in a straight line	87 cent.
Length of carapace along curve	118 ,,
Width of carapace in straight line	76 ,,
Width of carapace along curve	115 ,,
Length of plastron (greatest)	85 ,,
Width of anterior lobe of plastron	32 ,,
Width of posterior lobe ,, ...	34 ,,
Width of episternal prolongation	15 ,,

The dimensions of the female specimen are much smaller; some of these are:—

Length of carapace	51·3 cent.
Width of carapace	34·5 ,,
Length of plastron...	45·2 ,,
Width of anterior lobe of plastron	21 ,,
Width of posterior lobe	22·5 ,,

In the former account, owing to the fact that the presence of a nuchal shield was not recognised, it was stated that these species approached the Galapagos tortoises rather than those of the African islands. Now, however, it seems possible that there may be some relationship with the species inhabiting Madagascar and the Aldabra Islands, a much more probable suggestion.

The presence of the nuchal shield, on the other hand, separates this form somewhat more widely from some of the Tertiary species with which it has been compared. Nevertheless, in many respects it is similar to *Testudo perpiniana*, described by Depéret and Donnezan from the Lower Pliocene of Roussillon, and it may also be allied to *T. léberonis*, Depéret, from the Miocene of Mount Lebéron, and *T. gigas*, Bravard, from the Upper Oligocene of the Allier.

As was suggested in the former note, "it seems probable that in the present species we have an early representative of a large group of tortoises, members of which occur at several horizons in the Tertiary beds of Europe, and of which *T. pardalis* and *T. calcarata* may be modern forms. *T. Atlas* and *T. Cautleyi*, of the Siwalik Hills, and the still existing *T. Sumeirei*, of Mauritius, may also fall into this group." To this it may be added that probably the giant species of Madagascar and the Aldabra Islands are also related.

EXPLANATION OF PLATE XVII.

Shell of the type-specimen of *Testudo Ammon*, photographed from the side. Reduced to about $\frac{1}{6}$ natural size. From the Upper Eocene beds of the Fayûm, Egypt.

Reproduced from a photograph made in the Geological Museum, Cairo: copied with the permission of Captain H. G. Lyons, F.G.S., the Director-General of the Geological Survey of Egypt. The original specimen was obtained by H. J. L. Beadnell, Esq., F.G.S., of the Geological Survey, during his excavations in the Fayûm early in 1902.

II.—Note on the Lower Culm of North Devon.

By Arthur Vaughan, B.A., D.Sc., F.G.S.

In the Geological Magazine, August, 1904, pp. 392–403, Dr. Wheelton Hind describes the Lower Culm beds of North Devon and assigns them to the 'Pendleside' series.

From the original paper[1] dealing with that series I gather that in the North of England the 'Pendleside' beds lie *above* the uppermost zone of the Carboniferous Limestone, and are the equivalents of the Millstone Grit of the South Wales and Mendip areas. Dr. Hind's contention is, then, that the Lower Culm of North Devon was laid down at a time *subsequent to the deposition* of the whole of the Carboniferous Limestone of the Mendips and South Wales.

The Carboniferous Limestone of South Wales, Chepstow, Bristol, and the Mendips lies but a short distance N.E., N., and N.W. of the Culm crop. It seems then highly probable that, if any difference exists, the faunal sequence in North Devon will resemble that of the neighbouring areas, rather than that of Lancashire and the Midlands.

It is, without doubt, an astonishing instance of the geographical inversion of the faunal sequence that Brachiopods and Corals which, in the North, occur in supra-Viséan beds should, in the South, be only characteristic of infra-Viséan rocks.

Remarkable as this phenomenon unquestionably is, it scarcely affects the purpose of this note, which is to demonstrate that, *if the faunal sequence in North Devon is identical with that in the neighbouring areas*, the Lower Culm must be placed, not above the Viséan, but well below the uppermost limit of the Tournaisian or lower division of the Carboniferous Limestone.

If the Carboniferous Limestone be studied in the extreme west at Tenby, in the neighbourhood of Severn Tunnel Junction, or in the Forest of Dean, in the Sodbury and Bristol areas, or at its most southerly crop in the Mendips, the faunal sequence is essentially the same at all points; furthermore, this result is deduced from continuous sections in which there is no possibility of misreading the order of the beds. Throughout the Carboniferous Limestone outcrop which lies nearest to the Culm of North Devon the faunal facies varies from zone to zone, but the same fossil *assemblage* always characterizes the same horizon, even if the points at which

[1] "The Pendleside Group at Pendle Hill, etc.," by Dr. Wheelton Hind and Mr. J. A. Howe: Q.J.G.S., vol. lvii (1901), p. 388.

it is examined lie 100 miles apart, as in the case of Tenby and the Mendips.

(The detailed demonstration of this fact is fully set out in a forthcoming paper, of which an abstract has already been published.[1] From this abstract it is only necessary to extract the following information: The *Cleistopora* zone is succeeded by the *Zaphrentis* zone, and the *Zaphrentis* zone by the *laminosa* subzone, and these three zones make up the Tournaisian or lower division of the Carboniferous Limestone.)

I am much indebted to Mr. J. G. Hamling, F.G.S., of Barnstaple, for his kindness in sending me, for examination at my leisure, the Brachiopods and Corals which he has collected from Coddon Hill and neighbouring localities. These specimens are mostly casts, but this character increases rather than lessens the certainty of their determination. The arrangement of the muscular scars in the Brachiopods and the grouping of the septa, the nature of the fossula, and the cystoid tabulæ of the *Zaphrentes* are beautifully shown in many of the specimens. I have also been able to compare Mr. Hamling's specimens with a large series of very similar casts collected by myself at Undy (about two miles west of Severn Tunnel Junction), where a similar faunal assemblage is to be found.

The results of my examination are as follows :—

Coddon Hill and Landkey.
- *Chonetes Hardrensis*,[2] vars.
- *Leptena analoga.*
- *Rhipidomella Michelini.*
- *Cleiothyris glabristria.*
- *Orbiculoidea*, sp.
- *Zaphrentis* aff. *Phillipsi.*

South of South Aller; North-west of South Molton.
- *Cleiothyris Reyssii* (mut. β).
- *Chonetes Hardrensis*,[2] var.
- *Spirifer* aff. *clathratus.*

All the specimens from which the above lists are drawn up are not merely similar, but are actual duplicates of forms which occur in the neighbouring areas at the horizons to which I assign the beds; hence the deductions here drawn require no effort of palæontological subtilty.

In the surrounding area every one of the above fossils to which I have assigned a specific name (i.e. with the exception of *Orbiculoidea*) is confined to the Tournaisian, and *does not occur in any higher beds.*

I further deduce from the above faunal lists that the Coddon Hill Beds belong certainly to the *Zaphrentis* zone, but that those near South Molton lie at a somewhat lower level, and may be either upper *Cleistopora* zone or the lowest part of the *Zaphrentis* zone. Assuming, then, that the *Posidonomya* shales lie immediately above the Coddon Hill Beds (a fact of which both Dr. Hind and Mr. Hamling are convinced), my conclusions seem to be in agreement

[1] Abstract of Proc. Geol. Soc., June 8th, 1904.

[2] *Hardrensis* is merely used as a connotative term, and for this purpose it is preferable to *laguessiana*, which implies a particular member of the circulus.

with those of Dr. J. H. Parkinson, who refers[1] similar beds in Germany to the Tournaisian division.

Since writing the above note Mr. T. F. Sibley, B.Sc., has drawn my attention to two specimens of a coral which he had himself obtained from Coddon Hill, from beds in which he found none of the fossils enumerated in the above lists. This coral is, I have little doubt, the species of *Cyathophyllum* which characterizes the upper beds of the *laminosa* subzone in the Mendip, Bristol, and South Wales areas. Not only, then, do the Brachiopods and Corals of the typical Coddon Hill Beds agree with those which are characteristic of the main *Zaphrentis* zone in the surrounding areas, but higher and lower horizons in the Tournaisian division seem also to be represented in the immediate neighbourhood.

It is necessary, however, to state that I am not personally acquainted with the Coddon Hill district, and that my knowledge of the fossils is entirely derived from specimens collected by other geologists.

III.—Notes on the Rhætic Rocks around Charfield, Gloucestershire.

By L. Richardson, F.G.S.

The object of this communication is to record some recently-made notes on the Rhætic beds of the neighbourhood of Charfield.

In 1876 Mr. H. B. Woodward, F.R.S., wrote: "Turning to the escarpment of Penarth beds between Tites Point and Wickwar, we find them exposed in many places. Long ago Sir Roderick Murchison stated that 'passages from the Lias into the underlying New Red Sandstone can be observed in the sides of Whitecliff Park Hills, south of Berkeley; but the clearest and best instances are to the east of Wickwar, near Sturt Bridge, on the sides of the new road ascending to Wotton.'"[2] This is all that has been written on the area now under consideration. As is well known, the junction of the Rhætic and Keuper Series is usually marked by a low but distinct escarpment. Between Tites Point and Berkeley Road Station this physical feature is not pronounced, but becomes gradually more prominent to the south of the Junction.

At Standhill Green, near Stinchcombe, a section of considerable interest can be studied in the banks and bed of a small brook. Its position is approximately indicated by an arrow on the Geological Survey Map, Sheet xxxv.

Section in Brook at Standhill Green, Stinchcombe.

			ft.	ins.	
Upper Rhætic.	1.	Limestone mixed with marl.			
	2.	Pale-yellow marls much disturbed.			
	3.	*Estheria*-bed, 2 to 6 inches . .	0	4	*Lycopodites lanceolatus*, *Estheria minuta*, var. *Brodieana*.
	4.	Pale-yellow marls . . . about	6	0	Full of shell-fragments.

[1] Geol. Mag., June, 1904, pp. 272–276.

[2] Mem. Geol. Surv., "Geology of East Somerset and the Bristol Coalfields" (1876), p. 74; see also "Silurian System," p. 449.

			ft.	ins.	
Lower Rhætic.	5*a*.	Shales, dark, marly . . about	1	0	Shell-débris.
	5*b*.	Limestone, hard, dark-grey, arenaceous, 0 to 3 inches	0	2	*Gyrolepis Alberti* (scale), *Pecten valoniensis.*
	6.	Shales, thickly laminated . about	1	6	*Cardium cloacinum, Protocardium rhæticum, Schizodus Ewaldi, Avicula contorta, Modiola* sp.
	7.	Limestone, dark-grey, almost rubbly, earthy, 2 to 3 inches .	0	3	*Schizodus, Protocardium rhæticum, Placunopsis alpina.*
	8.	Shales, black, somewhat firm, seen	0	6	
			[*Gap.*]		
	9.	Shales, black, thinly laminated, seen	2	0	*Schizodus Ewaldi* (rare).
	10. 11.	Shales, black, laminated, with yellow streaks	1	9	
	12.	Shales, dark-grey, non-laminated, micaceous	0	10	Crowded with *Schizodus Ewaldi*; *Pleurophorus angulatus, Protocardium rhæticum, Avicula contorta.*
	13.	Sandstone, usually very pyritic .	0	1	Scales and teeth of *Gyrolepis Alberti, Plesiosaurus* (small tooth), *Acrodus minimus*?
	14.	Shales, black, often sandy . . .	0	2	
	15.	Sandstone, light-grey, calcareous, sometimes pyritic, 2 to 4 inches	0	3	*Gyrolepis Alberti* (scales), casts of *Schizodus* (?).
Keuper.	I.	'Tea-green Marls,' seen . . .	1	8	

The beds from the 'Tea-green Marls' to No. 9 can be studied in the side of a small pond. Unfortunately it is impossible to obtain the exact thickness of each bed, and the upper portion of the section is considerably obscured. The basement bed is a conspicuous stratum of grey, calcareous sandstone, sometimes pyritic, but with few vertebrate-remains. It forms the bed of the brook at the fence near the little pond. Slightly higher upstream a thin layer of very pyritic rock can be observed, and if a piece be removed will be found to be separated by a deposit of shale two inches thick from the basal Rhætic bed. This pyritic sandstone (13) occasionally occurs in two layers, the lower being of 'bone-bed' nature. When conjoined, the inferior portion is full of fish-remains. Immediately above are dark-grey, non-laminated shales, crowded with specimens of *Schizodus Ewaldi*, especially at the base. The Lower *Pecten*-bed (7) crops out in the stream, but contains few fossils. The precise thickness of the shale-deposit intervening between this bed and the next limestone band is uncertain. Higher up-stream this second limestone band crops out, and the shale immediately below is excessively fossiliferous, the specimens being very well preserved. *Cardium cloacinum* is especially abundant. Bed 5*b*, however, is intermittent, occurring sometimes in nodule-shaped masses.

In order to study the lower portion of the Upper Rhætic Stage it is necessary to proceed down-stream again, when a steep portion of the bank will be noticed on the left-hand side. At the top of this bank, under the roots of a tree, is the *Estheria*-bed. The phyllopod and the plant-remains, however, are rare: as is usually the case, they occur in the cream-coloured and less compact portion of the bed.

In the more immediate neighbourhood of Charfield and Wickwar the Rhætic beds crop out in the sides of ramifying valleys of much picturesqueness, but few deeply-cut lanes traverse their sides, and consequently there are few exposures of the beds under consideration. In a field a quarter of a mile due south of Neathwood Farm is a pond in the sides of which limestones and grey marls are exposed, but they are somewhat disturbed. No distinctive fossils were found, but the deposits belong probably to the upper portion of the Upper Rhætic Stage. Fragments of a slightly conglomeratic bed, probably on the horizon of the Cotham Marble, yielded crushed specimens of *Modiola minima* and *Pseudomonotis decussata* and fish-scales (*Legnonotus cothamensis*, Egerton).

Red Marls, 'Tea-green Marls,' and Rhætic black shales are exposed in the sides of Chase Hill Lane. Resting directly upon the 'Tea-green Marls' is the Bone-bed, but it is not a very extensive deposit at this locality, since one or two masses were all that rewarded the writer's investigation. But these are crowded with vertebrate-remains, the fish-scales being unusually large. The matrix in which these fossils are imbedded is a hard, grey, crystalline limestone, with irregular, but nevertheless conspicuously rolled pieces of what appears to be 'Tea-green Marl' marlstone and of less compact green marl. Obscure casts of a *Schizodus*-type of Lamellibranch are not uncommon, and a broad form of *Modiola* was also recorded. There are a few small quartz-pebbles, many coprolites, *Saurichthys acuminatus*, *Acrodus minimus*, *Hybodus minor*, *H. cloacinus*, *Gyrolepis Alberti*, and many other remains in a very fragmentary condition. Above are black shales.

About half a mile to the east of the place where this highly fossiliferous bed was discovered the road branches; that to the right leads into a little valley and crosses a brook near a cottage. In one side of this brook shales are visible underlain by a greenish argillaceous limestone about seven inches thick, with a mammillated surface. In places the limestone passes into marl. This bed may be the equivalent of the *Estheria*-bed, but no fossils were noted.

Close at hand, in the stream-side to the east of the cottage, the Cotham Marble is well exposed, and this is the most northerly point at which the writer has noticed it in its typical form.

Section near Chase Hill, Wickwar.

		ft.	ins.	
Lower Lias.	Shales, pale-green, calcareous, with a few thin hard layers near base.			
	Limestone, dark, earthy	0	1	*Ostrea liassica*, *Modiola minima* (abundant).
	Shale-parting	0	$0\frac{1}{4}$	
	Limestone, hard, dark	0	$3\frac{1}{2}$	*Ostrea liassica* (abundant), *Modiola minima*.
Rhætic.	Cotham Marble. The top portion is very rubbly; the remainder a good 'landscape stone'	0	5	Fish-scales in upper portion.

A little farther up the stream, bluish-grey shaly clays, with layers of earthy nodules, are exposed. About three-sixteenths of a mile to the south-west of the cottage, Cotham Marble can be seen near a spring.

When stone is required for mending the tracks in the sylvan district composed of Stoneybridge, Bays, Litley, Workhall, and Hawkesbury Woods, shallow excavations are made, and the Cotham Marble is usually laid bare. It is present here in its typical form, and in cracks are frequently found iron-pyrites and baryto-celestine, whilst in the upper layers of the marble *Pseudomonotis decussata* is in places abundant. In a quarry near the brook between Bays and Stoneybridge Woods, the Cotham Marble has been worked, and in close proximity to that bed must be limestones with *Psiloceras Johnstoni*. Above are clay-deposits, such as were noted in the stream-side near the cottage to the north of Hawkesbury Wood.

The section in the lane near Sturt Bridge referred to by Murchison is overgrown now, unless it be that in Chase Hill Lane.

IV.—On some Minor British Earthquakes of the Years 1901–1903.

By Charles Davison, Sc.D., F.G.S.

THE number of earthquakes originating within the area of the British Islands during the three years 1901–1903 is 37, of which 9 occurred in England, 20 in Scotland, and 8 in Wales. In the 15 years 1889–1903 the total number recorded is 152, 39 in England,[1] 90 in Scotland, and 23 in Wales. So far as I know, not a single undoubted earthquake has originated in Ireland during this period; but four earthquakes (the Pembroke earthquakes of 1892 and 1893, the Hereford earthquake of 1896, and the Carnarvon earthquake of 1903) were felt in many of the eastern counties.

List of Earthquakes, 1901–1903.

1901.—July 9, 4.23 p.m. Carlisle (principal earthquake).
,, about 4.26 p.m. Carlisle.
,, 4.45 p.m. Carlisle.
July 11, about 11.10 p.m. Carlisle.
Sept. 16, 6.4 p.m. Inverness.
Sept. 18, 1.24 a.m. Inverness (principal earthquake).
,, about 1.35 a.m. Inverness.
,, about 2 a.m. Inverness.
,, about 2.30 a.m. Inverness.
,, about 3 a.m. Inverness.
,, 3.56 a.m. Inverness.
,, 9 a.m. Inverness.
Sept. 23, about 7.30 a.m. Inverness.

[1] Excluding the slight shock felt on Aug. 27, 1895, near Blisland (Cornwall), which may have been caused by a fault-slip precipitated by mining operations.

Sept. 26, 11.40 a.m. Inverness.
Sept. 27, 1.47 p.m. Inverness.
Sept. 28, about 4 a.m. Inverness.
Sept. 29, 9.6 p.m. Inverness.
Sept. 30, 3.39 a.m. Inverness.
Oct. 1, about 4.35 a.m. Inverness.
Oct. 6, 4.24 a.m. Inverness.
Oct. 13, 4.24 p.m. Inverness.
Oct. 22, about 10.15 a.m. Inverness.
Nov. 15, about noon. Inverness.
1902.—April 13, about 11.50 a.m. Hessle (East Yorkshire).
Oct. 14, 5.15 p.m. Strontian (Inverness-shire).
1903.—Mar. 24, 1.30 p.m. Derby (principal earthquake).
,, about 1.45 p.m. Derby.
,, about 5 p.m. Derby.
May 3, 9.22 p.m. Derby.
June 19, about 4.25 a.m. Carnarvon.
,, 10.4 a.m. Carnarvon (principal earthquake).
,, 10.9 a.m. Carnarvon.
,, 10.12 a.m. Carnarvon.
,, 10.16 a.m. Carnarvon.
,, 11.8 a.m. Carnarvon.
June 21, 8.6 a.m. Carnarvon.
July 1, 1.16 a.m. Bala.

The four series of earthquakes, including 34 out of the 37 shocks recorded, have been described in the following papers:—

"The Carlisle Earthquakes of July 9th and 11th, 1901": Quart. Journ. Geol. Soc., vol. lviii (1902), pp. 371–376.

"The Inverness Earthquake of September 18th, 1901, and its accessory shocks": ibid., pp. 377–397.

"The Derby Earthquakes of March 24th and May 3rd, 1903": ibid., vol. lx (1904), pp. 215–232.

"The Caernarvon Earthquake of June 19th, 1903, and its accessory shocks": ibid., pp. 233–242.

The other three shocks, together with some doubtful or spurious earthquakes, form the subject of the present paper. A few earthshakes in mining districts (at Camborne on June 4 and 10, 1902, and Barnsley on October 25, 1903) will be described shortly in a separate paper.

Hessle Earthquake: April 13, 1902.

Time of occurrence, about 11.50 a.m.; intensity, 4; centre of isoseismal 4 in lat. 53° 33·4′ N., long. 1° 11·5′ W.; number of records, 34, from 28 places, and 77 negative records from 76 places. (Fig. 1.)

Hessle lies on the north shore of the Humber, about 4 miles west of Hull. As a rule, the shock was felt only in villages, and, as it occurred on a Sunday during the morning service, I have found it difficult to obtain many records. The only isoseismal that can be drawn is that which corresponds to the intensity 4 (Fig. 1).

It is 34 miles long, 22½ miles wide, and about 600 square miles in area. Its centre lies 15 miles south-west of Hessle, the longer axis being directed from E. 25° N. to W. 25° S. Outside the isoseismal 4, a tremulous motion was also felt under favourable conditions at Clarborough (3½ miles to the south), Hull, Beverley, and Beeford (2½, 7, and 17 miles to the north-east), and Leeds, Horsforth, and Rawdon (24, 28, and 30 miles to the north-west). The sound was also heard at Clarborough, Hull, and Horsforth.

The shock consisted of a single series of vibrations, increasing in intensity to a maximum and then dying away. The average duration of the shock was about 4 seconds.

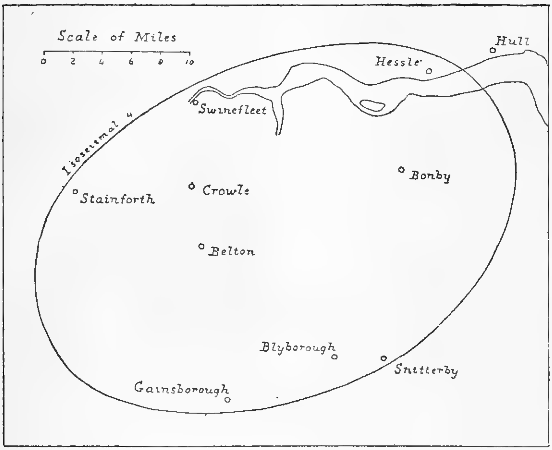

Fig. 1.—Diagram Map of the Hessle Earthquake: April 13, 1902.

The sound was heard by 96 per cent. of the observers; and was compared in 48 per cent. of the records to passing vehicles of various kinds, in 38 per cent. to thunder, and in 14 per cent. to wind. The beginning of the sound preceded that of the shock in 42 per cent. of the records, coincided with it in 50, and followed it in 8 per cent.; the end of the sound preceded that of the shock in 10 per cent., coincided with it in 50, and followed it in 40 per cent.

With regard to the origin of the earthquake, I can offer no suggestion, except that the direction of the originating fault was probably about E.N.E. and W.S.W. On the Geological Survey map of the district (Sheet 86) only one fault is marked, and this is 4 or 5 miles from the epicentre and inclined to the longer axis of the disturbed area.

Strontian Earthquake: Oct. 14, 1902.

Time of occurrence, about 5.15 p.m.; intensity, 5; centre of isoseismal 5 in lat. 56° 44·4′ N., long. 5° 30·5′ W.; number of records, 47, from 38 places, and 38 negative records from 33 places. (Fig. 2.)

The curves in Fig. 2 represent isoseismal lines of intensities 5 and 4. The former curve, which is the less accurately drawn of the two, is 38½ miles long, 22 miles wide, and 670 square miles in area. Its centre is situated 4 miles N. 10° E. of Strontian, and its longer axis runs from E. 36° N. to W. 36° S. The isoseismal 4 is 49 miles long, 31 miles wide, and contains 1,180 square miles. Its longer axis is parallel to that of the isoseismal 5; the distance between the two curves, as drawn, being 5 miles towards the north-west and 4 miles towards the south-east. Outside this isoseismal, the sound was heard at Kinlochhourn, Roy Bridge, and Fasnacloich, the shock being also felt at the last-named place. All three places are 4 miles from the isoseismal, and lie respectively towards the north, east, and south-east.

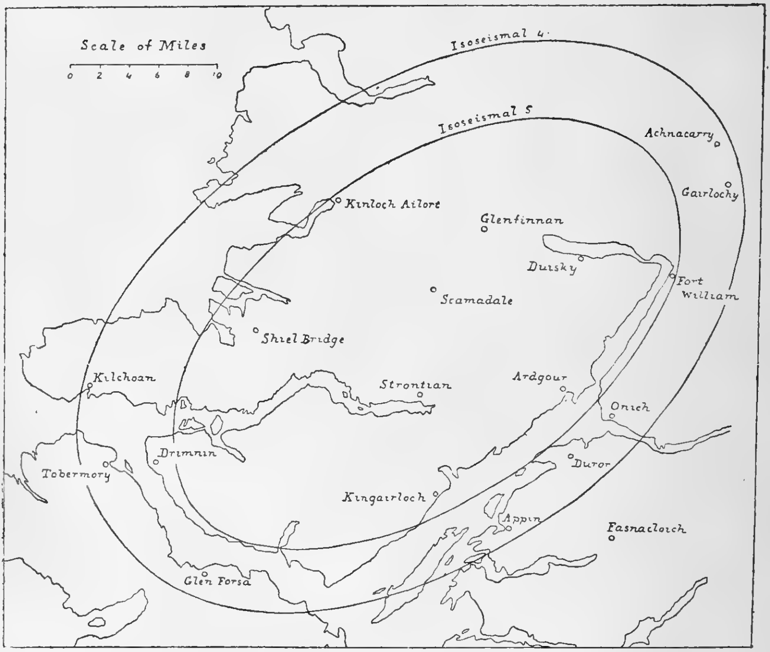

FIG. 2.—Diagram Map of the Strontian Earthquake: Oct. 14, 1902.

The shock consisted of a single series of vibrations, which increased in intensity and then died away, the average duration of the movement being 3 seconds.

The sound was heard by 98 per cent. of the observers. It was compared to a passing train or heavy vehicle in 43 per cent. of the records, to thunder in 43, wind in 3, and to miscellaneous sounds in 11 per cent. The beginning of the sound preceded that of the shock in 71 per cent. of the records, and coincided with it in 29 per cent.; while the end of the sound coincided with that of the shock in 40 per cent. of the records, and followed it in 60 per cent. In every case the duration of the sound was greater than that of the shock.

We may infer, from the seismic evidence, that the mean direction of the originating fault is from E. 36° N. to W. 36° S. Its hade is probably to the north-west, and, if so, the fault must pass a short distance to the south-east of the centre of the isoseismal 5, and probably not far from Strontian. It is possible, however, that the course of the isoseismal 5 is not drawn with sufficient accuracy to determine the hade of the fault. Mr. Horne kindly informs me that "the ground has not been surveyed west of Strontian, but the ground between Loch Eil and Glen Gower has been finished and west to Glen Strontian." No faults, he adds, have been detected in the position indicated above, though the Great Glen fault sends off a branch along the west side of Loch Linnhe.

Bala Earthquake: July 1, 1903.

Time of occurrence, 1.16 a.m.; intensity, 4; number of records, 10, from 5 places, and 3 negative records from 3 places.

Most of the records on which this brief account is founded I owe to the kindness of Mr. T. Ruddy, of Palè, near Corwen. The five places at which the shock was felt are Bala, Brynbwlan, Llandderfel, Palè, and Tynddynllan (near Llandrillo); and the three places from which no records are forthcoming are Bryn Tegid, Eryl Aran, and Rhos-y-gwaliau. All of the first five places lie close to the great Bala fault, and it is probable that the earthquake was caused by a slip along this fault or one of its branches. The connection with the fault cannot, however, be considered as proved; for the observations do not provide sufficient places for determining the boundary of the disturbed area. The length of this area in the direction of the fault is about 7 miles.

Mr. Ruddy described the shock at Palè as consisting of a single series of horizontal vibrations, lasting 4 or 5 seconds, increasing in intensity to a maximum and then dying away, the direction of the movement being from west to east. It was accompanied by a rushing noise, which other observers compared to thunder or the beating noise of a motor-car.

Doubtful Earthquakes.

Two slight shocks were felt on October 19 and 22, 1901, in the district surrounding Framlingham, a small town in Suffolk about 14 miles north-east of Ipswich.

Framlingham Earth-shake: Oct. 19, 1901.—Time of occurrence, about 7.25 p.m.; intensity, 4; centre of isoseismal 4 in lat. 52° 12·6′ N., long. 1° 15·0′ E.; number of records, 18, from 11 places, and 27 negative records from 23 places.

With one exception, the places where the shock was felt are included within a nearly circular area 6½ miles long from east to west, 6 miles wide, and containing 31 square miles. Both shock and sound were observed at Rendlesham, 2½ miles south of the isoseismal; and the sound was also heard, but no shock felt, at Dennington, one mile north-west, and Earl Soham, 3 miles west, of the same curve. The centre of the isoseismal is situated at a point one mile south-west of Swefling and 15 miles north-east of Ipswich.

There was a sudden shock followed by a brief tremulous movement, lasting for a few seconds. The sound was heard by all observers, three of whom compared it to passing waggons, etc., one to thunder, one to the fall of a building, three to the fall of a heavy body, and six to explosions or the firing of a heavy gun. Thus, 9 out of 14 observers make use of types which are of short duration.

Framlingham Earth-shake: Oct. 22, 1901.—Time of occurrence, about 9.15 a.m.; intensity, 4; centre of isoseismal 4 in lat. 52° 12·7′ N., long. 1° 15·2′ E.; number of records, 22, from 13 places, and 27 negative records from 23 places.

With two exceptions, the shock was felt within an area of the same dimensions, and almost exactly the same position, as in the former earth-shake. The shock and sound were noticed at Earl Soham, 3 miles west of the isoseismal 4; the shock was also felt at Snape, one mile to the south-east, and the sound was heard at Cretingham, 3½ miles to the west.

The shock was similar to that of the first earth-shake, consisting of one prominent vibration followed by a tremulous motion, and lasting altogether about 3 seconds. The sound was heard by 18 out of 20 observers, and was compared to thunder in 2 cases, to the fall of a heavy body in 7, and to explosions or the firing of heavy guns in 8 cases; 15 out of 17 comparisons being to types of short duration.

Origin of the Earth-shakes.—While I am unable to point to any definite disturbances as the cause of the earth-shakes, their seismic origin seems to me doubtful for the following reasons:—

(1) The shock was a sudden disturbance followed by a brief tremulous motion.

(2) The sound was compared by nearly half the observers to that of an explosion or the firing of a heavy gun, and by more than three-quarters to types of brief duration.

(3) While inquiries were made throughout the surrounding district, the places from which negative records come are, with one exception in each case, absent from the south-east of the disturbed area.

These conditions seem to me to point to the firing of a moderately heavy gun some distance to the south-east, probably in the neighbourhood of Orford Ness, which is 14 miles S.E. of Framlingham. The shock and sound are such as would be so produced; and, in the immediate neighbourhood, would be assigned at once to their true cause. It is only at a distance of some miles from the origin that they begin to lead to the suspected occurrence of an earthquake. From the intermediate region it is usually difficult in such cases to obtain any records, either descriptive or negative. It is known that gun-practice is occasionally carried out in the neighbourhood of Orford Ness; but my inquiries (made some time after the occurrence) failed to establish the fact in this case.

Church Stretton: April 4, 1903.—A slight shock, lasting about 3 seconds, and strong enough to make bedroom-ware rattle, was felt at about 2.30 a.m. A rumbling noise preceded the shock. (I am indebted for this notice to Mr. E. S. Cobbold, F.G.S.)

Pontesbury (near Shrewsbury): May 8, 1903.—A very slight shock, without any rumbling noise, was felt at 10.20 p.m. at Pontesbury, and also at Worthen, about 6 miles to the west. (Information received from Rev. W. J. Lightfoot Harrison.)

Ilkley: May 17, 1903.—At 4.50 a.m. Mr. H. Stuart Thompson heard two apparently subterranean reports, like distant explosions, which were immediately followed by a shaking of about 2 seconds' duration.

Saffron Walden: Nov. 1 *and* 6, 1903.—Under the heading of "spurious earthquakes," reference is made to some supposed earthquakes that were caused by the explosion of fireworks on Nov. 1. Mr. Guy Maynard, of the Museum, Saffron Walden, to whom I am indebted for this information, has kindly given me the following notices of disturbances which were distinct from those caused by the fireworks. On Nov. 1, at 7.10 p.m., three distinct series of vibrations, each lasting about 5 seconds with intervals of 3 seconds between them, were felt at Newport, 4 miles south-west of Saffron Walden. No sound was heard with the vibrations. At about 8.45 p.m. Mr. Maynard, while walking a few miles from Walden, heard a long drawn-out rumbling, with two maxima of intensity, and lasting about half a minute. The rolling was too rapid and too loud to be caused by a train. Again, on Nov. 6, at 12.10 a.m., the serjeant of police and constables on night duty at Walden heard a heavy booming noise, lasting about half a minute, and causing the pheasants in the preserved woods round the town to cry out for about five minutes. This, or a similar noise, was also heard at the same time at Stanstead (9 miles to the south of Saffron Walden), with the same effect on the pheasants in the neighbourhood.

Spurious Earthquakes.

Channel Islands and South Devon: April 24, 1901.—Between 1 and 1.45 p.m. five reported earthquakes were observed in Guernsey, and eight at Paignton in South Devon. The disturbance bore a close resemblance to those produced by the firing of heavy guns at a distance. They were of very short duration; windows were shaken, but there was no perceptible tremor of the ground. Observers in Guernsey compared the sounds to thunder or the firing of very heavy guns; but those on the English coast were, as a rule, unconscious of any sound. Yet the impression of an observer at Salcombe was that a cannon had been fired to the south, but "too far away to bring the noise." Trials with heavy guns are said to have been made along the coast of France on April 24. I have not succeeded in ascertaining the place or the hour of the firing; but there is little doubt, I think, that the reported earthquakes must have been due to a cause of this kind.

West Essex: June 3, 1902.—During the night of June 3 several tremors and rumbling sounds were observed in the west of Essex and parts of the adjoining counties. The times given range from about 11.15 to 11.45 p.m. The resemblance to earthquakes must have been rather close, for several persons accustomed to earthquakes in other countries were convinced that they were of seismic origin. They were, in fact, caused by the firing of very heavy guns which, as I am informed by the Garrison Adjutant at Sheerness, took place at the mouth of the Medway at the times mentioned above. In the north-west quadrant, the places from which records come range without any great break from Chelmsford (22 miles from the mouth of the Medway) to North Mimms and Elstree in Hertfordshire (46 miles) and Little Shelford, near Cambridge (55 miles). At places nearer the Medway than Chelmsford, the disturbances were no doubt attributed without hesitation to their proper cause.

North Wales: June 6, 1903.—Three distinct shocks were felt about 8.10 p.m. at Llandudno and other places in North Wales, and also at Skerries in co. Dublin. So closely did they resemble earthquake-shocks that one of my correspondents in Anglesey refused to believe that they were caused, as they were no doubt caused, by practice with the 38-ton gun and quick-firing guns at Seaforth Battery, near Liverpool. The distance of Skerries from Seaforth is 128 miles.

Saffron Walden: Nov. 1, 1903.—Loud reports, resembling the tipping of bricks, were heard at 12.20 a.m., at about 1.40 p.m., and at 9.30 p.m. They were extremely local, although the first was heard by the police on night duty at a distance of 4 miles. There was no vibration with them, and they were undoubtedly caused, as Mr. Guy Maynard informs me, by large fireworks or dynamite exploded by a young Army officer in the town.

In addition to the above, a few disturbances were felt that were attributed in newspapers to earthquakes, but which have so little resemblance to these phenomena that they should, I think, be regarded as spurious or fanciful, rather than as doubtful, earthquakes. Such were the disturbances reported from Cheadle on July 9, 1902, and Melton Mowbray on Oct. 26, 1903.

V.—On Boulders from the Cambridge Drift, collected by the Sedgwick Club.

By R. H. Rastall, B.A., F.G.S.

During the past two years the Sedgwick Club has been at work on the glacial deposits in the neighbourhood of Cambridge, with special reference to the boulders contained therein. As usual, the great majority of the boulders are of local origin, but far-travelled rocks are fairly abundant, and several hundred specimens which appeared likely to be of interest have been collected. By the kindness of Professor T. McKenny Hughes, F.R.S., about fifty of the more promising types have been sliced.

An examination of this collection shows that a large number can be definitely identified as belonging to certain petrographical districts.

Many specimens are clearly referable to the Devonian soda-bearing intrusions of southern Norway; in this connection special mention must be made of the rhomb-porphyry, of which a considerable number of typical examples have been collected from the district lying to the east, south, and west of Cambridge.

A rather coarse-grained pink rock from Pampisford consists of quartz, felspar, and abundant ferromagnesian minerals. Practically the whole of the felspar is perthite of various kinds. The most common coloured mineral is a green pleochroic soda-pyroxene, which is moulded in a characteristic way on the quartz. There are also a good many small crystals of a deep blue, intensely pleochroic mineral, with an extinction angle up to 14°. This sometimes occurs in parallel intergrowth with the pyroxene. It is identified as arfvedsonite. This slice agrees, down to the minutest details, with Brögger's soda-granite, from the Christiania district.

A specimen from Newnham shows quartz, felspar, and long needles of ferromagnesian mineral. The felspars are very variable in character, and include all types of perthite, and especially microcline-perthite. The coloured mineral is chiefly ægirine; it occurs in very long needles, with a very low extinction angle. There is also a small quantity of arfvedsonite, like that in the rock last described. These two rocks are evidently very closely related.

Another coarse granitic rock from Newnham contains brown biotite and arfvedsonite, and is evidently nearly related to Nordmarkite. A slice from Barnwell shows the peculiar amphibole described by Brögger as kataphorite, along with perthite and abundant nepheline. Many other examples contain similar characteristic minerals, and give evidence of relationship.

Besides the above-mentioned rhomb-porphyries, other acid and intermediate intrusives are very common, and in thin slices they often show characters that seem to connect them with the Christiania family.

The commonest type of quartz-porphyry shows large corroded hexagons of quartz and phenocrysts of perthite, together with some ferromagnesian mineral now represented by irregular aggregates of deep brown and strongly pleochroic biotite. This method of alteration also occurs in some other slightly different rocks. The groundmass is microcrystalline, and often micropoecilitic. This rock is identified by Professor Sjögren as coming from Dalecarlia.

Another common porphyritic rock contains abundant phenocrysts of felspar, both perthite and plagioclase, with a few rounded quartz crystals, in a microcrystalline groundmass of quartz and felspar, with numerous radiating groups of minute crystals of tourmaline.

Porphyritic lavas of intermediate and basic character are very common in the district, and many of them can safely be referred to the Old Red Sandstone volcanic series of the Cheviots and central Scotland. The most abundant is an enstatite-augite-andesite of the usual character.

A porphyrite from Lord's Bridge is remarkable for having a great variety of porphyritic minerals: the most prominent are a plagioclase near to oligoclase, with a secondary border of orthoclase, original orthoclase, biotite, hornblende, and notably sphene; the groundmass is micrographitic, with a tendency to orthophyric structure. A few rounded quartz grains also occur.

Mr. G. Barrow has kindly looked over some selected slices, and he identifies half a dozen of these as belonging to the Garlton plateau and Forth district. These include two specimens of analcime diabase of the Forth Valley type. Some slices of olivine basalt show the glomeroporphyritic structure which is so characteristic of this series.

A rock from Pampisford gravel-pit proves to be an unusually fresh example of a very basic lava; it is a porphyritic rock with phenocrysts of olivine and augite in a groundmass of augite and deep brown glass, with a few laths of felspar. This rock must be classed as a limburgite; its place of origin has not been identified.

Enough work has not yet been done to enable any definite conclusions to be drawn as to the glacial phenomena of Cambridgeshire, but the facts here shortly summarised are sufficient to indicate the presence in this area of a large number of the rock-types which are so characteristic of the glacial deposits of other districts in the east of England, and especially many of the best known Norwegian rocks. So far no rock has been identified from the Lake District or any region to the west of the central watershed of Great Britain.

VI.—River Capture in the Don System.

By the Rev. W. Lower Carter, M.A., F.G.S.[1]

The river Don has a remarkable semicircular course. Rising in the Middle Grits, west of Dunford Bridge, at 1,500 feet above O.D., it flows eastwards to Penistone (700′), where it makes a bend to the south-east, quickly deepens its valley to 500′, and at Wortley breaks through the great watershed (1000′) of the Grenoside and Wharncliffe grits. It then receives the Little Don, the Ewden, and the Loxley, on its right bank, and falls into the valley of the Sheaf at Sheffield (150′). The Don then makes a rectangular bend to the north-east, following the old valley of the Sheaf to Conisborough, receiving the Rother on its right bank at Rotherham (87′) and the Dearne on its left bank at Denaby (45′). It then traverses the Magnesian Limestone escarpment in a fine gorge, and

[1] Paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

continues past Doncaster in a north-easterly direction to Thorne, where it bends northward towards the Aire. It has, however, been artificially diverted by the Dutch River to the Ouse at Goole.

The history of the present river course is presumed to have commenced when the Pennine anticlinal rose from the Cretaceous sea, and the original consequent streams commenced to run down the dip-slope of the Chalk. Slack Beck (Broadstone Dyke), which is diverted south-east at Ingberchworth by a tributary of the Don, is considered to be the head-stream of the brook that runs by Cawthorne, only a narrow dip in the watershed dividing them. The Don at Penistone (700′) faces a watershed of 700 feet, which forms a dip between Hoyland Swaine (900′) and Thurgoland (810′). Immediately beyond this watershed are the head-waters of the Dove, flowing eastward in direct continuation of the course of the Don above Penistone. The Dove is thus considered to be the beheaded remnant of the Don. The southerly bend of the Don and the cutting of the Wharncliffe gorge are explained as due to river capture by a feeder of the Sheaf. This Wharncliffe stream, with a rapid fall to the Sheaf, was able to capture successively the Loxley, the Ewden, and the Little Don, and then the watershed at Wortley was attacked by a branch of this stream, and on the other side by a feeder of the Don. As the watershed was cut through, the Wharncliffe stream, by reason of its steeper fall, captured the Wortley feeder of the Don and then the Don itself.

(2) *The Dearne.*—At a very early date the Bretton stream must have been captured by the Darton feeder of the Cawthorne stream, as it flows straight at the Woolley Edge escarpment (527′), and therefore must have been captured before the land was reduced to this level. The Dearne flows eastwards, by Barnsley to Cudworth Common, where it makes a rectangular bend southwards, and cutting through the Upper Chevet Rock (225′) at Darfield, enters the old valley of the Dove (100′). This gorge at Darfield proves the extension of the 225-foot contour eastwards, towards Hickleton, forming the watershed between the Dearne and the Dove, and there is an old river valley at Frickley (200′) between Clayton and Hickleton, which was probably the original course of the Dearne, which flowed through Hampole gorge into the central plain. The Darfield gorge is a case of river capture by a feeder of the Dove. The Dove itself had probably been captured by the Sheaf at a period before the present level of the Magnesian Limestone escarpment was reached by denudation.

(3) *The Rother.*—The original consequents of the Rother are Shire Brook, the Moss, and the Staveley stream. The Shire and Moss probably coalesced and formed the head-waters of the Ryton. The two gorges (330′) uniting at Kiveton are plainly traceable, and have subsequently been used, in all probability, as a channel of glacial overflow. The Moss must have captured the Staveley stream before it was itself captured by the Rother.

The whole inner Don system is thus explainable by a series of river captures, due to the deep cutting of its valley by the Sheaf, and its consequent predominant power in capturing consequent streams north and south.

The northwards bend of the Don, after its entrance into the central plain, is due to river capture by a feeder of the Aire. The course of the old Don river from Thorne, along the north side of Hatfield Chase to Adlingfleet on the Trent, is clearly traceable, and was the previous channel of the river before its artificial diversion by the Dutch River to Goole.

VII.—The Glaciation of the Don and Dearne Valleys.

By the Rev. W. Lower Carter, M.A., F.G.S.[1]

In studying the geological history of the rivers of the Don system, my attention was specially directed to the evidences of glacial action in the area, with the object of ascertaining whether glaciation had anything to do with the interesting diversions of the Don, Dearne, and Dove. Certain valleys in the area, also, attracted my attention as possessing abnormal features with respect to the present drainage of the district, and I began to inquire what their relations might be to an altered system of drainage during the Glacial Period. The present paper is an attempt to piece together the scattered glacial evidence, and to ascertain the effect that the advance of a glacier from the north and north-east would have on the drainage of this district, and how far the present valleys would help to explain the water-flow under such conditions.

1. *The Glacial Deposits of the Don System.*—These are fragmentary and scattered, and probably but relics of considerable deposits of drift. There are two considerable areas covered with true Boulder-clay in this district—one at Staincross, Carlton, and Royston, near Barnsley, and the other at Balby, near Doncaster—each filling a small valley which, since the Glacial Period, has been slightly removed from the line of direct drainage, and hence has escaped denudation.

The Staincross Boulder-clay, as described in the "Memoir on the Yorkshire Coalfield," consists of two beds of stiff, unstratified till, separated by a thin seam of warp and sand, the lower containing only boulders of Carboniferous Sandstone and Limestone, chert, and a blue, close-grained trap. The upper bed is more sandy, and on the surface have been found many erratics, including a large Shap granite (25 cwt.), Armboth felsite, Threlkeld quartz-porphyry, andesitic ash, rhyolite, etc. These beds fill a hollow cut out of the Woolley Edge Rock; the junction is much shattered and smashed, and large blocks of the sandstone are embedded in the clay. The Yorkshire Boulder Committee report that the country to the north and east of this patch is covered with erratics, and similar Boulder-clays are found at Burton Grange, near Barnsley, and at Ardsley, on the opposite side of the river Dearne. Mr. Walter Hemingway, of

[1] Paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

Barnsley, has recently traced two tongues of this drift into the valley of the Dearne, and has recorded a section of contorted shale with pockets of erratics from the excavation for the Barnsley gasometer.

The Balby Boulder-clay covers an area of about five acres in extent. It occupies part of a small valley in the Magnesian Limestone, which previously was filled with Bunter Sandstone. In three large pits a magnificent section of 40 feet of stiff till is shown which has yielded many erratics, including a Shap granite (2 cwt.), andesites and andesitic breccias, Eskdale granite, St. John's Vale quartz-porphyry, Carboniferous Limestone, chert, Millstone Grit, etc. The Bunter Sandstone on which this till is seen to rest has been scooped out to form a clean, level floor, without any sand or gravel intervening under the clay. In the excavations for the workhouse a section of this till showed masses of Bunter sandstone torn off and embedded in the till.

About half-way along the arc joining Staincross and Balby is another patch of Boulder-clay at Adwick-on-Dearne, containing Carboniferous Sandstone, quartzite, felstone, and encrinital chert. Close to this patch was found a third boulder of Shap granite (15 cwt.). Contiguous to this zone are several patches of gravel containing Carboniferous Sandstone with quartzite and chert, and a boulder of ganister lies on the summit of Wombwell Hill.

Beyond and to the south of this zone are several scattered patches of drift. At Barbot Hall, about one mile north of Rotherham, is a little hill covered with clay containing pebbles of quartz, sandstone, Carboniferous Limestone, and Oolitic rocks. At Masbrough sand and gravel are found containing pebbles of Carboniferous sandstone and quartz rock, and at Sitwell Vale, one and a quarter mile south of Rotherham, is a clay with pebbles and boulders of Carboniferous Sandstone. Near Hooton Roberts are three or four patches of gravel containing Carboniferous Sandstone, with quartz, quartzite, and black chert.

At the western entrance of the gorge of the Don, at Conisborough, a bed of Boulder-clay (about 15 feet thick) is shown at the Ashfield Brick Works (225 feet above O.D.), including Lake Country andesites, Carboniferous Limestone, a talcose schist with garnets, and other rocks. About the same level, on the opposite side of the gorge, at Cadeby, is a patch of drift with Carboniferous Limestone blocks. Mr. H. H. Corbett, of Doncaster, has also kindly told me of a section of Boulder-clay recently exposed in the valley between the railway station and Conisborough Castle. At Sprotborough and Cusworth, on the north side of the gorge of the Don, are patches of drifted sand and pebbles, and from the fields have been ploughed up small boulders of diorite, basalt, Mountain Limestone, ganister, and quartz-porphyry. At Hexthorpe Flats, near Doncaster, striated Carboniferous Limestone with encrinites has been found, and between Hexthorpe and Balby the ground is covered with drifted pebbles and fragments of limestone. The Magnesian Limestone escarpment south of Conisborough is strewed for some miles with patches of drifted pebbles of quartz, sandstone, and Trias.

This evidence points to glaciation from the north and north-east by two movements of ice. Two distinct tills, separated by warp and pockets of sand, are found at Staincross, the lower with Carboniferous boulders and the upper with Lake Country rocks. The drift patches are also of two kinds, one set being of a specially Carboniferous type and the other rich in Lake Country rocks. It is the latter type that forms the Conisborough and Balby clays. In the Balby pits there is also found a large percentage of Middle Coal-measure material, which forms a perplexing mixture to explain.

The author suggests that there was a double glaciation of this area early in the Glacial Period, first by Pennine ice, and secondly by the Tees glacier.

It seems probable that at the commencement of the Glacial Period, before the Irish Sea was filled with ice, the Pennine Chain was an area of great snowfall, and extensive glaciers were formed in the valleys of Western Yorkshire. These glaciers would probably send down considerable streams of ice into the central plain, laden with Mountain and Yoredale limestones, cherts, ganisters, and Carboniferous sandstones. As the Glacial Period advanced the pressure of the Norwegian ice forced the Tees glacier into the Vale of York, and this in its turn would push back the Pennine ice into the lowlands of Airedale and over the low watershed between the Aire and Don, inside the Magnesian Limestone escarpment, where it spreads out westwards and southwards as far as Staincross, Rotherham, and Conisborough. This seems to have been the line of farthest extent of this glacier, which, though it interfered for a time with the drainage of the Don, does not appear to have passed through the gorge at Conisborough.

The country south of Frickley has undergone extensive denudation since the cutting of the Darfield gorge, and it seems probable that this was effected by this ice, and, on its northward retreat, by the deflected drainage of the Aire and Calder, which, as its course eastwards would still be blocked by the advancing Tees glacier, would find a ready route of flow through Frickley gorge. Thus a large quantity of Middle Coal-measures material must have been carried through the Conisborough gorge into the plain at Doncaster, and would probably be suitably situated for the second glacier to carry forward to Balby. As it has been suggested that this material might be due to a glacier moving down the valley of the Sheaf from Dore and Totley, this question has been carefully considered. The geological surveyors do not record any drift in the valley of the Sheaf, and a careful search of the 6-inch contour maps has not disclosed any valleys which could have carried off the drainage of the upper Don if it had been obstructed by such a glacier at Sheffield. It is therefore concluded that no glacier capable of advancing to Conisborough was formed in the valley of the Sheaf.

The retreat of the first glacier may have been due to a lessening of the snowfall on the Pennine watershed, owing to the shifting of the area of greatest precipitation to the west of the Pennine Chain as the Irish Sea became filled with ice. The evidence, then, points to a second invasion of the Don and Dearne Valleys by ice, the stream this time coming principally from the Tees. This glacier, which had advanced down the central plain, was now, by the retreat of the Pennine ice, enabled to push over the Aire-Don watershed and Magnesian Limestone escarpment. Westwards it abutted against the high land of Woolley Edge, and sent down a lobe of ice at Staincross and Monk Bretton into the valley of the Dearne. This second glacier does not, however, seem to have advanced far south of the Barnsley-Adwick-Conisborough curve, and laid down the upper clay of Staincross, the Shap granites of Royston and Adwick, and the numerous Lake Country erratics of the district to the north and east of the Dearne. This glacier seems to have advanced over the Magnesian Limestone with a south-westerly movement, gradually closing the gorge of the Don and carrying the material of denuded Bunter and limestone beds over the escarpment to the south of Conisborough, of which the pebble drifts are the relics.

This movement does not appear to have extended much farther southwards, as the Kiveton gorge seems to have presented a clear course for the overflow of the lake formed by the damming back of the drainage. The second glacier appears to have retreated north of the Aire before the overflows at the head of Calderdale were in full swing. The Don and Dearne valleys were therefore, in all probability, clear of ice during the later part of the Glacial Period, and have been subjected to enormous denudation, both during the Glacial Period and since, which has cleared away the bulk of the Boulder-clay and only left relics of previously widespread deposits.

2. *Glacial Lakes and Overflow Valleys.*—Such a series of glacier movements as has just been indicated would divert the normal drainage of the district and produce lakes in the valleys thus dammed up. The Boulder-clay at Ashfield's Pit, and near the railway station at Conisborough, and at Cadeby, on the opposite side of the Don, shows that this gorge must have been filled with ice up to the 225-foot contour. The scattered patches of drift from Edlington to Clifton and Braithwell, reaching up to 400 feet, indicate that the gorge was entirely closed above the 350-foot contour. This is the general height of the Midland watershed of the Don system, and is only broken through at one point south of Conisborough, the Kiveton Valley (330 feet), near the middle of which one of the sources of the river Ryton takes its rise. These considerations warrant one in assuming the existence of a great glacial lake, rising to the level of the 330-foot contour to the west and south, and dammed back by ice from Conisborough to Barnsley. This lake would overflow by the Kiveton gorge towards Worksop. One cannot expect to find abundant evidences of lake deposits in an area which has suffered so severely by denudation as this; but the geological surveyors map from 4 feet to 9 feet of brick-earth and clay resting on gravel at Parkgate, and from 3 feet to 7 feet of brick-earth near Wombwell. These indicate a lake both in the Don and Dearne valleys, covering up the old river gravels.

Following this line of argument, and taking the various patches of drift as the relics of moraines, and therefore as indications of periods of rest in glacial movement, I have attempted to map out the lakes that would be produced at the different positions of the ice-front, and have examined the watersheds to see if overflow channels existed such as would be necessary to drain such lakes. The whole has been plotted out on the 6-inch contoured maps, by which the results have been carefully tested, and a series of lakes made out discharging successfully over cols from 175 feet to 335 feet above O.D. These overflow valleys are not of the type so characteristic of Cleveland and the Cheviots. The long period of subaërial denudation to which they have been subjected has worn back their sides so that they are now V-shaped, but they are streamless either in whole or in part, and often the nearest streams cut across their ends.

In spite of this weathering back there has probably been little alteration of their level, and their present levels may be taken approximately as those of the Glacial Period. Some of them are strike-valleys formed by the denudation of the shales between the outcrop of a bed of Carboniferous Sandstone and the dip slope of a lower grit. The objections against such valleys as overflows have been carefully considered, but as the movement of the ice seems to have brought its margin parallel to the general strike of the Coal-measures of this area, it is natural that the deflected drainage should sometimes escape by such routes. In considering the course of the first glacier, it seems probable that it would dam up the Dearne at Ardsley and form a lake overflowing by the Stairfoot valley at 175 feet. A forward movement would carry it to the Wombwell ridge, and the overflow would be by the Wombwell and Swinton strike-valleys. Further south the ice would probably abut against the projecting spur of the 350-foot contour west of Rawmarsh, and hence would form a lake about that level stretching up to Elsecar, Cawthorne, and Bretton. In searching the watershed for a possible overflow for such a lake, a narrow cut through the 350-foot contour was found at the head of the Wentworth Woodhouse valley, sloping back to the 400-foot contour on each hand, and with a little stream running across each end at right angles to the direction of the col. By this valley at 335 feet the Elsecar lake would be discharged into a smaller lake held up by the ice in the Wentworth Woodhouse valley. When the ice laid down the Masbrough and Sitwell Vale patches of drift the Rother valley would be blocked, and the glacial drainage would be discharged round the lobe of ice by channels at Greasborough and Sitwell Vale at 275 feet, and thence into the Don by the Hooton Roberts valley (180 feet). A slight forward movement of the ice to the gravel patches east of Hooton Roberts would close that valley and cause the drainage to discharge by a col on Conisborough Parks at 260 feet.

The second glacier does not seem to have advanced far beyond the curved line stretching from Barnsley through Adwick-on-Dearne to Conisborough. This, by damming the Dearne at Ardsley, would re-form the Barnsley lake, discharging over the Stairfoot col at

175 feet. This drainage would then escape by a narrow notch between Adwick-on-Dearne and Swinton into the Don at Mexborough.

A further advance would bring the Wombwell-Swinton valleys into use as overflows, and the Hooton Roberts valley would be the route into the Don. The damming of the Dearne at Barnsley by a lobe of ice would bring into use a couple of small valleys at Barnsley as overflow channels. The gradual advance of the ice across the Conisborough gorge would cause the blocking of the Don, with the formation of a constantly enlarging lake, which would overflow first by the Hooton Roberts valley (180 feet), and then by a series of cuts through the 275-foot contour on Conisborough Parks, first draining into the Don behind Castle Hill, then, as the Warmsworth watershed was reached by the ice, into the Balby valley, and, when this was closed by the ice, over the low watershed into the Loversall valley.

The further advance of the ice-front to Edlington caused a shallow cut to be made through the 300-foot contour, discharging into the Loversall valley and thence into the Trent. This channel, which bends round in a semicircle, became the permanent course of the Wadsworth drainage on the retreat of the ice, the old channel at Balby having been filled up with till. When the ice rose above the 330-foot contour the gorge of the Don was entirely closed, and the drainage of the great lake, reaching from Bretton Park and Cawthorne, north of Barnsley, to Clay Cross and Heath, south of Chesterfield, would all be discharged by the Kiveton gorge into the river Ryton.

This explanation may be thought to rest too largely on suggestions, but where the evidence is so scattered and imperfect it is difficult to see how this can be avoided if any explanation is to be attempted.

NOTICES OF MEMOIRS, ETC.

I.—Note on Lower Cretaceous Phosphatic-beds and their Fauna. By G. W. Lamplugh, F.G.S.[1]

It has been customary to regard the fossils more or less imperfectly preserved in the condition of phosphatic casts in different parts of the English Lower Cretaceous series as derivative from the Jurassic rocks. In previous papers the writer has brought forward evidence to show that the fauna of such beds at Speeton and in Lincolnshire is not derivative, but occurs at its proper horizon and, so far as it goes, indicates the life of the period. Personal investigation of the localities, and of the fossils obtained from the 'coprolite-beds' at Upware, Potton, and Brickhill, has led him to conclude that in these deposits also the greater part of the so-called derivatives are really of Lower Cretaceous age. Thus, one of the

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

most abundant phosphatic fossils of these places is the ammonite, usually fragmentary, which has habitually been named *Amm. biplex*, but belongs in almost every case to one or another of several allied species of Lower Cretaceous Olcostephani. Most of the lamellibranchs can likewise be best matched by Lower Cretaceous forms; and there are good grounds for suspecting that many of the Saurian and fish remains from the above-mentioned places and from the Faringdon 'Sponge-Gravels' which have been classed as Jurassic are true Lower Cretaceous forms.

It is acknowledged that the presence of transported pebbles of older rocks in the deposits at Upware, Potton, and Faringdon renders the occurrence of derivative fossils at these places more probable than in the case of the Speeton and Lincolnshire 'coprolite-beds'; and in the collections examined a few specimens were noticed that seem to have been washed from older rocks. But the writer believes that these instances are exceptional, and he urges that no fossil should be set down as derivative unless the evidence is conclusive, as much confusion has arisen through the unquestioning adoption of the hypothesis of derivation.

While there is still much to be learnt as to the physical conditions requisite for the concretion of phosphatic nodules and for their segregation into bands, it seems clear that an important determinative was the existence of submarine currents occasionally impinging upon the sea-floor with sufficient strength to sweep away the matrix in which the nodules had been formed, so that there was a gradual accumulation of the partially eroded nodular residues. Such residues, though of inconsiderable thickness, may represent a long period of submarine conditions. The term 'aggregate deposits' has been suggested by J. F. Blake for beds of this character.

II.—On the different Modifications of Zircon. By L. J. Spencer, M.A., F.G.S.[1]

SOME very irregularly developed crystals of zircon from the gem-washings of the Balangoda district in Ceylon were found to have characters differing widely from those of zircons of more common occurrence. Although of low specific gravity (4·0), they are not increased in density when strongly ignited, as are many zircons of specific gravity below 4·7. They further differ from ordinary zircon in their very feeble, or absence of, birefringence. The crystals are dark brown in colour and almost opaque, but after ignition they are bright green and quite transparent.

While some of the crystals consist wholly of zircon of this type, others contain an intergrowth of a second kind, which may be present in greater or less amount. The latter has a higher specific gravity, and increases in density when ignited; it is optically biaxial with very strong birefringence. A section cut perpendicular to the

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

principal axis of such a compound crystal shows, when moved across the microscope-stage in convergent polarised light, a gradual transition from a biaxial to a uniaxial figure, the coloured rings at the same time moving outwards and becoming further apart owing to the diminution in the strength of the double refraction, which is positive throughout; finally, when the rings have all moved out of the field of view, the black cross also disappears, and the corresponding portion of the section is optically isotropic. The mean refractive index has about the same value in all portions of the section.

Zircon of the first type has been previously described by Professor A. H. Church (1875) and by Dr. S. Stevanović (1903), and from the researches of these and other authors it would seem that there are, at least, three modifications of zircon, viz.:—

α. Those of specific gravity 4·0, which do not increase in density when ignited.

β. Those of specific gravity 4·7, also not increased in density when ignited.

γ. An unstable form of specific gravity about 4·3, which when ignited is increased in density to 4·7.

That these different kinds are often intergrown in the same crystal is shown by the frequent occurrence of zonal structures in zircon, and further by the behaviour of the crystals when heated. A crystal consisting of an intergrowth of *α*-zircon and *γ*-zircon will be increased in density on ignition, but not to the higher limit of 4·7; on the other hand, an intergrowth of *β*-zircon and *γ*-zircon will reach the higher limit when ignited.

In crystalline form and chemical composition (as far as could be determined by qualitative tests) *α*-zircon and *β*-zircon are identical, and these appear to be also the same for *γ*-zircon.

III.—On Derived Plant Petrifactions from Devonshire. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

Some interesting plant petrifications in which the structure has been to some extent preserved by means of a mineral agent have recently been discovered in the higher beds of the Upper Culm Measures (Upper Carboniferous) in Western Devon. Although the preservation is not sufficiently good to render this discovery of any botanical importance, the manner in which the fossils occur is interesting from a geological point of view. The plant remains consist of small rolled fragments of stems, of an inch or less in length, arranged without order in a fine-grained sandstone. They are in all probability derived from some pre-existing beds, and are not contemporaneous with the sandstone in which they are found. Such derived plant remains are very rare, if not unknown, from the Palæozoic rocks.

[1] Abstract of report read before the British Association, Cambridge, Section C (Geology), August, 1904.

IV.—On the Fossil Plants of the Upper Culm Measures of Devon. By E. A. Newell Arber, M.A., F.L.S., F.G.S.[1]

The Upper Culm Measures form by far the largest portion of the Carboniferous sequence in Devon and the adjacent counties. Fossil plant remains are abundant in these beds, but their preservation is rarely sufficiently good to permit of even generic determination. A number of well-preserved specimens have, however, recently been obtained from the one horizon in which coal or 'culm' occurs in these beds in the Bideford district. They include *Calamites undulatus, Calamocladus charæformis, Alethopteris lonchitica, A. Serli, Neuropteris obliqua, Sigillaria tessellata,* and many others. *Neuropteris Schlehani* and *Megalopteris* (?) sp. are also recorded from Britain for the first time.

This flora confirms the previous conclusions with regard to the Upper Carboniferous age of these beds, and indicates that the coal-bearing beds of the Bideford district are the equivalents of the Middle Coal-measures elsewhere in Britain—a higher horizon than has previously been assigned to these beds.

V.—On the Occurrence of Pebbles of White Chalk in Aberdeenshire Clay. By A. W. Gibb, F.G.S.[1]

The record of the Cretaceous period in the north-east of Scotland is a very fragmentary one. The principal traces hitherto noted consist of a deposit of the nature of a Greensand—not proved to be *in sitû*—at Moreseat, Cruden, and large numbers of flints scattered over the surface of the ground in the same locality between Buchanness and the Hill of Dudwick.

Further indications of Cretaceous strata have recently been found at Strabathie, in the district of Belhelvie—about five miles north of Aberdeen—in a bed of laminated clay close to the sea. The clay is found to contain pebbles of white chalk in considerable abundance. Some of the pebbles measure nearly a foot in length, but the majority are small. Some of them inclose flints. That they have been worn off an adjoining land surface is shown by the fact that numbers of them are markedly glaciated, and that pebbles of other rocks, identical with or similar to the rocks of the district, are found in the same pit. These facts indicate that Upper Cretaceous beds have once been, and perhaps somewhere are still, *in sitû* in the locality.

It has been ascertained by boring that the clay deposit covers a considerable area, and as fresh exposures are constantly being made in the process of working the bed further finds may be anticipated.

[1] Abstract of paper read before the British Association, Cambridge, Section C (Geology), August, 1904.

VI.—Edenvale Caves, Co. Clare.—Final Report. By Dr. R. F. Scharff (Chairman), Mr. R. L. Praeger (Secretary), and a Committee appointed to explore Irish Caves. (Drawn up by the Chairman.)[1]

Since our last report was submitted to the British Association, Mr. Ussher has completed the excavations of the extensive caves of Edenvale, co. Clare, and sent altogether a collection of more than 50,000 bones to be named. Besides these there were flints and implements used by primitive man and relics of various periods, on which it is proposed to submit a detailed report to the Royal Irish Academy during next winter.

Mr. Ussher has explored other districts of Ireland with the view to continuing the cave researches, but this Committee do not propose to apply for a further grant.

The Edenvale remains have not been fully determined, but so far they have yielded the following species:—

Man (*Homo sapiens*).
Bats (several species).
Hedgehog (*Erinaceus europæus*).
Domestic Cat (*Felis domestica*).
Wild Cat (*Felis caligata*).
Dog (*Canis familiaris*).
Fox (*Vulpes alopex*).
Irish Stoat (*Putorius hibernicus*).
Marten (*Mustela martes*).
Bear (*Ursus arctos*).
Badger (*Meles taxus*).
Arctic Hare (*Lepus timidus*).
Rabbit (*Lepus cuniculus*).
Irish Rat (*Mus hibernicus*).
Field Mouse (*Mus sylvaticus*).
Arctic Lemming (*Dicrostonyx torquatus*).
Domestic Ox (*Bos taurus*).
Domestic Sheep (*Ovis aries*).
Domestic Goat (*Capra ægagrus*).
Domestic Pig (*Sus scrofa domestica*).
Wild Pig (*Sus scrofa ferus*).
Red Deer (*Cervus elaphus*).
Giant Deer (*Megaceros giganteus*).
Reindeer (*Rangifer tarandus*).
Horse (*Equus caballus*).
Birds (many species).
Frog (*Rana temporaria*).
Fishes (several species).
Land Mollusca (many species).

VII.—Brief Notices.

1. Peat Moors of the Pennines.—In an article entitled "Peat Moors of the Pennines: their Age, Origin, and Utilization" (*Geographical Journal*, May, 1904), Mr. C. E. Moss remarks that the Pennine peat moors represent a valuable asset which is turned to little account: not only is there enormous value in products manufactured from peat, but he believes there is fuel enough to last the hillside population for a thousand years.

2. Najas in the Peat.—Mr. Clement Reid records the occurrence of *Najas marina* in the Megaceros-marl of Lough Gur (*Irish Naturalist*, vol. xiii). This little "submerged flowering plant" is known to exist in Britain only at a single spot in Hickling Broad, in Norfolk. It is found in the Cromer Forest-bed Series, and in

[1] Abstract of report read before the British Association, Cambridge, Section C (Geology), August, 1904.

later deposits in England and Wales, but has not hitherto been recorded from Ireland.

3. Rhodesia.—A useful pamphlet on "The Geology of Southern Rhodesia," by Mr. F. P. Mennell, has been issued by the Rhodesia Museum at Bulawayo. This is accompanied by pictorial and other illustrations, and by a sketch geological map on the scale of an inch to four miles. The author deals with the igneous rocks and schists, the coal series, superficial deposits, and scenery.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom.

The Tertiary Igneous Rocks of Skye. By Alfred Harker, M.A., F.R.S., with Notes by C. T. Clough, M.A., F.G.S. pp. xi, 481, 84 text-figures, 27 plates, and one coloured map. (Glasgow, 1904. Price 9*s.*)

THE appearance of this memoir awakens the echoes of past controversies. The region with which it deals shows within a narrow compass such a complex group of rocks that diversities of opinion might well arise as to their mutual relations. Broadly speaking, two series of igneous rocks occur, an acid and a basic, ranging in both cases from plutonic masses and intrusive sills and dykes to lava-flows; and the views first enunciated, according to which the plutonic masses were regarded as the denuded cores of volcanoes from which the lavas (first the acid and then the basic) had been poured out, appeared to be a simple and reasonable explanation of the facts observed.

As is well known, very different views from the above as to the sequence of these igneous rocks were held by the late Director-General of the Survey, under whose direction, in fact, was planned much of the work the result of which is recorded in the present memoir. The result of Mr. Harker's researches, it may be here briefly stated, has been to convince him of the correctness of Sir Archibald Geikie's main conclusions that the basaltic lavas which cover such an extent of country in the Western Isles of Scotland and in the north of Ireland are amongst the earliest volcanic rocks of the region and were probably due to fissure-eruptions, that the gabbro-masses were intruded into them and are consequently of later date, and that finally these basic rocks were invaded by the granites and granophyres. Supporters of the earlier views will find, therefore, little encouragement in these pages, although here and there a glimpse may be caught of difficulties in the case of phenomena easily capable of misinterpretation, such as the presence in the earlier basic agglomerates of fragments of gabbro and granophyre identical in character with the later rocks which constitute the main mass of the Cuillins and the Red Hills, and the occurrence of basic dykes which traverse certain rocks freely and end abruptly against others (such as granite and agglomerate), not because the latter are of later date, but owing to the resistance they offered to the passage of the dykes. Like many of the other problems which have confronted Mr. Harker in this region, this last observation is an important one and capable of wide application; for, as he suggests, it may lead to a reconsideration of the age attributed to certain intrusions which intersect the Carboniferous and older strata in parts of England and Wales.

The memoir is confined principally to the area mapped in detail by Mr. Harker during the years 1895–1901, comprising the central laccolitic masses of gabbro and granophyre and their surroundings, the basaltic plateaux to the west and north-west, and some of the islands off the east coast; but the south-eastern part of the island, which was surveyed by Mr. Clough, also receives consideration in the descriptions of the minor intrusions in the older stratified rocks.

After an introduction dealing chiefly with the general relations of the volcanic series, the different rock-groups are treated as far as possible in chronological order, and in each case descriptions are first given of the field relations and then of the petrographical characters. As regards the latter, Mr. Harker has been on the whole merciful, and spared us too great detail; in some cases an additional interest is given to the description of thin-slices by the discussion of the chemical analyses, no less than sixteen of which have been made for the purpose of the memoir by Dr. Pollard.

Although the gabbro and granite masses have been deposed from their position as ancient volcanic cores, yet the remains of vast craters filled with agglomerates have been detected in Skye. These were the vents from which took place the explosive eruptions which marked the earliest phase of igneous activity in the island. The succeeding tranquil fissure-eruptions of basalt were also accompanied and partly succeeded by paroxysmal eruptions of trachyte and rhyolite. In comparison with the basalts, however, the pyroclastic rocks and more acid lavas play but a very minor rôle. A fact with respect to the basalts, which Mr. Harker considers has not been hitherto sufficiently appreciated, is the extent to which their apparent thickness has been increased by the intrusion of dolerite sills of later date. The greater part of the alteration (with production of amygdules) which characterises these basalt lavas is attributed by the author, not to ordinary weathering, but to changes produced in them soon after their eruption by the "action of water of volcanic origin." In the subsequent contact-metamorphism by the gabbro and granite it is these early formed amygdules which show the most interesting effects, viz., a restoration of the minerals (felspar and augite) from which the zeolites and chlorites were originally derived.

To the second or plutonic phase of igneous activity are due the most picturesque features of the scenery of Skye. This phase consisted in the intrusion of laccolitic masses first of ultra-basic rocks, then of gabbro, and lastly of granite and granophyre. The descriptions of the partial fusion and incorporations of the gabbro by the invading granite magma with the consequent production of hybrid rocks of abnormal chemical and mineral composition, and the detailed accounts of the peculiar composite sills and dykes outside the mountain tract, form perhaps the most important and interesting feature of the memoir. In the case of Skye the author finds that the heterogeneity of these intrusions is invariably due, not to differentiation subsequent to intrusion, but to successive injections of different rock-magmas, the acid magma showing a tendency to be guided by a pre-existing basic dyke or sill.

Of the third and final phase of igneous activity in Skye which was characterised by minor intrusions in the form of sills and dykes, the most important rôle was played by the great group of basic sills previously referred to, which are intercalated among the basaltic lavas to such an extent that they and not the basalts really form the salient features of the plateau country. Amongst a minor group of basic sills an interesting type is the peculiar composite sills of Roineval, to one of the constituents of which the author gives the provisional name of Mugearite. This and Marscoite (a hybrid of gabbro and granite, produced, however, before intrusion) it is a relief to see are the only new rock-names which appear in a memoir which deals with so many rocks of exceptional composition. To the rocks composing most of the basic dykes and sills we are glad to find that Mr. Harker applies the name olivine-dolerite, although he has not been able to avoid altogether the use of his term diabase for some of the coarser-textured types near to gabbro.

In an interesting penultimate chapter is given a general review of Tertiary igneous activity in Skye. As the cause of this activity two distinct elements of crustal strain are recognised, the one regional and probably related to the great Atlantic depression, and the other local: to the first are attributed the fissure eruptions of basalt, the great group of basic sills, and the system of parallel dykes, and to the second the central volcanic eruptions, the plutonic intrusions, and the radial group of dykes peculiar to the Cuillin district.

In the last chapter, the physical features and scenery of the island and their relation to the geology are discussed. A very complete bibliography of the geological literature referring to the igneous rocks of Skye is given in an Appendix.

The memoir is illustrated by 84 text-figures and 27 plates. References to the figures in the text might have been with advantage more often accompanied by indications of the pages on which they occur.

In conclusion, it remains to congratulate Mr. Harker on the completion of an arduous but very successful piece of work, and the Geological Survey on the production of a volume which with its numerous and excellent illustrations can be offered to the public at so low a price.

II.—Stanford's Geological Atlas of Great Britain [based on Reynolds's Geological Atlas], with plates of characteristic fossils, preceded by a Description of the Geological Structure of Great Britain and its Counties, and of the features observable along the principal lines of Railway. By Horace B. Woodward, F.R.S., F.G.S. pp. x and 140, with 34 geologically coloured Maps and 16 double octavo Plates of Fossils geologically arranged. (London, 1904: Edward Stanford, 12–14, Long Acre, W.C. Price 12*s.* 6*d.*)

EVERY well-informed person at the present day is not necessarily a geologist; nevertheless, there are a vast number of people who are more or less *acquainted* with geology (if it is only "a bowing acquaintance," like Mark Twain's with the Prince of Wales). To those more or less interested in this study, and especially for those who have little time to spare, a handy *vade-mecum*, a small book, not too small, as a pocket-companion, to beguile the tedium of travel in an agreeable and intelligent manner, is likely to command the attention of the public. The book before us weighs only 18 ounces, and measures 5 by $7\frac{3}{4}$ inches, just the size for a bicycle bag or a side-pocket, and is crammed full of information of the best quality and written by an experienced practical geologist, who tells his readers what is to be seen of geological interest on every line of railway and in every separate county in the kingdom, illustrated by 34 maps *coloured geologically*, so that he who rides, by road or rail, can take out his book and *look* or *read* as he is so minded.

Before starting out, the beginner should at least read the first 34 pages, which in clear and simple language will convey to him an outline of what geology teaches about the broad features of our island, and how they have been produced by the agencies of the sea or by rain and rivers, or the slow movements of the solid crust, during vast periods of past geological time; how the old sediments which form our stratified rocks were accumulated and afterwards uplifted, and then slowly carved out into earth's physical features, just as a sculptor might carve the features of a man out of a block of marble, or, as the same thing is sometimes done now, by means of the 'sandblast' process—so our hills and dales and great cliffs and rugged mountains have been slowly carved by atmospheric agencies, ice, snow, frost, rain, and rivers, nay, even by wind and sun, heat and cold.

The reader will get some notion too of the periods of geological time and of the relative antiquity of the various rocks, which he will speedily recognise in the handy little maps of the counties by their several geological colours, first as expressed in the frontispiece of the whole of Great Britain, admirably executed by chromolithography, as Stanford's know so well how to do it. Each geological colour is numbered in the Index on the General Map, and on a larger scale on the single folding-plate (facing p. 1), which gives at a glance the number, colour, and name of each formation and the names of its characteristic fossils. Then, if the reader be going to travel from

London, say, through Middlesex, Hertford, Bedford, or Buckinghamshire, he will turn up Map 2, and tracing his intended route will easily note, by the colours and the numbers, the formations he will travel over, and so will read with greater interest in the pages devoted to each county (pp. 40–101) what are the features of each, both physically and geologically; or in the pages which follow (pp. 102–134), after selecting his line of road or railway, he may read what are the rocks and the kind of country he is about to travel over.

If travelling by road on bicycle or motor-car (or with knapsack and on foot), he may stop a few minutes by roadside section or quarry, or even by a heap of native stones picked off the land or obtained from an excavation near by, and find here and there a fossil which the plates of fossils (xxxv–l) will often enable him to identify. All these details are full of interest to the inquiring and intelligent student who wants to know the inside of things, and for teaching him there is nothing like pictures and colours. The only fear is that such aids to intellectual improvement may be made too easy and agreeable; but though the full-fledged geologist may feel these matters too simple, the less advanced inquirers, of whom there are many, will certainly not be disappointed in the pleasure to be derived from the companionship of this very useful little book.

The original work, entitled "Reynolds's Geological Atlas," which gave the cue to the present volume, and now renamed "Stanford's Geological Atlas," has a history, and has long been known and regarded as a useful companion and guide to those journeying on business or pleasure in Great Britain who take interest in the geology of the country. The first edition, issued in 1860, was prepared with the assistance of the late Professor John Morris, F.G.S. (for 21 years one of the Editors of the GEOLOGICAL MAGAZINE), and the second edition, published in 1889, was revised by the late Mr. Robert Etheridge, F.R.S. L. & E., F.G.S. (*also* one of the Editors of this journal from 1865 to the present year).

The present volume has been carried out upon the general plan of the older work; the text has, however, been entirely rewritten by Mr. Horace B. Woodward, F.R.S. Fuller descriptions of the geological formations, with lists of localities for fossils, have been given; the particulars relating to each county have been amplified, regard being paid to the more interesting geological facts, irrespective of the size or industrial importance of the county, and notes on seaside resorts have been appended.

The descriptions of the geological features observable along the main lines of railway is entirely a new feature. A few of the original text illustrations are the same as in the earlier edition, the others have been borrowed from Sir Andrew Ramsay's "Physical Geology and Geography of Great Britain."

The figures of fossils, forming sixteen double octavo plates, have been reproduced chiefly from Lowry's "Tabular View of British Fossils" and from his "Chart of Characteristic British Tertiary Fossils"; others have been taken from the "Chart of Fossil

Crustacea," drawn by J. W. Salter, F.G.S., and Henry Woodward, F.R.S.; a few are from Ramsay's "Physical Geology." They are very well selected, and will serve to illustrate the forms of the leading fossils that are to be met with in the various British stratified rocks.

The maps in the original atlas were based to a large extent on those published by the Geological Survey, and they have now been revised, as far as the scale has permitted, from the later published maps of that institution and from Sir A. Geikie's Geological Map of Scotland. The work reflects credit on both the author-editor and publisher, and deserves to prove a success, and is certainly a very useful addition to our geological library.

III.—A Guide to the Fossil Mammals and Birds in the Department of Geology and Palæontology, British Museum (Natural History), Cromwell Road, London, S.W. Eighth Edition. 8vo; pp. xvi and 100, with 6 plates and 88 text-figures. (London, 1904. Price 6*d.*)

THE Guides to the Geological Department bid fair to continue to be "the cheap sixpenn'orth" of the Museum. The aggregate sales of the seven earlier editions (1881–1896), we are told, amounted to about 20,000 copies; and we may safely prophesy that the one issued this year will find equal favour with the public.

This work has been entirely rearranged and rewritten; 28 of the text-figures used in the earlier editions have been withdrawn, and 14 new text-figures introduced, 5 octavo plates of fossils, a new geological table of fossiliferous deposits giving British and European names of strata, also a folding plate-plan of the Mammalian and Avian Galleries.

The new illustrations comprise two views of the same block of a Lower Pliocene Bone-bed from Pikermi (near Athens), obtained by Dr. A. Smith Woodward, F.R.S.,[1] together with a large collection of fossil remains in 1901 (see Geol. Mag., 1901, pp. 481–486), crowded with bones of mammals and of birds. The three-toed Horse (*Hipparion*), various bones of antelopes, and some carnivora make up the great mass of the block.

A block of flint from Crayford, Kent, broken by Palæolithic man in making flint-knives, is illustrated on p. 7 as one of the prehistoric series. The restored skull and mandible of the giant lemur, *Megaladapis insignis*, from a cave in Madagascar, is drawn (p. 11), and the gaping jaws and outline of head of the sabre-toothed tiger (*Machærodus*) (p. 13) from South America. After such a yawn, do you think he could ever shut his mouth again? The skeleton of *Hyænodon* from Dakota (p. 16) is also new.

Of wonders added to the collection lately is the skull and mandible of *Arsinoitherium zitteli* (fig. 38, p. 47), a mighty herbivore of the new order Barypoda (see Dr. C. W. Andrews, Geol. Mag., October, 1904, p. 481), from the Upper Eocene of

[1] Author of the present Guide, and Keeper of the Geological Department.

the Fayûm, Egypt, a beast off which the royal sabre-toothed tiger might have dined well after fair fight. The pictured skeleton of *Phenacodus*, like that of *Hyænodon*, are both in American Museums. *Toxodon platensis*, a huge herbivore, is represented by a restored reproduction in the gallery (T). Of the Elephants, there is a new figure of *Elephas* (*Stegodon*) *ganesa* from the Sewaliks of India; and near it (p. 64) is figured the four-tusked *Tetrabelodon*[1] from Sansan, France, the skull and mandible of *Palæomastodon beadnelli*[2] and of *Mæritherium lyonsi*,[3] both from the Eocene of the Fayûm, Egypt.

A new figure is also added of the skeleton of *Glyptodon clavipes* (case Z, pavilion) from the Pampa formation of Buenos Aires (p. 75), and on plate iv pieces of the skin of the extinct ground-sloth, *Gryphotherium Listai*, nearly as large as the *Mylodon*, whose remains, associated with man, were obtained from a cavern near Last Hope Inlet, Patagonia, where these great phytophagous mammals appear to have been kept alive, and fed upon cut grass (also preserved) by these wild people, who afterwards ate them, leaving the bones and skin behind.

The lower teeth of the existing Monotreme *Ornithorhynchus* are figured (p. 85) to show their multituberculate crowns, which closely resemble the teeth of some of the earliest Prototherian mammals found fossil. A figure is added (p. 90) of the restored skull of the great extinct bird *Phororachos*, also from Patagonia; and on pl. v is given a beautiful figure of the skeleton of the gigantic Moa (*Dinornis maximus*) from New Zealand, set up in the gallery some years since. Plate vi gives an excellent figure of the long-tailed and toothed fossil bird, the *Archæopteryx*, from the Lithographic Stone of Eichstädt, Bavaria (described and figured by Dr. Henry Woodward in the *Intellectual Observer*, vol. ii, for 1862).

In the folding table of stratified rocks the range of each great group of organisms is shown in the stratified series, and the approximate European equivalents of the British rocks are given in parallel columns.

In a museum the student is more concerned with the succession of life than with the succession of stratified rock-masses; and a grouping by means of epoch names—that should be used all the world over, if possible—is to be commended.

The fresh column of Ages, as present day, historic, neolithic, palæolithic, glacial, would be excellent if all were simple and accepted terms, but such names as 'Priabonian,' 'Artinskian,' 'Pliensbachian,' etc., have been very little used in this country; it is, however, possible they may be adopted when known and appreciated; but for the people who buy the Guide they do not seem likely to be of much assistance.

Another new column added gives, diagrammatically, the relative lengths of Epochs, with the thickness of each, and anyone who likes may colour this part for himself with great advantage.

[1] See Geol. Mag., Dr. C. W. Andrews, on *Tetrabelodon*, 1903, p. 225.
[2] Article by Dr. C. W. Andrews, see Geol. Mag., March, 1904, p. 113.
[3] See Geol. Mag., March, 1904, p. 110.

Among the figures eliminated from the Guide, we miss the picture of the 'Musk-ox,' and the molar teeth of the Indian and African elephants (useful for comparison); these are probably excluded as living forms, but by the time a new edition is called for we may see the whole of the recent and fossil mammalia and birds amalgamated in one Guide. Signs are not wanting of what Sir Henry Howorth, writing to the *Times*, described as the coming fusion of the Louvre and the Luxembourg Galleries.

IV.—PHYSIOGRAPHY: AN INTRODUCTION TO THE STUDY OF NATURE. By T. H. HUXLEY. Revised and partly rewritten by R. A. GREGORY, Professor of Astronomy, Queen's College, London. 8vo; pp. xi, 423, with 301 illustrations. (London: Macmillan and Co., Limited, 1904. Price 4*s.* 6*d.*)

IT was in 1877 that Huxley's "Physiography" was introduced to the public, and to a certain extent it revolutionized, as was the aim of the author, the old method of teaching Physical Geography. He sought to convey scientific conceptions by an appeal to observation; to create interest in the study of 'Earth-knowledge' by commencing with the local geography, "until step by step the conviction dawns upon the learner that, to attain to even an elementary conception of what goes on in his parish, he must know something about the universe." Thus "the knowledge of the child should, of set purpose, be made to grow in the same manner as that of the human race has spontaneously grown."

The original edition of Huxley's book owed much, as the author cordially acknowledged, to the editorial care of Mr. F. W. Rudler. The work became at once popular in the best sense of the term, a third edition was issued in 1880, and it has continued to hold its place with comparatively little alteration until the appearance of the present work. The progress of science during the past quarter of a century has, however, made necessary many additions and modifications in detail, while here and there alteration in plan has been deemed desirable.

The most prominent change is in the omission of the special reference to the Thames and its basin, which Huxley had taken for his 'text'; instead, the central idea has been transferred to any river basin. This difference in treatment is marked when we compare the index of the present volume with that of Huxley's third edition. In the latter there are more than sixty references to the Thames and its basin. In the present index the Thames is not recorded. Considering the interest of the subject, a little more space might have been given to the "Development of a drainage area," as but scant justice can be accorded in a page of print to the views enunciated by Professor W. M. Davis; and his nomenclature of rivers is not even mentioned.

A conspicuous feature in the new work consists in the number of admirable pictorial and other illustrations, of which six only appeared in the old editions; and it is satisfactory to find that while the work has been thoroughly revised, yet a great deal of the original text has been retained. Moreover, Professor Gregory, whose sympathies may be considered to lean towards the astronomical side of physiography, has very fairly upheld the balance of power allotted by Huxley to the claims of the several sciences concerned in the subject. Physiography is thus kept well within its legitimate bounds of Earth-knowledge, or, strictly speaking, Nature-knowledge, despite the tendency, as Professor Lapworth observed last year in his address to the Geological Society, for "Physiography to embrace much that truly belongs to Astronomy." Professor Gregory, indeed, commences his work in a way that must delight Professor Lapworth, by dealing with "Maps and Map-reading," a subject eminently fitted to interest and instruct, but hitherto strangely neglected in all spheres of society.

The chapter on "Geological Structure and History" contains many effective pictures, but here and there some emendation is required in the text. We are at a loss to interpret fig. 234, "Greensand with boulders at Headington, 2½ miles below Oxford." The 'Lower Greensand' of Shotover Hill, by Headington, rests on Portlandian beds with huge 'doggers'; and at a lower level there is Kimeridge Clay resting on the Corallian Limestone, strata that answer better to the figure than to the legend attached to it. On the same page (331) it is stated that "the hills of Middlesex are formed of London Clay," whereas Stanmore Hill, the highest ground, is capped by gravel; Hendon, Finchley, and Muswell Hill, by gravel and boulder-clay; Harrow, Hampstead, and Highgate, by Bagshot sand. On the next page we find Edge Hill included among the escarpments of the Oolites, whereas, to be precise, it is a scarp of Marlstone or Middle Lias. These, however, are but trifling defects that may readily be put right in a new edition.

V.—Geological Survey of the Transvaal: Report for the year 1903. (Pretoria, 1904. Price 7*s.* 6*d.*)

The Geological Survey of the Transvaal, as organized under the British Government, was constituted in February, 1903, under the direction of Mr. Herbert Kynaston, B.A., F.G.S. The present report deals with the first year's field-work carried on by the Director and two geologists, Mr. E. T. Mellor, B.Sc., F.G.S., and Mr. A. L. Hall, B.A., F.G.S. It is a folio work of 48 pages, accompanied by 24 plates of pictorial views, sections, plans, and colour-printed maps, all admirably rendered. The area chosen for survey was that to the east of Pretoria, bordering the railway as far east as Balmoral on the way to Middelburg; and the main results of the field-work are depicted on a map on the scale of about $2\frac{1}{3}$ miles to an inch. The older stratified rocks include (1) a *Dolomite Series*, (2) shales and quartzites grouped as the *Pretoria Series*, (3) the *Waterberg Sandstones and conglomerates*, (4) the *Karroo System*, comprising glacial conglomerate, coal-measures, etc., and (5) alluvial deposits. Granite, felsite, syenite, elæolite-syenite, diabase, and volcanic breccia are likewise represented. Evidence is brought forward to show that there is a considerable break between the Waterberg and Pretoria Series. The glacial conglomerate, which lies at the base of the Karroo System, is on the same horizon as the well-known Dwyka conglomerate of Cape Colony. Glaciated surfaces have been met with further north than had previously been observed by Dr. Molengraaff, and the evidence of the striæ and of the boulders indicates that the general direction of the ice-movement was from north to south. Excellent pictures of glaciated surfaces are given. Investigations were made into the diamondiferous deposits of the Schuller, Kaalfontein, and Montrose mines. The diamonds are found in true pipes or volcanic vents, and in alluvial and other superficial deposits. The pipes appear all to belong to the same geological period, and they are evidently younger than the Pretoria Series, into which they have been intruded. There is, however, much resemblance in behaviour and constitution between the pipes now described and those of Kimberley, and if they prove to be contemporaneous the Transvaal pipes would be of post-Karroo age.

Mr. Kynaston and his fellow-workers are to be heartily congratulated on the results of their first year's work in the Transvaal, showing, as it does, abundant evidence of careful scientific research by well-trained observers, who are at the same time keenly alert with regard to questions of economic geology on which their labours are calculated to throw light.

OBITUARY.

ROBERT FISHER TOMES, J.P., F.G.S.

BORN 1823. DIED JULY 10, 1904.

LAST July the geological world had to mourn the loss of a veteran geologist, Robert Fisher Tomes, of South Littleton, near Evesham. Although he may have appeared to have lived a somewhat secluded life, it was nevertheless an extremely active one. The administration of justice, educational matters, parish and county work, various branches of archæology, zoology, and geology, all received attention; whilst he was an excellent carver of old oak and an enthusiastic collector of old china—especially Worcester. His collections of fossil corals and birds are particularly fine, and he also possessed a number of type-specimens of bats, which unfortunately went to decay owing to inadequate preservation.

Mr. Tomes was born at Weston-on-Avon in 1823, and was the brother of Sir John Tomes, Bart., F.R.S., F.R.C.S., L.D.S., who died in 1895 (an odontologist of no mean rank, and a friend of Sir Richard Owen). He was Vice-Chairman of the Chipping Campden School Board for many years; Chairman of the Board of Guardians of Stratford-on-Avon for thirteen years (until 1879), when he went to live at South Littleton. He was appointed Alderman for the County Council of Worcester; subsequently being placed on the Standing Joint Committee, on which he remained until his death in July of the present year. His knowledge of geology, especially of the country around Evesham, enabled him to indicate in the Cotteswold Hills places whence water was obtained for the supply of thirteen or fourteen villages. His views met with considerable opposition at first, but were, however, accepted without question by the engineer, and the work was accomplished at a moderate cost.

In 1860 Mr. Tomes was made a Corresponding Member of the Zoological Society of London, in recognition of the labour spent and the excellent results obtained from the examination of the Cheiroptera, and for his descriptions of many new species. His fine collection of birds from the county of Worcester testify to his taxidermic skill and knowledge of ornithology.

About the year, however, that he was elected a Corresponding Member of the Zoological Society, Mr. Tomes directed his attention to geological matters, opening the discussion as to the age of the Sutton Stone and Lias conglomerates of Glamorganshire. The subject was broached in 1863 on account of a *Gryphæa* having been sent by Mr. Tomes to John Jones, of Gloucester, for the purpose of figuring and describing in his paper "On *Gryphæa incurva* and its varieties" communicated to the Cotteswold Club; the stratigraphical position of the fossil having been given by Mr. Tomes as "White Lias of Bridgend, Glamorganshire." The fact that the *Gryphæa* was of great interest if it really occurred in what was known as the "White Lias," was naturally appreciated by Jones, but the fact was contested by Charles Moore, F.G.S., of Bath. Moore denied that Rhætic beds were exposed in the Bridgend cutting; but admitted that if the *Gryphæa* was associated with *Ostrea intusstriata* (*Plicatula intusstriata*), then the evidence for the Rhætic age of the deposit was strong, as it was then generally believed that *Plicatula* only occurred in the White Lias. Accordingly it was agreed that Tomes, Moore, Kershaw, and Gibbs should make a fresh examination of the section. Tomes discovered the little *Plicatula* adhering to a lump of Mountain Limestone firmly embedded in the Lias rock. Near the same horizon a large specimen of *Coroniceras Bucklandi* was discovered by Moore. After an examination of the coast-section in the neighbourhood of Sutton and a re-investigation of the Bridgend cutting (where a *Gryphæa* with "no less than six small specimens of *Ostrea intusstriata*" adhering was found), it was agreed that the species had a much more extended range in time than had been hitherto thought, and therefore could "no longer be looked upon as typical of White Lias." The matter then appeared settled, for Mr. Tomes submitted that there was but one explanation, and that was "that during the period of the deposition of the Rhætic beds *no such deposition* took place at the locality in question [Bridgend]," an opinion he re-stated in 1877, and added, "the Rhætic fauna of that period became in this manner mixed up with that of the true Lias, which was subsequently deposited." He held this opinion to the end, reiterating it in 1903 when dealing with the coral *Heterastræa rhætica*, from the *Avicula contorta* beds of Deerhurst, Gloucestershire.

Mr. Tomes became a Fellow of the Geological Society in 1877, and communicated numerous papers which appeared in the Quarterly Journal of the Society from 1878 to 1903. Whether short or long, these papers—all on fossil corals—embodied the results of critical examination and accurate field-work, although the results arrived at from an examination of the corals were frequently contested by Duncan. To the GEOLOGICAL MAGAZINE he contributed an even greater number of papers on the same subject, always making his own drawings.

L. RICHARDSON.

LIST OF TITLES OF PAPERS BY ROBERT FISHER TOMES, F.G.S.

"On the Position of *Gryphæa incurva* in the Lower Lias at Bridgend": Proc. Cotteswold Nat. F.C., vol. iii (1865), pp. 192–194.

"On the Stratigraphical Position of the Corals of the Lias of the Midland and Western Counties of England and of South Wales": Quart. Journ. Geol. Soc., vol. xxxiv (1878), pp. 179–195, and pl. ix.

"A List of the Madreporaria of Crickley Hill, Gloucestershire, with Descriptions of some New Species": GEOL. MAG., 1878, pp. 297–305.

"On the Fossil Corals obtained from the Oolite of the Railway Cuttings near Hook Norton, Oxfordshire": Proc. Geol. Assoc., vol. vi (1879), pp. 152–165.

"Description of a New Species of Coral [*Thamnastræa* (*Synastræa*) *Walfordi*] from the Middle Lias of Oxfordshire": Quart. Journ. Geol. Soc., vol. xxxviii (1882), pp. 95, 96, and fig. in text.

"On the Madreporaria of the Inferior Oolite of the Neighbourhood of Cheltenham and Gloucester": Quart. Journ. Geol. Soc., vol. xxxviii (1882), pp. 409–449, and pl. xviii.

"On the Fossil Madreporaria of the Great Oolite of the Counties of Gloucester and Oxford": Quart. Journ. Geol. Soc., vol. xxxix (1883), pp. 168–196, and pl. vii.

"On some new or imperfectly known Madreporaria from the Coral Rag and Portland Oolite of the Counties of Wilts, Oxford, Cambridge, and York": Quart. Journ. Geol. Soc., vol. xxxix (1883), pp. 555–565, and pl. xxii.

"A Comparative and Critical Revision of the Madreporaria of the White Lias of the Midland and Western Counties of England, and of those of the Conglomerate at the base of the South Wales Lias": Quart. Journ. Geol. Soc., vol. xl (1884), pp. 353–374, and pl. xix.

"A Critical and Descriptive List of the Oolitic Madreporaria of the Boulonnais": Quart. Journ. Geol. Soc., vol. xl (1884), pp. 698–723, and pl. xxxii.

"On some new or imperfectly known Madreporaria from the Great Oolite of the Counties of Oxford, Gloucester, and Somerset": Quart. Journ. Geol. Soc., vol. xli (1885), pp. 170–190, and pl. v.

"Observations on some imperfectly known Madreporaria from the Cretaceous Formation of England": Quart. Journ. Geol. Soc., vol. xli (1885), Abs. of Proc., pp. 111, 112.

"On the occurrence of Two Species of Madreporaria in the Upper Lias of Gloucestershire": GEOL. MAG., 1886, pp. 107–111.

"On some new or imperfectly known Madreporaria from the Inferior Oolite of Oxfordshire, Gloucestershire, and Dorsetshire": GEOL. MAG., 1886, pp. 385–398 and 443–452.

"On Palæozoic Madreporaria": GEOL. MAG., 1887, pp. 98–100.

"On *Heterastræa*, a new genus of Madreporaria from the Lower Lias": GEOL. MAG., 1888, pp. 207–218.

"Notes on an Amended List of Madreporaria of Crickley Hill": Proc. Cotteswold Nat. F.C., vol. ix (1890), pp. 300–307, and plate.

"Observations on the Affinities of the Genus *Astrocœnia*": Quart. Journ. Geol. Soc., vol. xlix (1893), pp. 569–573, and pl. xx.

"Description of a New Genus [*Stelidioseris*] of Madreporaria from the Sutton Stone of South Wales": Quart. Journ. Geol. Soc., vol. xlix (1893), pp. 574–578, and pl. xx.
"Observations on some British Cretaceous Madreporaria, with the Description of two New Species": Geol. Mag., 1899, pp. 298–307.
"Description of a Species of *Heterastræa* from the Lower Rhætic of Gloucestershire": Quart. Journ. Geol. Soc., lix (1903), pp. 403–407, and figs. in text.

JOHN BELL HATCHER.[1]

Born October 11, 1861. Died July 3, 1904.

The Editor of the *Annals of the Carnegie Museum*, Pittsburgh, Pennsylvania, U.S., records with deep regret the death, on July 3rd, 1904, of his trusted associate, Mr. John Bell Hatcher.

Mr. Hatcher was born at Cooperstown, Brown County, Illinois, on October 11th, 1861. He was the son of John and Margaret C. Hatcher. The family is Virginian in extraction. In his boyhood his parents removed to Greene County, Iowa, where his father, who with his mother survive him, engaged in agricultural pursuits near the town of Cooper. He received his early education from his father, who in the winter months combined the work of teaching in the schools with labour upon his farm. He also attended the public schools of the neighbourhood. In 1880 he entered Grinnell College, Iowa, where he remained for a short time, and then went to Yale College, where he took the degree of Bachelor in Philosophy, in July, 1884. While a student at Yale his natural fondness for scientific pursuits asserted itself strongly, and he attracted the attention of the late Professor Othniel C. Marsh, the celebrated Naturalist, at that time palæontologist of the United States Geological Survey. Professor Marsh, as soon as the young man had received his diploma, commissioned him to undertake a palæontological investigation in south-western Nebraska. From the summer of 1884 until the year 1893 he was continuously in the employment of Professor Marsh. During these years he conducted explorations over a wide area in the States of Nebraska, the Dakotas, Montana, Utah, Wyoming, and Colorado. These expeditions to the western country, which usually began early in the spring, continued until late in the fall, or even into the early winter. He also collected in the winter months and early spring in Maryland and North Carolina. His success as a collector was phenomenal, and the scientific treasures which he unearthed greatly enriched the collections of the United States Geological Survey and of the Peabody Museum in New Haven. It was upon the collections of vertebrate fossils made by J. B. Hatcher that Professor Othniel C. Marsh based to a very large extent many of his most important papers, and to Hatcher more than to any other man is due the discovery and collection of the Ceratopsia, perhaps the most striking of all the extinct reptilia. Very little had been known about them, and before

[1] Reprinted, slightly abridged, from Dr. W. J. Holland's notice in *Annals of the Carnegie Museum*, vol. ii, No. 4 (1900), pp. 597–604.

Hatcher succeeded in discovering a large number of skulls and skeletons they were at best represented by a few fragments, the nature of which was hardly understood even by the most advanced students. At the time of his lamented death Professor Marsh was engaged in preparing a monograph upon this material, and it fell to his distinguished student, who had discovered these colossal creatures, to take up in 1902 the work which Marsh had left unfinished, and he was devoting himself to this work at the time of his death.

In 1890 Mr. Hatcher was made Assistant to the Chair of Geology in Yale University, and in 1893 he was elected Curator of Vertebrate Palæontology and Assistant to the Chair of Geology in the College of New Jersey at Princeton.

While at Princeton he continued his geological and palæontological explorations in the Western States with his usual enthusiasm and success. For many years he had cherished the wish to undertake the exploration of Patagonia and Tierra del Fuego from a geological and palæontological standpoint. He finally undertook the collection of a fund to enable him to carry out this object. Generous subscriptions were made by a number of the alumni and friends of Princeton University, and he himself out of his small savings contributed a large portion of what proved to be required to undertake the work. His plans were thoroughly approved and enthusiastically supported by Professor W. B. Scott, the Professor of Geology in Princeton. Three expeditions were made. The first extended from March 1st, 1896, to July 16th, 1897. On this expedition Mr. Hatcher was accompanied by his brother-in-law, Mr. O. A. Peterson, as an assistant. The second expedition extended from November 7th, 1897, to November 9th, 1898, when he was accompanied by Mr. A. E. Colburn as taxidermist. The third expedition was carried on from December 9th, 1898, to September 1st, 1899, when Mr. O. A. Peterson again accompanied Mr. Hatcher. The story of these expeditions has been published in the first volume of the Reports of the Princeton University Expeditions to Patagonia, which are being issued under the editorial supervision of Professor William B. Scott upon the J. Pierpont Morgan Publication Fund of Princeton University, the fund having been generously given by Mr. Morgan in order that the scientific information secured by Mr. Hatcher might be made known to the world. In the conduct of these expeditions J. B. Hatcher strikingly revealed not only his great scientific insight, but his undaunted courage and great tenacity of purpose. Twice he nearly lost his life, once as the result of a singular accident which befell him while taking a lonely road across the pampas, once while confined to his tent amidst the deep snows of winter by a violent attack of inflammatory rheumatism, from the ill effects of which he never quite recovered.

The results of Hatcher's explorations in Patagonia were of the most important character. The collections of vertebrate fossils made by him and his assistants, and now preserved at Princeton

University, are enormous in extent and of the very highest scientific value. Some of these collections were made by him at great personal risk, the strata in which they were found being only exposed for a few hours at low tide on the margin of the ocean. Working rapidly he and his assistant took up what they could, and then hurried back over the wide beach to the cliffs, to presently see the water from fifty to sixty feet deep rolling over the spot where they had been excavating. The explorers literally snatched their treasures from the hungry jaws of the ocean. In the fields of recent zoology and botany he made extensive collections. His geographical discoveries were of great importance. He added immensely to our knowledge of the interior of Patagonia, traversing vast territories upon which civilized man had never before planted foot. He discovered mountains and lakes, and traced the course of rivers which had never before been mapped. One of the great mountain ranges, by the consent of both the Argentine and Chilian Governments, bears his name. His decision that the crest of the Patagonian watershed in parts of its course lies far east of the crest of the southern Andean ranges, had an important bearing upon the question of the boundary-line between the Argentine Republic and Chile, and in the arbitration of this question, which has happily been settled without recourse to arms, as was at one time threatened, the discoveries of the young American explorer were brought into prominence in diplomatic circles.

On February 1st, 1900, J. B. Hatcher accepted the position of Curator of Palæontology and Osteology in the Museum of the Carnegie Institute in Pittsburgh, where his brother-in-law, Mr. O. A. Peterson, immediately after his return from Patagonia, had been employed as an assistant. Installed in his new post, with the assurance of the unqualified and generous support of the founder of the Institute in all wise efforts to make his work successful, he began to lay out in connection with the Director of the Museum plans to create one of the most important palæontological collections in America. For four summers in succession he carried on explorations in the Western States. In 1903 he was associated for a portion of the time with Mr. T. W. Stanton, of the United States Geological Survey, in an effort to ascertain the relative position and geological age of the Judith River beds, which had been for some time the subject of earnest discussion among geologists. His views in relation to this subject, which had been opposed by almost every other geologist in America, were finally ascertained to be correct, and it was a matter of great personal gratification to him, as the writer of these lines knows, that the accuracy of his observations and of his conclusions, which had been reached many years before, had been verified.

While Professor Hatcher wrote very little in relation to geology, he nevertheless was regarded as being one of the very ablest of American geologists, his great experience in the field and his close attention to the subject having given him a practical knowledge such as was possessed by few of his contemporaries. One of the leading geologists in America, in speaking of him said to the writer, "I regard Professor Hatcher as one of the best informed geologists in the United States. He is pre-eminent in this field, though he sets comparatively small store by his attainments."

The last five years of his life, during which he was connected with the Carnegie Institute, were not only years in which he proved himself remarkably successful as a collector, but in which he revealed his ability as a scientific author. A number of important papers from his pen have appeared in the Annals and Memoirs of the Carnegie Museum. The first volume of the Reports of the Princeton University Expeditions was written by him during this time. He contributed numerous brief articles to various scientific journals, and in 1902 undertook for the United States Geological Survey the completion of the Monograph of the Ceratopsia which had been left unfinished by Professor Marsh at the time of his death. The writer believes that this great work had been brought so far that it will be possible to complete it with comparatively small effort on the part of some one reasonably familiar with the subject. Various other important papers of a monographic character had been begun. Unfortunately these for the most part are not in such condition that they can be published.

One of the great undertakings which had occupied much of his time and thought during the past eighteen months was the reproduction of the skeleton of *Diplodocus carnegiei*, a restoration of which had been ordered by Mr. Andrew Carnegie for the purpose of presentation to the British Museum of Natural History, the Trustees of which in February, 1903, had formally signified their acceptance of Mr. Carnegie's kind offer to have such a reproduction made for them. The superintendence of this work was a most congenial labour to him. On the 1st day of July, 1904, a small company of scientific men and women, together with the Trustees of the Carnegie Institute, had the pleasure of a private view of this restoration, which had been temporarily set up prior to its shipment to England. The absence of Professor Hatcher from the little company was feelingly alluded to by many. But none of the party dreamed, although he was known to be seriously ill, that he had reached the end of his life's work.

Mr. Hatcher's position as a palæontologist was unique. He is universally admitted by those who are most competent to pass judgment to have been the best and most successful palæontological collector whom America has ever produced. The larger proportion of the choicest vertebrate fossils now in the Peabody Museum at Yale University, in the collection of the United States Geological Survey, in the Museum of Princeton University, and in the Museum of the Carnegie Institute at Pittsburgh were collected by him. To a very large extent the American methods of collecting such remains, which are now universally admitted to be the best known, were the product of his experience in the field and of his careful thought. In a letter just received by the writer from Professor Henry Fairfield Osborn, the Palæontologist of the United

States Geological Survey, he says, alluding to the death of Professor Hatcher: "I can hardly tell you how shocked and grieved I am. I had often thought of the probability of Hatcher's death while in the field when taking great risks and entirely away from medical and surgical attendance, but of his death at home I had not thought a moment. In his intense enthusiasm for science, and the promotion of geology and palæontology, and the tremendous sacrifices he was prepared to make, and *had made*, he was a truly rare and noble spirit, the sort of man that is vastly appreciated in England and in Germany, but I fear very little appreciated in America. His work as a collector was magnificent, probably the greatest on record."

Professor W. B. Scott, in the columns of *Science*, says: "Hatcher may be said to have fairly revolutionized the methods of collecting vertebrate fossils, a work which before his time had been almost wholly in the hands of untrained and unskilful men, but which he converted into a fine art. The exquisitely preserved fossils in American museums, which awaken the admiring envy of European palæontologists, are, to a large extent, directly or indirectly due to Hatcher's energy and skill, and to the large-minded help and advice as to methods and localities which were always at the service of anyone who chose to ask for them." Testimony of like character as to the great achievements of Professor Hatcher has come from many other sources.

Hatcher was an indefatigable student and a very keen observer. He was fertile in resources. He had great mechanical aptitudes, and succeeded, sometimes when alone, by patient effort in accomplishing apparently impossible tasks in the removal of huge and weighty objects from difficult positions, which would not have been undertaken by others. The writer recalls one or two cases in which he dared great physical risks and even death, when alone, far from human companionship, in extracting large masses from their original position and moving them by a skilful arrangement of levers to points where they could afterwards be taken up. One such instance occurred in the autumn of 1903, and the writer could not refrain, while admiring the courage and skill displayed, from earnestly warning Mr. Hatcher against the repetition of such risks as he at that time assumed in attempting to handle a block of rock weighing nearly a ton without the assistance of other men.

While accomplishing a vast amount of most important work during the last five or six years of his life, there was hardly any time in which, as the result of the illness and exposure which he had undergone in Patagonia, he did not suffer pain, and at times of a most excruciating character, and yet he was patient and uncomplaining.

Perhaps the most striking characteristic of Mr. Hatcher was his extreme modesty. He was always reticent in speaking of what he had done, and shunned publicity other than that which came to him through his scientific writings.

Hatcher was a most charming companion, and when he could be prevailed upon to relate the story of his adventures in strange and distant places, the listener found his companionship fascinating.

Though living so much of his life in the wilderness, he was a man of strong domestic attachments. He loved his home, and to none of all the wide circle of his acquaintance does his untimely death bring deeper and more poignant grief than to his wife and four young children. To them the writer renews in these lines his expression of the deepest sympathy. W. J. HOLLAND.

MISCELLANEOUS.

DESLONGCHAMPS' TYPES OF JURASSIC BRACHIOPODA.—The British Museum (Natural History) has received a valuable donation, one particularly interesting to students of British Jurassic Brachiopods. It consists of about 100 plaster casts of the types (holotypes, hypotypes), etc., of the Jurassic Brachiopoda figured by E. Deslongchamps in the Paléontologie Française Terr. Jurass., with a few other treasures of the Deslongchamps Collection figured elsewhere. Among the latter is a cast of the holotype of the very rare *Rhynchonella Deslongchampsi*, Davidson—the Museum already possesses the historic Tesson example of this species; also a cast of the holotype of *Terebr. biplicata* (Brocchi), which is not a Cretaceous fossil at all, but is a Jurassic *Ornithella*. Among the Pal. Franç. specimens the examples of *T. conglobata*, *T. Ferryi*, *T. Jauberti*, and others of Deslongchamps' species will be of especial interest. The Director, Professor E. Ray Lankester, F.R.S., has presented this fine series to the Museum.

MR. C. FOX-STRANGWAYS, who joined the staff of the Geological Survey under Sir Roderick Murchison in 1867, has retired from the public service. During the course of his long, detailed, and invariably careful work in the field, he has surveyed large areas in Yorkshire, including portions of the great Coalfield, the country around Harrogate, and most of the moorlands and wolds of the North and East Ridings. Thence crossing the Humber he continued work in North Lincolnshire, and finally passed on to Leicester, from which town as a centre he has re-surveyed the Leicestershire Coalfield, Charnwood Forest, and a large area extending from the borders of the Warwickshire Coalfield across the Liassic vale east of Leicester. The results of this work have been published in numerous maps, sections, and memoirs, amongst which may be mentioned two volumes dealing particularly with the Jurassic rocks of Yorkshire. Apart from his official work Mr. Fox-Strangways has stirred up much local interest in geology in the localities where he has lived and laboured, especially at Leicester, where his services in conducting excursions have been frequently given, and have always been highly appreciated.

COTTESWOLD NATURALISTS' FIELD CLUB.—The President, Dr. C. Callaway, refers (Proc., vol. xv, part 1) to the loss sustained in the death of their old member Robert Etheridge. After giving some account of the excursions made during the year, Dr. Callaway contributes a short essay on Pre-Cambrian Volcanoes, as evidenced by the Uriconian rocks of Malvern and elsewhere. The 'Charnian' rocks of Charnwood Forest are regarded as the equivalent, at least partially, of the Uriconian. In the same Journal Mr. L. Richardson gives an interesting account of the Rhætic beds of Worcestershire; and Messrs. J. W. Gray and G. W. S. Brewer contribute an article on evidences of ancient occupation on Cleeve Hill, with an appendix on the vertebrate and molluscan remains by Messrs. M. A. C. Hinton and A. S. Kennard. The human settlement appears to have belonged to the Iron age, and the domesticated animals included the horse, ox, sheep, pig, and fowl. The Cotteswold Club has also issued (as a Supplement to vol. xiv) a useful Table of the Contents of the Proceedings, vols. i to xiv, 1847–1903. In this the title of the first printed paper should have been given—it is "On the Geology of the district explored by the Cotteswolds Club, and more particularly of the Clay subsoil of the [Royal Agricultural] College Farm," by S. P. Woodward, pp. 2–8.

Tertiary Plutonic Rocks from the Isle of Rum.[1]—Mr. Alfred Harker, M.A., F.R.S., writing on the Plutonic rocks of Tertiary age, which make up about one-half of Rum, states that the ultrabasic group is the most important. It includes various peridotites, some essentially of olivine, but others containing pyroxenes, and especially anorthite. A noteworthy amount of lime and alumina, giving rise to anorthite, is indeed a special characteristic of the group. Equally striking is a tendency to separation of the more peridotic and the more felspathic portions of the magma, usually with a stratiform disposition. With bands of true peridotite alternate others of allivalite, a rock consisting of anorthite (predominant) and olivine, and even containing seams of pure anorthite rock. Another peculiar type, styled harrisite, is composed essentially of olivine (predominant) and anorthite, the olivine occurring here as large lustrous black crystals, with good cleavage.

Later than all these rocks, and intruded beneath them, comes the eucrite group, which shows less variety. The rocks are usually somewhat rich in olivine; much of the pyroxene is hypersthene, and the felspar is near anorthite. Still later comes the granite group, mostly hornblendic and often with granophyric structures. The acid magma has entered into peculiarly intimate relations with the eucrite, not only metamorphosing and impregnating that rock, but enclosing and partially incorporating portions of it, large and small. The enclosed portions, in a half-digested state, have been streaked out by movement, and there has arisen a group of well-banded gneisses, closely resembling the Lewisian of the north-western highlands. These Tertiary gneisses are all of the nature of hybrid and composite rocks, of which the contributing elements are the eucrite and the granite, and their genesis can be traced step by step in the field.

[1] Read before the British Association, Cambridge, Section C (Geology), Aug., 1904.

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DECEMBER, 1904.

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THE

GEOLOGICAL MAGAZINE.

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No. XII.—DECEMBER, 1904.

ORIGINAL ARTICLES.

I.—The Kishon and Jordan Valleys.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

THAT broad trench through the Palestine Highlands, an ancient highway and battlefield of nations—the plain of Esdraelon or the valley of Megiddo, together with the plain of Acre—has for long presented to me a difficult problem in Physical Geology, for it seemed inexplicable by subaerial denudation under existing conditions. Its floor varies roughly from five to eight miles in breadth; running approximately from south-east to north-west, it is bounded on the more western side by the limestone mountains of Samaria and on the more eastern by those of Galilee. The former descend from the ridge of Carmel (1,742 feet at highest) with a fairly steep escarpment, which becomes a little less regular as we follow it to the bastion-mass of Mount Gilboa; the latter correspond in their general outlines with those of the eastern portion of Samaria, but the advance of a lower spur towards the south-west divides the plain of Esdraelon from that of Acre, by a kind of strait in which, so far as I could see, there is but little level ground on either side of the Kishon. This spur, however, of the northern hills, hardly does more than interrupt the floor of the Kishon valley, for above it the great trench is continued between two hill masses, much of these ranging from thirteen to sixteen hundred feet above sea-level. Beyond the strait the upper basin (plain of Esdraelon) quickly broadens out, extending towards the south-east for about fifteen or sixteen miles, where it is divided into two arms by Jebel Duhy (Little Hermon) (1,690 feet), which is thus isolated from Tabor (1,846 feet) on the north, and from Gilboa (1,698 feet) on the south; a broad, rather shallow, grassy valley descending from the last-named mass to lose itself in the plain. Neither it nor one or two other tributaries from the Galilee hills count for much, but the two arms maintain their trench-like form, cutting through the limestone isthmus which must once have united Samaria and Galilee. These are still, though much narrower than the plain of Esdraelon, disproportionately broad; their watersheds are low, ill-marked, and lie farther west than the natural position. The gap between Duhy and Tabor is the narrower, and, so far as I can ascertain, a few feet the higher; that between the former and Gilboa is between two and three miles wide and about 270 feet above sea-level. One position in the 'strait' leading to the plain of Acre, according to the Palestine survey map, is 80 feet above sea-level, so the average down-slope of the plain of Esdraelon must be about four yards in a mile. A plain it is not, however, in such a strict sense of the word as the Cambridgeshire fenland; for the bases of the hills of Galilee on one side and of Samaria on the other shelve gently down with occasional slight undulations so as to fuse imperceptibly with the actually level ground near the river brink. All this low land is covered with a thick, rich brown earth, a broad fertile expanse of arable land and herbage, in striking contrast with the comparatively bare limestone masses on either side.

Obviously this is a river valley—a trench not less than a thousand feet deep cut through the limestone highlands of Palestine—but it is on much too large a scale to have been excavated by the present Kishon system. The difficulties increase when we examine the Jordan valley. That is another trough, seldom less and often more than four miles wide. Its bed, where reached by the southern of the two passes, must be at least 700 feet below sea-level,[1] so the drop from the watershed must be quite 950 feet. The Jordan has carved its present course through old lacustrine deposits, of which we need now only say that they were formed when an unbroken sheet of water extended from the divide between the Red and the Dead Seas to the northern end of Lake Huleh.[2] They extend into a recess between the roots of Little Hermon and Gilboa, where, about 350 feet above the river, is Beisan, the ancient Bethshean.

The depth of the Sea of Galilee is about 165 feet, and it may occupy a true rock basin, for the river, no great distance below its outlet, runs, according to Lynch,[3] over a rocky bed. The surface of the Dead Sea is about 1,292 feet below the Mediterranean, its greatest depth being 1,278 feet, and the watershed between it and the Red Sea, on which are outcrops of limestone, is 660 feet above the latter. As so much has been written on the Jordan valley,[4] it

[1] The Sea of Galilee is 682·5 feet below sea-level.

[2] The water in this ancient lake seems to have risen to about 1,398 feet above its present level, or some 98 feet above the sea; that would be, in round numbers, 90 feet above the present surface of Huleh.

[3] "Expedition to the Dead Sea and the Jordan," chs. viii and ix.

[4] The literature connected with this subject is extensive, but I may say that, until I formed the conclusion expressed in this paper, I consulted books to ascertain facts rather than opinions. I made great use of Professor Hull's Memoir in the "Survey of Western Palestine" (though venturing to differ in one or two matters from him). Valuable references to literature are to be found in Professor Suess' classic work "Das Antlitz der Erde," Professor Lartet's "Géologie de la Mer Morte," and Professor Gregory's "Great Rift Valley," ch. xiii. I may also mention Professor I. C. Russell's paper in this Magazine (1888, p. 338, etc.), and the one by Mr. Hudleston on the Central African Lakes in the present volume. I have also consulted papers by Dr. Diener and Dr. Blanckenhorn, though to one or two of their writings I have not had access.

will suffice to say (1) that all features which meet the eye are indicative of subaerial erosion; (2) that examination of its geological structure shows it to have been initiated and determined by a series of more or less parallel faults, which extend from somewhere south of the Taurus range to the junction of the Gulf of Akabah with the Red Sea, where they run up against another and still greater system; (3) that some geologists consider the depression, now partly occupied by the Dead Sea, and the elevation to the south of it, to be original features produced by unequal subsidence during the process of faulting, while others maintain that the Jordan once found its way southward through the Gulf of Akabah and that the present configuration of its bed is due to subsequent movements differing in direction from the original.

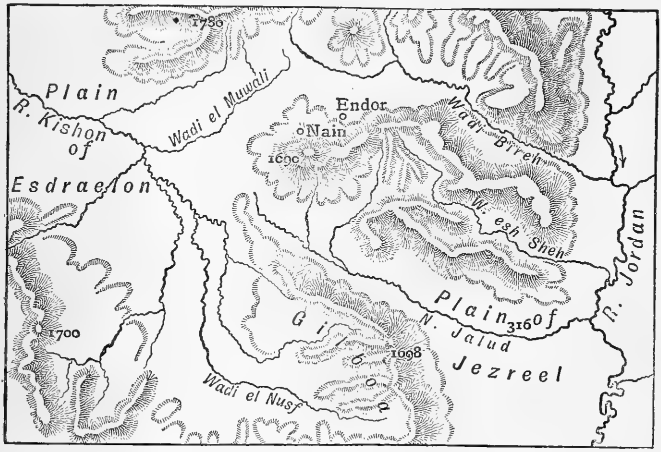

Fig. 1.—The Neighbourhood of the Esdraelon Gap.

Before proceeding farther I venture to call attention to the misapplication (increasing, I think) of the term 'rift valley' to the Jordan. In the strict sense of the word 'rift' (according to good dictionaries of our language) such a valley must be, on any large scale, a great rarity. One would not, however, quarrel much with the application of the term (as by Professor Gregory in Masailand) to a valley where the surface of rupture, at least on one side, was still comparatively 'raw'—unmodified by denudation. That cannot be said of the Jordan, where the fault system can only be detected on examination. Every feature in the landscape speaks of ordinary meteoric agencies, so that the Lake of Gennesaret and the Dead Sea are no more suggestive of 'rifts' than the Lakes of Orta or of Geneva. The Jordan valley, to use the accurate phrase applied to it by Suess,[1] is part of a 'graben versenkung.' 'Rift' is not an accurate translation for 'graben'; 'trough' is far better, and as we speak of

[1] "Antlitz der Erde," vol. i, pp. 481, 482, etc. (See p. 373 et seq. of the newly published translation by Miss & Professor Sollas.)

a 'trough-fault,' why not a 'trough valley,' or, if we wish to be very precise, a 'trough-fault valley'? But a new word, especially if a little improper, seems to be as fascinating to some geologists as it is to children!

No one doubts that the physical features of Palestine have all been developed since the age of the Nummulitic Limestone; their broad outlines were probably determined, as we shall presently see, by the beginning of glacial times.[1] To excavate the broad 'Kishon valley' requires, in my opinion, not only a heavier rainfall, but also a much larger drainage area than now exists. It is obviously a 'beheaded' valley;[2] the two streams descending to the Jordan on either side of Jebel Duhy have trespassed westwards and pushed the watershed in that direction. In other words, I consider the Kishon valley to be older than that of the Jordan, and still to retain, west of the passes, its principal ancient features.[3] But where was the original watershed? If it were to the west—somewhere out in the Mediterranean—then Jebel Duhy must have been an island dividing the river into two channels; a thing possible, but the less probable hypothesis. The features described above appeared to me, when I visited the country, to demand a watershed well to the east of the line connecting Tabor with Gilboa over Duhy. The watershed may have disappeared in the trough-faulting which determined the Jordan valley; but I doubt, apart from other obvious difficulties, whether that would be far enough to the east, and am disposed to place it on the Syrian highlands nearer to that from which streams now descend westwards to the Jordan, because the lower part of the valley, the present Kishon, seems to me so deep, level, and flat that it could only have been made by a stream not much less important than that of the Jordan itself. I am unable to identify the old course of its upper waters with any existing valley; but that is not surprising, because the amount of subsidence in the Jordan trough has maintained, if it has not accelerated, denudation on its western flank,[4] while cutting off the supply has left the lower part of the ancient valley—the Esdraelon–Acre trench—very much as it was.[5] So I suppose the movement which first raised the Syrian highlands (including Palestine) above the sea culminated at an axis still indicated by the head waters of the Jarmuk, the Zerka, and many other streams,

[1] It is almost needless to observe that in this interval much work was done in 'making scenery' all round the Mediterranean border.

[2] My friend Professor J. W. Gregory emphasises this conclusion in his "Great Rift Valley" (pp. 253–255), but I may say that each of us reached it independently of the other, and we take opposite views as to which was the executioner. The sketch-map inserted above (Fig. 1), for which I am indebted to his kindness and that of his publisher, Mr. J. Murray, brings out very clearly the extent of the trespass.

[3] The outlet of the Orontes (Nahr-el-Asi), perhaps also of the Leontes (Nahr-el-Litany), may be contemporary features in the structure of Syria.

[4] To this, of course, I attribute the westward trespassing of the shorter streams on that side.

[5] To behead a valley, as we can see in the case of the Inn between St. Moritz and the Maloya, practically puts a stop to erosion in the uppermost basin.

which formerly made their ways (the final outlets not being numerous) westwards to the Mediterranean.

We come next to the great trough-valley. So much has been written about this, which includes the whole course of the Jordan and the major part of both the Leontes and the Orontes, that I need not enter into minute details. Dr. Blanckenhorn's section across southern Palestine[1] makes the general structure perfectly clear. The high upland west of the Jordan is formed by a flattened anticline, the eastern arm of which is dropped down by three parallel faults, the outermost practically forming the west side of that valley. A single but greater downthrow does the same on the opposite or eastern side, so the higher strata on both sides of the river are nearly on a level. The western flexure is prolonged, exaggerated, and complicated in the Lebanon range; the eastern in that of Anti-Lebanons, which I suppose to have been the earlier of the two.[2] Was the watershed between the Gulf of Akabah and the Dead Sea, with the formation of the latter and the peculiar depression of the major part of the Jordan valley, mainly determined by unequal subsidence of the faulted down trough-blocks, or was this valley, after its first definition, excavated down to the live rock which, though now generally invisible, must form its true floor, and subsequently traversed by flexures, due to forces acting nearly at right angles to the former set, which produced the general depression at the northern end and the marked barrier near the southern? Most authorities adopt the former view. They consider that the limestone, which crops out in ridges near this barrier in the bed of the trough, and the fact that the glens north of it trend towards the Dead Sea and south of it to the Gulf of Akabah, indicate the Arabah–Akabah watershed to have existed from the first. But travellers describe the valley bed as if (apart from the lacustrine deposits) it agreed very closely with the Ghor itself. But we should expect that, if these ridges were the remnants of an ordinary watershed, the united streams from each side of it would have carved in the floor of the trough a pair of narrow 'wadies' running in opposite directions: in other words, that we should find here a closer resemblance to the valley of the Jordan north of Lake Huleh. As a considerable amount of denudation must have taken place while the Jordan Lake was filling, and must have been continued while it was shrinking (for I suppose the cutting of terminal ravines such as those of the Kedron and the Kelt to be distinctly late features),[3] I am not surprised at the general directions of the larger valleys.

[1] Through Bethlehem; see Zeitschr. d. Deutsch. Palest. Vereins, xix (1898), pp. 1–59.

[2] To compare smaller with larger mountains, the structure here seems generally similar to that of Switzerland from the French frontier to the watershed between the Rhine and the Inn.

[3] In fact, more than one feature which I observed during my short visit to Palestine suggested that in the uplands denudation was proceeding very slowly, but became much more rapid in the vicinity of the Jordan.

But the study of its fauna and flora has much strengthened the arguments for the former connection of the Jordan valley with the Gulf of Akabah. In Canon Tristram's words,[1] written twenty years ago (which, as we can see from the excellent summary given by Professor Gregory,[2] have been fortified by additional evidence), "A review of the botany as well as the zoology of the Dead Sea basin reveals to us the interesting fact that we find in this isolated spot . . . . a series of forms of life, differing decidedly from the species of the surrounding region, to which they never extend, and bearing a strong affinity to the Ethiopian region, with a trace of Indian admixture. As the species which serve as the most striking illustrations of this fact live either in or beside fresh water, a river connection is the most natural agency by which to account for it, and as these species are absent from the Lower Nile valley and from Egypt, the river connection must have been established along the eastern side of the range of highlands which separates the Nile from the Red Sea." Professor Gregory, though advocating this connection, thinks it unnecessary to assume that "a river flowed the whole way from the Jordan to the northern end of the Red Sea," because fish from the south might have made their way to a lake, which is shown by its deposits[3] to have existed on the northern side of the watershed and a few feet below it, when "an occasional flood or a slight earth-movement would have enabled them to enter the stream which flowed northwards." That, no doubt, is possible, though I should think not very probable, unless the spawn were conveyed by birds, but it does not account for the continuous trench of the Arabah–Akabah valley. Professor Hull is not unconscious of this difficulty, for he says, speaking of the valley of the Arabah and this watershed,[4] "it is difficult to see how this great valley, which is sometimes seven or eight miles in width, especially near its centre,[5] could have been excavated and levelled down unless the action of the rivers and streams of the bordering hills had been originally supplemented by the levelling action of the sea waves on the south and the inland waters of a great lake on the north of the watershed." But so far as I am aware, there is no proof that the old Jordan valley lake ever rose more than about a hundred feet above the Mediterranean, and if the sea waves were to approach near to this barrier, to cut a fjord from forty to forty-five miles long, north of the present shore at Akabah, either the sea must have been more than 600 feet higher or the land the same amount lower than at present. In the former case I think that the Mediterranean would probably have occupied the valley of Esdraelon and gained access to the inland lake on one or both sides of Jebel

[1] "The Fauna and Flora of Palestine" (1884), p. xvi.
[2] "The Great Rift Valley" (1896), p. 262.
[3] They were discovered by Professor Hull.
[4] Mount Seir (1855), p. 82.
[5] In the "Survey of Western Palestine" (Geology), p. 18, he says that north of the watershed it is nearly double (6 or 7 miles).

Duhy; in the latter some sort of upheaval is admitted. Prof. Lartet, in his excellent memoir, objects to a differential uplift in the bed of the Jordan valley on the ground that there is no disturbance of horizontality in the strata exposed in its flanks. But we must remember that as the beds on both sides dip (on the west rather strongly) towards the valley, a slope at right angles, or in its direction, would be masked, especially as this would be small.[1] But according to Professor Lartet's map the strata do dip in the required direction. Both he and Professor Hull represent Nubian sandstone cropping out beneath the Cretaceous limestone very near the Arabah–Akabah watershed. The former runs downwards to the south end of the Dead Sea, and can be traced beneath the great masses of limestone forming the Moab Hills, until it disappears opposite to Jebel Kuruntil.[2] After a time, according to Professor Hull's map, it again crops out, being seen for the last time nearly due east of Shechem. Thus there must be a considerable bending or displacement parallel with the east and west fault running from near Bethlehem to the Dead Sea. True, this only accounts for about one-third of the amount which the flexure hypothesis requires, but the beds may have been already somewhat bent down when the trough-faulting began. This hypothesis obviously implies that the whole region from the Arabah to the sources of the Jordan has been considerably depressed. The latter, so far as I can ascertain, range from about three to rather over seven hundred feet above sea-level, which would be too low if the drainage had ever reached the Gulf of Akabah. But this and the 'sag' necessary (as indicated above) to form the Sea of Galilee (in an east and west line with which are the plateau of Asochis and the Bay of Acre; also the marked escarpment in the hills west of Safed) all suggest a system of faults and flexures almost at right angles to, and so probably not coeval with, the north and south system defining the Jordan valley. All geologists agree that before the end of the Pliocene period, "the existing land surfaces on either side of the Jordan–Arabah valley were in a condition not very different from that of the present day, at least in their main features." Professor Hull, from whom these words are quoted,[3] says "at the close of the Miocene epoch," but I am doubtful whether we can adopt this limit. If, as is very possible, the two greater systems of disturbances, which certainly affected a large part of the Mediterranean area, extended thus far east, the first uplift would occur at the close of the Eocene and the consequent sculpture during the Miocene period; the formation of the Jordan trough would belong to the second, or immediately post-Miocene movements, by which large parts of the western half of the Alps were so profoundly affected; and its sculpture would proceed during the Pliocene, the flexure of the trough occurring rather

[1] Taking the watershed as 700 feet above, and the Dead Sea as 1,300 feet below, sea-level, we get in round numbers a drop of 2,000 feet in about 70 miles, or on a rough average 1 in 175—less than a degree.

[2] The Mount of Temptation, the supposed scene of the Forty Days' Fast, conspicuous from and to north-west of Jericho.

[3] "Survey of Western Palestine" (Geology), p. 112.

later in this period.[1] That it was complete before the Glacial Epoch began is generally admitted. Dr. Blanckenhorn,[2] adopting the three epochs of ice-extension recognised in Germany, gives this arrangement of the later history of the Jordan valley :—

(1) First ice-age (rain epoch) : greatest height of the Jordan valley lake.

(2) First interglacial (dry epoch) : probable sinking of lake to about 328 feet above present level, when the salt of Jebel Usdum was precipitated.

(3) Second ice-age : rise of lake and formation of the high terraces.

(4) Second interglacial : probably the age of the volcanic outbreaks,[3] so conspicuous in the northern part of the valley (also the cutting of the Ghor).

(5) Third ice-age : formation of the lower terraces.

This chronological scheme is rather hypothetical, but it deserves careful consideration. I think, however, I am right in claiming the Esdraelon valley as a fragment of a system older than the Jordan, and pronouncing that river guilty of removing its neighbour's landmark westward. Such a removal is almost inevitable, because the descent of its tributaries on the right bank is so much more rapid than the slope of the Kishon valley.

II.—On a new Crocodilian Genus (*Notochampsa*) from the Upper Stormberg Beds of South Africa.

By R. Broom, M.D., Victoria Coll., Stellenbosch.

Mr. A. L. du Toit, of the Cape Geological Commission, who has been for some months engaged in studying the Stormberg beds in the eastern part of the Colony, has been fortunate in making a number of discoveries of very great interest to the palæontologist. Among Vertebrates his most important finds have been the remains of two small crocodiles.

The first specimen, which was discovered by Mr. A. Isted in the Cave Sandstone at Funnystone, Barkly East, consists of the impressions of the under sides of most of the upper bones of the skull and of most of the dorsal armour. There are also preserved the remains of a scapula, a humerus, a radius and ulna, a femur, and a number of ribs. A restoration of the skull is shown in Fig. 1. When complete it probably measured 130 mm. in length, and the length of the whole crocodile was probably about 600 mm. Though the skull is too imperfectly preserved to show what are the relations to the already known families, enough is preserved to show that the crocodile belongs to the suborder Amphicœlia of Owen (= *Mesosuchia*, Huxley). The skull is characterised by the very large size

[1] One is reminded of the east and west flexures of later Pliocene age in the southern part of England.

[2] "Entstehung und Gesichte des Todten Meeres": Zeitsch. d. Deutsch. Palest. Vereins, xix (1896), pp. 1–64.

[3] There is nothing left to give a precise date to this period, during which, according to Dr. Blanckenhorn, prehistoric man appeared. It is supposed to be contemporaneous with that of the German loess.

of the squamosal bones, by the moderate size of the supra-temporal openings, by the nasals taking little part in the formation of the snout, and by each maxillary having only a few large teeth—probably 6 or 8.

I propose to call the form *Notochampsa Istedana*.

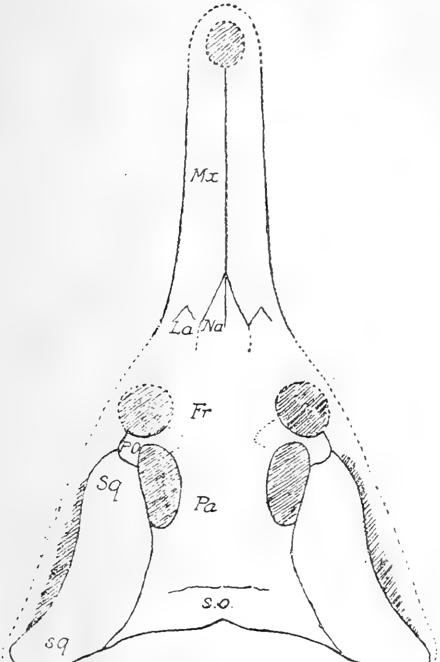

Fig 1

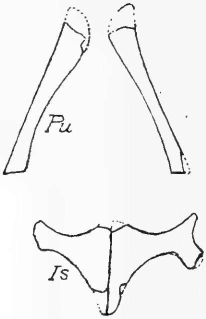

Fig. 2

Fig 3

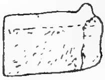

Fig. 4.

FIG. 1.—Restoration of skull of *Notochampsa Istedana*. × $\frac{2}{3}$. *Fr.* frontal; *La.* lachrymal; *Mx.* maxilla; *Na.* nasal; *Pa.* parietal; *P.O.* post-orbital; *S.O.* supra-occipital; *Sq.* squamosal.
FIG. 2.—Pelvic bones of *Notochampsa longipes*. × $\frac{1}{1}$. *Is.* ischium; *Pu.* pubis.
FIG. 3.—Twelfth dorsal scute of *Notochampsa Istedana*. × $\frac{1}{1}$.
FIG. 4.—Dorsal scute of *N. longipes*. × $\frac{1}{1}$.

The second specimen was found by Mr. Du Toit near the top of the Red beds at Kraai River, Eagles Crag, Barkly East. Though less is preserved than in the other specimen, the state of preservation is much better. The following bones have been displayed:—the almost perfect pubes and ischia, an imperfect ilium, the almost perfect right hind-limb, including the foot, the imperfect left hind-limb, the imperfect right fore-limb, portions of the dorsal and ventral armour, and a few imperfect vertebræ. A comparison of the dorsal plates with those of *Notochampsa Istedana* shows that the specimen from the Red beds belongs to a different species, though probably the same genus. The pelvis is typically Crocodilian in that the pubis does not enter the acetabulum. The ilium is of small size. The limb bones are unusually long and slender. There are only four digits developed in the pes. The vertebræ are biconcave, but the concavities are shallow.

For this second species I propose the name *Notochampsa longipes*. If the two specimens are both adult, then *N. longipes* would probably be about two-thirds the size of *N. Istedana*.

The Stormberg beds until recently have usually been regarded as Triassic. Seward, however, as the result of his study of the plants of the Lower Stormberg or Molteno beds, has recently shown that these beds are of Rhætic age, and as, according to Mr. Du Toit, the horizon of the fossil crocodiles is at least 1,000 feet above the Molteno beds, we are probably safe in regarding *Notochampsa* as of Lower Jurassic age.

A full description of the remains will appear in the Annals of the South African Museum.

In view of the great interest of the discovery the Geological Commission has kindly granted me permission to communicate this preliminary notice to the Geological Magazine.

III.—On the Homotaxial Equivalents of the Lower Culm of North Devon.

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

I AM glad that my paper on the Coddon Hill beds, published in the Geological Magazine, August, 1904, pp. 392–403, has aroused criticism, and could only have wished that Dr. Vaughan had been familiar with the Carboniferous sequence of the Pennine area and Belgium. The matter is not one to be solved by the casual appearance in any definite bed of a few Brachiopods, at one only of the many horizons at which they are known to occur in other localities, for the whole of the fossils, which are quoted by Dr. Vaughan as the foundation for his argument that the Coddon Hill Beds are low down in the Carboniferous sequence, are equivocal as far as their value as zone indices goes. And on the other hand, Dr. Vaughan completely ignores those fossils which are unequivocal and which denote a well-recognised horizon, and curiously enough, too, correspond with a marked change in lithological character of the Carboniferous sequence. In the first place, I do not see where Dr. Vaughan found any statement in Mr. Howe's and my paper on the Pendleside group at Pendle Hill (Q.J.G.S., vol. lvii) that the Pendleside series are the equivalents of the Millstone Grit of South Wales and the Mendip areas. The table on the page quoted (p. 388) distinctly shows that we consider the Pendleside series to lie universally below beds equivalent to Millstone Grit, and we do not mention the series of the Bristol and Mendip area because we were not well enough acquainted with that district to do so.

To turn to the evidence afforded by the Brachiopoda and Zaphrentoids of Coddon Hill Beds. Every species mentioned in Dr. Vaughan's list occurs in the Pendleside series in the Pendle and Bolland area and in North Staffordshire and Derbyshire, and my specimens have been kindly identified by Dr. Vaughan, with the exception of *Leptena analoga*, and they occur, not only in typical Pendleside beds, in the type area, but Dr. Vaughan recognises the following species in a small collection I made at Bishopton, north of Oystermouth, Glamorganshire :—

Chonetes aff. *Hardrensis*.
Cleiothyris glabristriata.
Spirifer aff. *clathratus*.

I also found there one or more species of Trilobites and a *Fenestella*. The latter Dr. Vaughan recognises as present in his Tournaisian of the Bristol area. I have it in my notes that a specimen of a Zaphrentoid coral was found in these beds in my presence. In the Summary of Progress of the Geological Survey of the United Kingdom, 1900, pp. 86–90, the position of these beds is discussed, and it is stated that beds of similar lithological character with rotten stone and Radiolarian cherts occur in the north crop of the South Wales Carboniferous basin as well as at Bishopton. Moreover, Dr. G. J. Hinde is quoted (p. 89) as having found Radiolaria and sponge spicules in specimens both from Carmarthenshire and Glamorganshire.

Further, Dr. Hinde says: "The character of the rock, the mode of preservation of the Radiolaria, and the forms themselves, are very similar to what are found in the cherts with Radiolaria from the Lower Culm of Devon and Cornwall. . . . . And two of the Radiolaria showing structure, *Porodiscus* and *Carposphæra*, are identical species with those figured in the Culm cherts."

There is therefore very strong evidence from Dr. Vaughan's own standpoint that the Bishopton and Penwyllt beds are the equivalent of the Coddon Hill Beds, and these beds overlie the thin-bedded limestones of Oystermouth, which lie above the Oolitic beds of the Carboniferous Limestone sequence.

The Bishopton Beds underlie a series of black shales with

Posidoniella lævis.
Glyphioceras bilingue.
Glyphioceras diadema,

specimens of which I obtained from the bed of a small stream immediately north of the Bishopton Beds, a fauna never yet found below beds with a Viséan fauna.

If the Bishopton Beds = Tournaisian, where are the representatives of the Viséan in South Wales? This question also is very pertinent in the Coddon Hill district if Dr. Vaughan's views are correct. In that area the researches of Mr. Newell Arber have conclusively demonstrated that the Upper Culm beds are the homotaxial equivalents of the Coal-measures, and he has rediscovered at Mouth Mill, Clovelly, and Instow the fauna mentioned at p. 397 of my paper, which indicate much lower beds. I regret I did not credit him with that discovery in my paper, but I was unaware that this discovery and rediscovery was entirely due to his work, and I take this, the earliest opportunity, of acknowledging my indebtedness to him both directly and indirectly. If Dr. Vaughan's contention is correct that

Coddon Hill Beds are Tournaisian, then either there must be a great unconformity between Coddon Hill and the Upper Culm, or the Viséan beds are represented by beds with a Millstone Grit and Coal-measure fauna and flora.

And yet another question may be asked—Has the fauna which I consider to be typical of the Pendleside series ever been found in beds of Tournaisian age? This point Dr. Vaughan entirely ignores. I am not aware that this has been the case, and hence another difficulty in accepting Dr. Vaughan's views.

We know that at Visé and Clavier, and Chokier, in Belgium, and in Yorkshire, Derbyshire, Staffordshire, North Wales, and the West of Ireland, the Pendleside fauna always succeeds a Viséan fauna, and never occurs below it, and I make this statement after personally examining De Koninck's large collection of types in the Musée Royale d'Histoire Naturelle at Brussels on many occasions, and many years collecting in the Pennine area in England and in the west of Ireland.

I knew that several similar species of Brachiopoda and Zaphrentis occurred both at Coddon Hill and in the Pendle area, but I attached no importance to them as indices of horizons, and did not quote them because I knew they occurred at several horizons. I know of at least three horizons several hundreds of feet apart in the Midlands where Zaphrentoid corals occur abundantly, and to go into details with regard to the Coddon Hill Brachiopoda:—

Chonetes Laguessiana (I still prefer this name) occurs at many horizons from the Calciferous Sandstone series up to the Gin Mine coal, high up in the North Staffordshire Coalfield, being abundant in beds about 2,000 or 3,000 feet below this coal in the Midlands.

Leptena analoga has not such an extensive vertical distribution. I do not know of this shell above the base of the Pendleside series, but it also occurs very low down in the Carboniferous Limestone series.

Rhipidomella Michelini occurs from the Calciferous Sandstone series up to the base of the Millstone Grits.

Cleiothyris glabristriata, Phillips.—Davidson considered this species to be the interior of *Athyris Royssii*, and I am not aware that Dr. Vaughan has yet published his views as to the rehabilitation of this species. At any rate it occurs at Bishopton, and I know of shells like the Bishopton specimen at several horizons.

Spirifer aff. *clathratus*.—This species must remain, for the present, a doubtful one, as we are not yet aware on what grounds Dr. Vaughan desires to re-establish the species. Davidson (Brit. Carb. Brachiopoda, p. 21), discussing *Spirifer striatus*, says, "Professor M'Coy is also of opinion that what he described in 1844 as *Sp. clathrata* must be added to the list of synonyms." M'Coy's type has disappeared, and he only gave a figure of the large or branchial valve without details of beak or area. Also it would be important to know from what locality the type came, and whereabouts in the Carboniferous series.

Spirifer laminosa.—This shell is very common indeed in the Redesdale ironstone, in the Ashfell Beds south of Kirby Stephen, and Dr. Vaughan recognises a specimen of mine which occurs with a Visé fauna at Treycliff, Castleton. The Redesdale ironstone is over 1,600 feet below beds with a Visé fauna, and *Productus cora* = *P. semireticulatus*, and *P. giganteus* occur with it. So that whatever may be the case at Bristol, it is abundantly plain that none of the Brachiopoda quoted in Dr. Vaughan's paper run true over the Pennine area in England, and on this account I consider them to be equivocal as evidence for the correlation of the two areas; and to repeat it, is the fact that from Visé and Clavier in the east to co. Clare in the west, the strata that immediately overlie the Carboniferous Limestone are characterised by beds containing:—

Posidonomya Becheri.
,, membranacea.
Posidoniella lævis.
,, minor.
,, Kirkmani.
Pterinopecten papyraceus.
Aviculopecten Losseni.
Pseudamusium fibrillosum.
Chænocardiola Footii.
Orthoceras Koninckianum.
Orthoceras Morrisianum.
Glyphioceras diadema.
,, reticulatum.
,, spirale.
Prolecanites compressus.
,, mixolobus.
Nomismoceras spirorbis.
Dimorphoceras Gilbertsoni.
Gastrioceras carbonarium,

and many others, none of which, as far as I know, occur in beds below the Viséan limestone.

I think that Dr. Vaughan has greatly strengthened my case that the Lower Culm beds of Devonshire and Cornwall are the homotaxial equivalents of the Pendleside series, having emphasised evidence which I neglected, and I think he will now admit that the Brachiopod and Coral faunas of the Coddon Hill and Bishopton Beds and part of the Pendleside series are identical.

IV.—The Devonian Rocks of Cornwall.

By W. A. E. Ussher.

[By permission of the Director of H.M. Geological Survey.]

SEDGWICK and Murchison, the Rev. D. Williams, and Dr. Holl, taking the Plymouth limestones as a middle division, placed them below the rocks to the south and above those to the north. The prevalent southerly dips of schistosity were regarded as ample evidence of a downward succession proceeding northward.

The Staddon grits and other Lower Devonian rocks were thus placed above the Middle Devonian, and the slates in which I have at various times since 1892 found Upper Devonian fossils (between Menheniot and St. Budeaux) were relegated to a position below the Middle Devonian.

Turning from these more general readings of the geology to the detailed work of De la Beche, as presented in Chapter iii of his Report, we find that this comparatively simple rendering, though fundamentally wrong, cannot be applied to Cornwall.

As regards South-East Cornwall (see p. 79), the fossiliferous Looe beds were said to be prolonged toward St. Germans and to become merged in the trappean rocks, etc., of St. Stephens and Saltash, both being considered as below the Plymouth (Middle Devonian) rocks. The calcareous strata of the Tregantle coast (the same series as the fossiliferous Looe beds) were taken as the probable westerly continuation of the Plymouth limestones. The latter error was endorsed by me in recording coast observations some years before I had any practical acquaintance with the Devonian rocks of South Devon.

As regards North Cornwall (see p. 91), we read "the slates of Watergate Bay rest on the sandstones of St. Eval and St. Breocks Down; and the red and variegated beds of St. Kew and St. Minver seem to be the same with the red and variegated beds of Watergate Bay; the calcareous rocks of Lower St. Columb Porth, Newquay, and the Gannel representing in a general manner the limestones of Rock, Padstow, and Permizen."

The anticlinal of St. Breocks Down is elsewhere referred to in Chapter iii, and as these grits do not crop up to the north, we are obliged to assume their identity with the Staddon grits.

It will thus be apparent that, as regards South-East Cornwall, De la Beche correlated the Looe beds[1] of the Looe district with rocks in the Saltash district which I have proved to be Upper Devonian, and the same Looe beds in the Tregantle district with Middle Devonian rocks in the Plymouth district. As regards North Cornwall, it will be seen that De la Beche did not treat the variegated slates of Watergate Bay as an anticline, but by assigning that structure to the Staddon grits he correlated the Lower Devonian rocks on the south with the Upper and Middle Devonian rocks on the north.

The Devonian geology of Cornwall prior to 1890 was thus left in a state of chaos. In that year, after two years' careful mapping of the Torquay, Totnes, and Newton Abbot area, I endeavoured, by a thorough perusal of De la Beche's Chapter iii with the maps before me, to follow his minor subdivisions, and to test his correlations in order to ascertain how far they might be made to agree with the subdivisions I had established by detailed survey. I then found that there was no escape from the conclusion that the grits of St. Eval and St. Breocks Down and of Boconnoc represented the Staddon grits which at Mount Edgecumbe are on the mean latitude of their South Devon outcrop. The difference in latitude I conceived to be due to the existence of a great north-westerly fault from Cawsand, *cutting off the Upper and Middle Devonian rocks on their westerly strike against the Lower Devonian subdivisions and shifting the outcrop of the Staddon grits northward.*

I had recognized the lithological affinities of the variegated slates of Mutley to the red and green Entom-yielding Upper Devonian slates of Ansteys Cove, Goodrington, and Highweek (Newton Abbot) in 1888. So that it became evident that the red and variegated slates to the north of the Staddon grits had been confounded with the Dartmouth slates in North Cornwall, and that the anticlinal structure assigned to the grits of St. Breocks Down was suggested by this similarity.

[1] Referred to the Siegener Grauwacke by Dr. Kayser, who established the Taunusian age of the fauna in 1882.

On the other hand, in South-East Cornwall it became evident that the Looe beds had been traced into Upper Devonian on their strike, *through the great structural fault between them having escaped detection.*

The results of this critical examination were contributed to the Royal Geological Society of Cornwall and appeared in the Transactions of that Society in 1891. The paper was entitled "The Devonian rocks as described by De la Beche interpreted in accordance with recent researches." It was accompanied by a map reduced from the 1 inch on which, after tracing De la Beche's minor subdivisions with infinite pains, as far as the information obtainable from the Report enabled me to do, I had *remodelled* them and referred them to *widely different horizons*. This map shows the relations of the Upper, Middle, and Lower groups of the Devonian for the first time, and with approximate general accuracy; it also furnishes the key to the Devonian geology of Cornwall.

Having since mapped the country from Plymouth to St. Austell in detail, I have found the inference of great structural faulting to be correct, the effect being produced by two or three faults, one of which runs in a north-westerly direction from Cawsand, as shown in the little map illustrating the results I arrived at in 1891. By the discovery of the Upper Devonian *Entomides, Styliolæ,* and traces of the Büdesheim fauna, I have proved the occurrence of Upper Devonian rocks where shown on the little map east of Liskeard.

In North Cornwall, the discovery of the Büdesheim fauna by Mr. Fox at Trevone and the researches of Mr. Parkinson have proved the general correctness of the map as showing the extension of Upper Devonian. The general line of the Lower Devonian outcrop is correct as far as the occurrence of the Staddon grits could be inferred from the materials in Chapter iii.

These results were achieved by analogy with a carefully mapped district, and they are directly contrary to De la Beche's correlations. As regards the run of the Lower Devonian subdivisions, the map had to be constructed from totally inadequate materials, so that the relative outcrops of the Dartmouth slates and Looe beds, in the absence of analogy, were very incorrectly shown.

An alternative rendering of the structure of Watergate Bay was given, showing the Dartmouth slates as an anticlinal, although not suggested by De la Beche. This structure has since been worked out by Mr. Reid.

I took the Grampound rocks as a base to the Devonian on account of their conglomeratic character and because there is nothing in the Report to show that they partake of the south-westerly strike of the rocks to the south, so that they appeared to mark the unconformable junction of a newer with an older group.

The revolutionary character of my paper of 1891 was pointed out by the late R. N. Worth in an article which appeared in the same Transactions (Royal Geol. Soc. Corn.) for the ensuing year, 1892. In it he criticized adversely the structure put forward, but in a most fair and candid manner. He corrected an error as to the Modbury elvan, which in subsequent mapping was found to be a granophyre.

So far as I am aware, Mr. Worth's criticisms on my paper of 1891 are the only ones that have appeared in print. The title of the paper is misleading, as De la Beche's descriptions merely furnished the material, but the Devonian geology was derived from my own work in South Devon, which gave the clue for separating his minor subdivisions into widely different horizons.

Mr. Upfield Green, in an article on the correlation of some Cornish beds with the Gedinnian of Europe (in the August number of the Geological Magazine), has pointed out my inadvertent use of the term 'Gedinnien' as applied to the Looe beds in 1900, but he has overlooked their correlation with the Siegener Grauwacke in the table of classification in the "Memoir on the Geology of the country around Torquay" in 1903. He has also omitted to state that Dr. Kayser first correlated them with the Taunusien in 1882.[1] Of this I was well aware, as Dr. Kayser had called attention to the fact in a brochure in 1888 giving the results of a trip to the North and South Devon Devonian in company with Professor Gosselet and others under my guidance. In my paper of 1891 I suggested the correlation of the Grampound grits with the Gedinnien; to this Mr. Green does not refer, although I gather from his paper that he places them in the same group that I did then, but hesitate to do now.

In a general way I gather that Mr. Upfield Green places those rocks between the Lizard district on the south and the St. Austell granite on the north, which are not admittedly Silurian, in the Gedinnian, including in that group the Mylor, Falmouth, and Portscatho beds of Mr. Hill, and placing the Dartmouth slates at the top. There is, however, one objection to this, viz., the assumed continuity of the Dartmouth slates "through Tywardreath and St. Austell to St. Stephens as described by De la Beche." I, too, assumed this continuity from De la Beche, but on investigating the ground I found that the Dartmouth slates are cut off by a nearly north and south fault near Tywardreath, and do not extend round the St. Austell granite, either on the north or south margin, to Watergate Bay.

Mr. Upfield Green has raised a very interesting question in claiming the non-Silurian rocks of South Cornwall as Gedinnien, but there is no proof that these rocks are below the Dartmouth slates. To entertain this suggestion the absence of Dartmouth slates on the south of the St. Austell granite would have to be explained by a very improbable change in character, or by a fault between the Perran Porth and Pentuan coasts throwing Gedinnian rocks on the south against the higher beds of the Meadfoot group on the north. Without an acquaintance with the district west of Grampound and Ladock I should not like to express any very definite opinion. Mr. Upfield Green, no doubt inadvertently, states that the Dartmouth slates may be traced "across the Start Peninsula as far as Babbacombe, south of Dartmouth in Devonshire." This

[1] Jahrb. d. kgl. preuss. Landesanstalt., p. 128, 1882.

should read "as far as Scabbacombe Head, east of Dartmouth." He asserts, moreover, that "they exist also on the north of the Devonian basin." There they are represented, no doubt, and in 1889[1] I tentatively classed them with the Foreland grits as Gedinnien but there is no distinct group of similar character in North Devon or West Somerset.

V.—The Older Deutozoic Rocks of North Britain.

By J. G. Goodchild, F.G.S., of the Geological Survey,
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It appears to be a common belief that there are two Old Red Sandstones in Scotland, and only two, which are referred to respectively as the Upper and the Lower. It is generally recognised that neither of these can be paralleled with any one of the subdivisions of the Devonian Rocks, properly so-called; though the fact that the Scottish rocks in question occupy a stratigraphical position somewhere between the top of the Silurian Rocks and the base of the Carboniferous System places their Devonian age beyond the possibility of a doubt. The Upper Old Red is considered by most persons to graduate upwards into the Carboniferous Rocks, which, by the way, is by no means universally the case. It is also stated, with equal confidence, and with as little regard to the facts, that the Lower Old Red Sandstone graduates downward into the Silurian Rocks, which it certainly does not, as will be shown more fully in another part of this paper. Furthermore, it is still commonly believed that bands yielding Silurian graptolites alternate with the base of the Lower Old Red Sandstone, and that Lower Carboniferous fossils occur in bands of rock interstratified with true Upper Old Red Sandstone. Both of these ideas are well known to have been due to errors of observation; yet the statements in question, having found their way into the papers set by examiners, seem destined to die a hard death, and therefore need to be contradicted.

The errors mentioned are by no means the only ones relating to the rocks of Devonian age in North Britain. Therefore, as no one else who is fairly well acquainted with these rocks has yet come forward with the object of stating the actual facts, I propose to take advantage of the present opportunity (when I am about to present some new suggestions regarding the age of some volcanic rocks on the northern margin of the Lake District) to give a conspectus of what is at present known about the Scottish rocks of Devonian age.

As much of the evidence bearing upon this subject is necessarily of a palæontological nature, I gladly avail myself of some of the published results of the important work done in this direction by Dr. Traquair, and accordingly give here lists of such fossils as serve to characterise the several horizons referred to. A list of

[1] Proc. Somerset Arch. and Nat. Hist. Soc., vol. xv, pt. 2, Table of Classification, in which 'Gedinnien' is placed in line with Lynton Beds through a printer's error.

such of Dr. Traquair's papers as bear upon this part of the subject is given in an appendix to the present paper.[1]

It need hardly be stated here that the Scottish rocks of Devonian age differ in almost every respect from the normal type. There is no satisfactory reason for regarding any of them as of marine origin; and, on the other hand, there is much to be said in support of the view that they were all formed under continental conditions, and under conditions of climate which, though doubtless varying much from time to time, were yet, on the whole, characterised by an annual rainfall decidedly below the average in amount. It is this feature which has imparted a common character to the whole of this series of rocks.

We may now proceed to review such of the chief points of interest connected with each of the Old Red Sandstones as bear more or less directly upon the chief matter to be discussed in this paper.

The newest subdivision of the Old Red Sandstones is the well-known Upper Old Red. This, by the way, *is* usually red in colour, and, also, it does consist mostly of sandstones. The remark is not altogether uncalled for, as much of the remainder of the Old Red is not red, and it does not, by any means, consist exclusively of sandstones. The Upper Old Red was formed at a period when the geographical conditions were slowly changing from those of a continental nature to those of an insular type. The rocks are, of course, extremely variable in thickness, because they were laid down upon a very uneven surface of the old land. They are also, but to a lesser extent, variable in mineral character. But where this formation is most fully and typically developed its petrographical characters may be described as referable to three types—(1) a basal conglomerate, which graduates upward into (2) a variable series of red sandstones, often full of desert-sand grains, and highly false-bedded in places, like an old desert sand-dune. This part is mainly red, with some poikilitic mottling and variegation. A few bands of marl[2] occur here and there. Calcareous matter is usually conspicuous by its absence from this division. Above this group of red rocks usually occurs (3) a higher subdivision, in which the sandstones are not so deeply coloured, and in which even purplish bands begin to occur. This upper group is generally characterised by the occurrence in it of some precipitated carbonate of lime. In some cases this compound occurs in the form of flakes, which obviously represent broken-up sheets of chemically-formed carbonate of lime; in other cases the calcareous matter has segregated into a nodular form; while in some few instances the calcareous matter may occur as lenticular masses closely resembling some bedded limestones.

[1] In here referring to it, I may perhaps be permitted to direct the reader's special attention to the beautiful and lifelike restorations of the fishes of the Orcadian Rocks which Dr. Traquair has given in Harvie Brown's "Vertebrate Fauna of the Moray Firth."

[2] The word 'marl' in the North means any clay that readily crumbles on exposure to the weather.

This upper subdivision is usually referred to as the Cornstone Series. I have suggested in several papers that this chemically-formed carbonate of lime of the Upper Old Red Cornstones marks a transitional phase of climate. The land had sunk to near the sea-level, and consequently humid conditions had set in, and vegetation had begun to flourish. The decomposing remains of trees, drifted into the lagoons, led to a precipitation of carbonate of lime from the sulphate of lime held in solution by the concentrated sea-water there. The presence of these cornstones is, therefore, useful to the geologist as indicating transitional phases of climate from arid to humid. Conversely, seeing that the same climatal conditions must have prevailed over wide areas, the occurrence of cornstones at several localities within an area of limited extent might safely be trusted as evidence of their contemporaneity. The validity of this reasoning has lately been put to a very severe test, which, I may add, it has successfully withstood.

The fauna of the Upper Old Red consists almost exclusively of fishes, which probably found their way into the sediments from the rivers of upland origin, whose waters were dissipated by the excessive evaporation when they reached the lowland areas. The fish belong to species, and in some cases to genera, not found elsewhere. Hence their remains serve a valuable purpose in determining the age of the rocks in which they are found. Amongst other fossil fishes may be mentioned such Crossopterygians as *Holoptychius* and some of its allied genera; the Ostracoderms *Asterolepis, Bothriolepis*, and others; such Dipnoans as *Phaneropleuron*, together with some other genera of equal biological interest, but as zonal forms of lesser interest to the geologist. Dr. Traquair has shown that the Upper Old Red contains two distinct fish faunas. The lower zone is characteristically developed around Nairn, and the higher is well seen near Elgin.

It is not strictly correct to speak of the Upper Old Red Sandstone graduating upwards into the Carboniferous Rocks; and, for the same reason, it is equally incorrect to describe this formation as the "Carboniferous Basement Bed." There can be no doubt that the Upper Old Red is quite a separate formation from the Carboniferous System, and it has certainly nowhere been seen to alternate with any rocks of undoubted Carboniferous age. In Central Fife there is a very marked overlap of the middle of the Lower Carboniferous Rocks on to the Upper Old Red Sandstone; and evidence is not wanting elsewhere of something like a true unconformity between the two formations.

As regards the base of the Upper Old Red Sandstone, it has long been known that, throughout Britain, it lies with a more or less violent discordance upon the rocks beneath. In Cumberland and Westmoreland the aggregate thickness of the rocks between the highest and the lowest horizons of the Protozoic rocks upon which it lies amounts to more than seven miles, i.e. 13,000 feet of Silurian Rocks, 12,000 feet of the Bala–Arenig volcanic rocks, and fully 12,000 of the Skiddaw Slates, to say nothing of other formations to be presently referred to. One of the most impressive geological phenomena I ever witnessed was presented by a section in the Basin of the Lune, of the Upper Old Red Sandstone lying in a nearly horizontal position upon vertical and highly-cleaved Upper Ludlow Rocks, of fragments of which the newer rock was largely composed. This was in the course of my first week's field-work on the Geological Survey, in 1867. Ever since then my recollection of that enormous hiatus has remained as vivid as at first, and it has added not a little to the pleasure afforded by somewhat extensive explorations made in recent years amongst the Scottish rocks which partly bridge over the vast gap. An unconformable junction of Cornstones on Highland Schists, exposed on the north shore of Arran, is hardly less striking; as is the better known case at the Siccar Point, where the Upper Old Red lies upon Gala Rocks.

Unconformable Junction of Cornstones with Highland Schists, north shore of Arran, east of Loch Ranza.

It adds still further to the impressive character of the unconformity at the base of the Upper Old Red Sandstone of the Lake District that this rock also contains rolled fragments of the granites, elvans, and porphyrites of that part. These plutonic and trappean rocks are certainly of later date than the cleavage of the rocks they invade and also than one phase of the great denudation that followed the development of the cleavage. That is to say, after the Protozoic rocks of the Lake District were folded, they were first cleaved, then denuded to an enormous extent; after that, great volcanoes rose upon the denuded surface, and, finally, the volcanoes themselves were gradually worn away to the very cores—all before the Upper Old Red Sandstone began to be laid down.

The full importance of this stupendous unconformity has not yet, I think, been adequately realised. When its significance comes to be thoroughly grasped much greater interest than is shown at present will be felt in the geological formations which help to fill in part of the gap. Most of these, as is well known, occur north of the Tweed.

The newest formation of these Old Reds, of prior date to the Upper, is the Orcadian Series, which is so extensively developed in the north-east of Scotland and in Orkney and Shetland. The Orcadian Series has formed the subject of several important memoirs, amongst the latest of which may be mentioned those by Messrs. Peach & Horne, Sir Archibald Geikie, Mr. Evans, and Dr. Flett. Even the highest beds of this formation lie unconformably below the Upper Old Red; and neither the natural top of the Orcadian Series nor its base has yet been found. Nevertheless, the thickness of this older subdivision, where it is most fully developed, has been estimated at some sixteen thousand feet. Three well-marked fossiliferous horizons occur within it. The highest one occurs in the upper beds, or John o' Groats Flags. This has yielded several fossil fish which have not been met with on any other geological horizon. Amongst these are *Tristichopterus alatus*, Egert., *Dipterus macropterus*, Traq., and *Microbrachius dicki*, Traq.

Lower down, and on horizons which are near the middle of the series, if we have regard to the maximum development of these rocks, come the fossiliferous beds of Thurso; and, still lower, those of Achanarras and Stromness, as well as at Cromarty and other places near the Moray Firth. Below these, again, come the Sandstones of Berriedale, the Badbea Breccia, and some local conglomerates. These three last-named subdivisions form the lower four thousand feet or so of the Orcadian Series; but in the absence of any satisfactory palæontological evidence their position in relation to the highest of the rocks forming the next older series cannot be fixed with certainty.

From the Thurso Flags Dr. Traquair has identified *Homosteus milleri, Coccosteus decipiens, C. minor, Mesacanthus peachi, Cheiracanthus murchisoni, Diplacanthus striatus, Rhadinacanthus longispinus, Glyptolepis paucidens, Gyroptychius microlepidotus, Osteolepis microlepidota, Thursius macrolepidotus* and *Th. pholidotus, Diplopterus agassizi*, and *Dipterus valenciennesii.*

The lower or Achanarras subdivision contains a fish fauna which Dr. Traquair has identified as follows: *Diplacanthus striatus* and *D. tenuistriatus, Rhadinacanthus longispinus, Mesacanthus pusillus, Cheiracanthus murchisoni* and *Ch. latus, Pterichthys milleri, Pt. productus* and *Pt. oblongus, Dipterus valenciennesii, Glyptolepis paucidens, Gyroptychius microlepidotus, Osteolepis macrolepidota, Diploterus agassizi, Coccosteus decipiens, Homosteus milleri,* and *Cheirolepis trailli.*

The fossiliferous portions of the Orcadian Old Red do not occur to the south of a westerly line drawn through Stonehaven. Whether the beds below the lowest of these horizons do so or not cannot be determined at present in the absence of any palæontological evidence; but there is a general belief amongst those who have the means of forming an opinion that these lowest beds are, like those above them, confined to the northern area referred to.

To the south of the line just indicated there occurs another formation, the general biological facies of whose fossils indicate, as J. W. Salter pointed out nearly half a century ago, a lower horizon than the Orcadian Old Red. In places this formation, also, is capped by the Upper Old Red, which here, as elsewhere, lies unconformably upon the rocks below. The formation to which reference is now being made has been termed the Lower Old Red Sandstone by several writers; but as there is another and still older formation which has also received that name, and as even the Orcadian Old Red has been also called the Lower Old Red, it is obviously better, in referring to these subdivisions, to make use of some territorial name, in order to prevent ambiguity. Therefore, many geologists who have felt the difficulty referred to have adopted the name Caledonian for this southern Scottish formation. This, besides being euphonious, and also useful in many ways, is rendered the more appropriate because the rocks denoted by that name were considered by Sir Archibald Geikie to have been formed in a lake to which he gave the name 'Lake Caledonia,' and furthermore, because this formation is pre-eminently the Old Red of Scotland, and because it is typically developed in the region distinguished by the Romans as Caledonia.

Like the Orcadian Old Red, the one under notice attains to a very considerable thickness. Sir Archibald Geikie, indeed, estimates that thickness at 20,000 feet (Text Book, vol. ii, p. 1008). Its natural top is not seen; nor, perhaps, is its base. As regards its mode of origin, there appears to be evidence of a satisfactory nature that the whole of this vast formation was accumulated under continental conditions, partly in large inland lakes, partly as torrential deposits of various kinds, partly as old desert sands, and partly as the results of extensive volcanic action. The lowest strata appear to be those which are exposed near Dundee, where they are brought up by a powerful anticlinal fold, whose effects are, I think, augmented by a large fault which does not appear to have been hitherto recognised. Most of the base on the north is faulted in by the Highland Boundary Fault. The newest strata are exposed in the western part of the lowland tract of Strathmore, along a powerful synclinal, which is correlative to the anticlinal just referred to.

Looking at the formation broadly, three subdivisions, founded upon petrographical characters, can be made out. The highest of these is formed by the conglomerates, sandstones, flags, and marls, whose outcrops form the great lowland tract of Strathmore. The middle subdivision consists chiefly of volcanic rocks, which are mostly andesitic lavas, with some quite subordinate beds of tuff. This volcanic series forms the Ochils and the Sidlaw Hills, in the part of Scotland at present under notice. To the north and north-east of Dundee the volcanic rocks pass, by the thinning of the lavas, into a series of alternately sedimentary and volcanic rocks—the sediments in this case being, therefore, contemporaneous with some of the volcanic rocks to the east. The confusion occasioned by this feature appears to be further complicated by the anticlinal and its accompanying fault just mentioned. It should be noted that these volcanic rocks form a very conspicuous feature in the stratigraphy of the Caledonian Old Red, and that they are usually present, in some form or other, even when the lower beds and the upper are entirely absent.

The Caledonian Old Red volcanic rocks of Perth and Forfarshire may well be several thousand feet in thickness where they attain their fullest development. Sir Archibald Geikie (loc. cit., p. 1008) further regards the volcanic horizon as occurring several thousand feet below the highest beds of Strathmore, and also as being several thousand feet above the base of the system.

The volcanic zone certainly overlies a considerable thickness of greywackes, flagstones, and mudstones, whose base has not been seen. These lowest sedimentary beds, it may be here remarked, bear a remarkably close petrographical resemblance to the type which forms much of the Silurian rocks; and it may be well to add that the physical relationship of these Arbroath Flags (as they may still be called) to the volcanic belt has not yet been quite clearly made out.

Turning now to the palæontological evidence, it may be said that very few fossils have yet been obtained from the higher parts of the Strathmore Sandstones; so there is no evidence to prove that these beds may not be contemporaneous with the very lowest subdivisions of the Orcadian Series. Near the base of the Strathmore Sandstones, and close to the top bed of the main part of the volcanic rocks, occurs an upper fossiliferous band which has yielded myriapods such as *Kampecaris* and *Archidesmus*, together with imperfectly preserved plants, some of which have been referred to *Psilophytum robustum*; while at a slightly lower horizon, and contemporary with some of the volcanic rocks, is the zone which has yielded the chief Acanthodian fish remains. One of the best known of these fossiliferous localities is at Tilliewhamland Quarry, Turin Hill, near the town of Forfar. These rocks are there extensively quarried for flagstones, and they have yielded fossils which have been catalogued by the late Mr. Powrie as follows:—*Mesacanthus mitchelli, Ischnacanthus gracilis, Climatius scutiger, C. uncinatus, C. reticulatus, Parexus recurvus, P. falcatus, Euthacanthus mitchelli, E. elegans, E. gracilis, E. curtus, Cephalaspis pagei, C. asper, Thelodus pagei*, and with *Pterygotus anglicus, Stylonurus ensiformis*, and also with *Parkæ decipiens*, etc. Similar beds occur near this horizon at Farnell.

The beds exposed at Turin Hill are on the north limb of the great faulted anticlinal above mentioned. The axis of this anticlinal ranges, roughly speaking, from near the confluence of the Earn with the Tay, below Perth, through a point about midway between the towns of Dundee and Forfar, and thence in the direction of Montrose. Hence the fossiliferous horizon represented at Turin Hill is repeated to the south of the line mentioned.

At a geological horizon lower still, as at Auchtertyre, near Newtyle, in Forfarshire, but still above the main mass of the lavas, occurs a bed which has yielded *Cephalaspis lyelli, Pteraspis mitchelli,* and some few Acanthodians.

Furthermore, at what I take to be still lower fossiliferous horizons, occur the beds of Carmylie, which have yielded most of the finest specimens of Eurypterids obtained from Forfarshire. Acanthodians of the types occurring at Turin Hill are found with these, as is also *Parka decipiens.*

What appear to be the lowest fossiliferous horizons occur at Myreton, Tealing, and Leoch.

The general biological facies of these Caledonian Old Red fossils indicates, according to Dr. Traquair, a formation of an earlier date than the Orcadian Old Red. This view of the relative positions of the Caledonian and Orcadian Old Red formations has now again met with general acceptance, and it will probably never again be called in question.

The volcanic rocks which have just been mentioned as giving rise to the most prominent features of the Caledonian Old Red in the Ochils and the Sidlaw Hills present physiographical features of even more strongly-marked character in the Pentland Hills, in Glen Coe, and also in the neighbourhood of Oban. The Cheviot Hills, again, owe much of their physiographical character to the presence of these rocks. St. Abb's Head, and some other places near that part of the Scottish coast, also consist of andesitic lavas and tuffs of the same age as those of the Pentland Hills and the Ochils. Here and there at several localities south of the Firths of Forth and Clyde the older sedimentary rocks below the volcanic zone are to be seen. As a well-known locality where such is the case may be cited the beautiful river-gorge in which are situated the Falls of Clyde. More generally, however, these sediments are absent, and the volcanic rocks form the lowest member of the series, and these may lie, often with a violent unconformity, upon any rock older than themselves.

Most of the granite bosses of the southern half of Scotland, and perhaps nearly all of those in the north of England, appear to have originated in connection with the volcanoes from which these Caledonian Old Red andesitic lavas and their associated dykes of Elvan and Porphyrite have been erupted. Where these Granites and Porphyrites occur we may, therefore, expect to meet at no great distance with remains of their related volcanic rocks.

Leaving these details. however, for reconsideration presently, we may now go on to consider the nature of the physical relation of the Caledonian Old Red to the rocks next older in the series. So far from graduating downward into the Silurian rocks, the local base of the formation under notice lies with a violent unconformity upon all of these rocks, and may repose indifferently upon Silurian, Ordovician, or even older strata, including the metamorphic rocks of the Southern Highlands of Scotland. What has been taken as the Caledonian Old Red in the cases where it has been supposed that a passage exists is in reality a series of quite different age. These rocks to which reference has just been made, being typically exposed in Lanarkshire, I have named the Lanarkian Rocks. These are the strata which, with part of the Upper Ludlow rocks, have lately been termed the Downtonian Series—a particularly ill-chosen name, as it seems to me, because the name Downtonian had previously been used to denote all the Silurian strata above the top of the Lower Ludlow Rocks. These Lanarkian Rocks form the upward continuation of the true Ludlow Rocks, and they clearly mark the oncoming of the continental conditions which brought the Silurian Period to a close, and marked the advent of those geographical conditions which ushered in the Devonian Period in what is now the northern part of the Kingdom. Their stratigraphical details need not be given here, for the reader will find them fully described in the Geological Survey Memoir on the Silurian Rocks of the Southern Uplands of Scotland—which, by the way, is one of the finest memoirs issued by the Department to which I have the honour to belong.

A study of the excellent sections given in the work just referred to will suffice to show that the Lanarkian Rocks have shared in all the disturbances to which the Silurian Rocks have been subjected. These disturbances had ceased, and had been followed by prolonged denudation, long before the oldest member of the Caledonian Old Red was laid down. Hence it results that the great unconformity, so often referred to, passes above what is left of the Lanarkian Rocks. There is no clear evidence of any unconformity below them.

If we take the original red colour of the sandstones in these Lanarkian rocks as evidence of their representing the very lowest 'Old Red' (which it seems reasonable to do), then it would be these rocks which form the true 'Lower Old Red,' and as such they were most admirably described many years ago (1860) by Sir Archibald Geikie. There are, however, no rocks containing Silurian fossils above them, nor do they present anywhere more than an accidental appearance of a conformable passage into the Caledonian Old Red; indeed, in the only section where these two have the same dip their interrelationship is similar to that of the Trias on the Upper Old Red near Elgin.

I have formerly ventured to speculate (on what seem to me to be good grounds) whether these Lanarkian Rocks might not have formed the lowest part of a very much thicker series of rocks, whose higher portion is now entirely absent through denudation effected prior to the Caledonian Old Red period; and I still think that these missing rocks may have included a band of marine limestone closely resembling the Devonian Limestone, as this is seen at Plymouth, due to a temporary return from continental to marine conditions.

At any rate, and however this may have been, these Lanarkian Rocks, which are certainly posterior in age to the Ludlow Rocks, are separated from the strata containing *Cephalaspis lyelli* by one of the most extensive unconformities in the whole geological series.

It may serve a useful purpose to summarise here, in a tabular form, the foregoing statements regarding the stratigraphical relations of the various Scottish Old Reds, which, accordingly, is as follows:—

Older Deutozoic Rocks, as developed in Scotland.

	Approximate thickness in feet.
Upper Old Red Sandstone.	
2. Higher subdivision, or Elgin Beds.	
1. Lower subdivision, or Nairn Beds.	0.—1,000.
[*Extensive unconformity.*]	
Orcadian Old Red.	
5. John o' Groats' Flags.	
4. Thurso or Rousay Beds.	
3. Achanarras, Stromness, and Cromarty Beds.	
2. Berriedale Sandstones.	
1. Badbea Breccias and Basal Conglomerate.	0.—16,000.
Caledonian Old Red Sandstone.	
3. Strathmore Sandstones (the upper part of which may be contemporaneous with the lowest part of the Orcadian).	
2. Myriapod Beds.	
Volcanic Rocks.	
Acanthodian Beds of Turin Hill.	
Cephalaspis Beds of Auchtertyre.	
Volcanic Rocks.	
Pterygotus Beds of Carmylie, etc.	
Tealing Beds.	
1. Lower Series of Sandstones, Mudstones, Conglomerates, etc.; base not seen.	Ranging to ? 20,000.
[*Extensive unconformity.*]	
The Lanarkian Rocks (Downtonians of the Geological Survey, the original Lower Old Red of earlier writers).	
Ludlow Rocks.	

It will thus be observed that what has been called "The Old Red Sandstone" in Scotland is by no means a single formation; nor can it be regarded as merely two. On the contrary, it must be obvious from a consideration of the foregoing statements that we are dealing with a succession of formations, which, it seems to me, must collectively have required a period of enormous length for their accumulation. This, it will be noted, is evidenced not only by the great thickness of both sedimentary and volcanic rocks accumulated, but also by the extensive unconformities, and equally so by the numerous and important palæontological changes which are known to have taken place during the period in question.

In reflecting upon these facts the chief interest centres upon the formations which are of older date than the Upper Old Red Sandstone and newer than those of Silurian age. If the remains of so varied and important a set of geological formations can be shown to exist even yet in Scotland, one is led to enquire whether it may not be possible that remnants of some of these may also exist on the English side of the Border, perhaps concealed beneath newer formations, or, it may be, even exposed at the surface in places where their identity has not hitherto been recognised.

As regards the possibility of these rocks occurring in the Lake District, it should be borne in mind that there are two lines of evidence which clearly point to the existence, in former geological times, of andesite volcanic rocks of the types which occur so widely throughout the Caledonian Old Red. One of these is, as I pointed out many years ago, the fact that the Upper Old Red of North Cumberland partly consists of pebbles and blocks of these lavas. These andesite pebbles are so abundant in some places, as, for example, near Melmerby, that I have long entertained the belief that a large tract of these Caledonian Old Red lavas must exist at no great distance, they being covered, of course, by rocks of later formation. Then, again, there is the well-known fact that several of the granite bosses and Elvan and Porphyrite dykes of the Lake District are of later date than the cleavage of the rocks around them, and are later even than the great denudation which preceded the formation of the Upper Old Red. Furthermore, fragments of these granites and their apophyses, as already stated above, occur in the conglomerates of the Upper Old Red. Lastly, the close resemblance in mineralogical constitution of these Lake District granites to those of the South of Scotland, which can almost be proved to represent the deep-seated parts of the cores of the Caledonian Old Red volcanoes, forms an additional link in the chain of evidence which points to these Lake District granites being contemporaneous with the later part of the Caledonian Old Red, and to their marking the sites of areas from which, at one time, andesitic lavas must have overspread the districts around.

During the past sixteen years it has been one part of my duty to arrange for exhibition in the Edinburgh Museum of Science and Art a very large series of Scottish Fossils, Minerals, and Rocks, amongst which last figure very largely representatives of the Scottish rocks of Devonian age. A large proportion of these rocks I have also studied *in situ*, always regarding them when doing so with considerable interest, as representing part of the series that must, in some one place or another, fill up the great hiatus between the Upper Old Red and the Protozoic Rocks of Cumberland and Westmoreland. Whenever a suitable opportunity has presented itself, I have taken advantage of it to go carefully over the field evidence presented by the district just named. There is one part of the Lake District in particular to which I have devoted attention at various times since 1873, and that is the part lying to the north and north-east of Saddleback. A thick series of basic andesite lavas with some tuffs occurs there. These pass unconformably beneath the Lower Carboniferous Rocks to the north and east; and their base, in the opposite direction, comes into contact with sedimentary rocks which are certainly very low down in the Skiddaw Slate Series.

Furthermore, there is a wide divergence in the strikes of the two series, and the volcanic rocks dip, as a whole, in the opposite direction to that of the sediments. Dr. Marr made a very important discovery of sediments of Lower Bala age, the Drygill Shales, near the margin of these. I still think that these Drygill Shales may lie unconformably upon some part of the Skiddaw Slates, and for a long time thought that the set of volcanic rocks at present under notice might possibly belong to an horizon near to that of the Drygill Shales. However, recent visits to the Caldbeck Fell area, with the facts summarised in the foregoing part of this paper in mind, have led me to alter that opinion. Therefore, although I am not aware as yet of any palæontological evidence which tells either the one way or the other, the balance of field evidence seems to me now to indicate that the volcanic rocks in question may really be of the same age as the Caledonian Old Red.

The strip referred to is that which, lying within the Carboniferous frame on the north side of the Lake District, stretches, everywhere with a strike discordant to that of the adjoining Skiddaw Slates, from Uldale, past Caldbeck, through the Caldbeck Fell mining area, to Carrok Fell, and is continued as faulted inliers at two places near Greystoke Park, including the well-known patch which is locally called Berrier Nittles, but which Mr. Ward referred to as Eycott Hill.

There is nothing in either the petrographical or the lithological characters of these rocks which would definitely link them on with the true Arenig–Llandeilo rocks which occur between Keswick and Ambleside, or Ullswater and Shap. On the other hand, the volcanic rocks in question agree in both petrographical and lithological characters with the volcanic rocks which form the Cheviot Hills, and they appear, as the Caledonian Old Red rocks do everywhere, to lie with a violent unconformity upon any rocks older in the series with which they may come into contact.

Whether any of the volcanic rocks near Melmerby can also be referred to this horizon is a question I hope to be able to answer soon.

R. H. Traquair, "Notes on the Nomenclature of the Fishes of the Old Red Sandstone of Great Britain": Geol. Mag., Dec. III, Vol. V (1888), pp. 507–517.

——— "On the British Species of Asterolepidæ": Proc. Roy. Phys. Soc. Edinb., vol. xi (1892), pp. 283–286.

——— "On the Discovery of *Cephalaspis* in the Caithness Flags": Ann. Scott. Nat. Hist., Oct. 1893, pp. 206–207.

——— "Achanarras Revisited": Proc. Roy. Phys. Soc. Edinb., vol. xii (1894), pp. 279–286.

——— "The Fossil Vertebrata of the Moray Firth Area": contained in Harvie-Brown & Buckley's "Fauna of the Moray Basin," Edinburgh, 1896.

——— "Note on the Fossil Fishes of the Old Red Sandstone of Scotland": contained in Mem. Geol. Surv., "Geology of Lower Strathspey" (Explanation of Sheet 85), 1902, pp. 81–82.

VI.—On the occurrence of Lower Miocene Beds between Cairo and Suez.

By T. Barron, A.R.C.S., F.G.S.

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It is remarkable that in this district so accessible to geologists and visited by so many observers, the presence of these beds has not hitherto been noted. When it is understood that the point where the main area occurs is only between 8 and 9 kilometres from Cairo, and lies immediately to the north of the Petrified Forest—a place visited by nearly all the travellers who come to Cairo—one is apt to doubt whether geologists have ever seriously examined this district.

It has been asserted by some geologists that Lower Miocene beds have been found at various places in this district, but on investigation it has always been shown to be a misinterpretation of the evidence, and up to the present no beds have been noted which contain a true Lower Miocene fauna.

In 1900 MM. Fourtau and Depéret published a paper[1] in which they claimed to have found at Gebel Genêffe beds containing a fauna belonging to the Upper Burdigalien (first Mediterranean stage), and analogous to that found in the basin of the Rhône, of Corsica, and still more to the Cartennian Sandstone of Algeria. They based their assertion mainly on the presence of *Pecten Tournali*, de Serres, *P. præscabriusculus*, Font., *P.* cf. *sub-benedictus*, Font., and *P. Kochi*, Loc. It is stated that the same beds are found at Dêr el Bêda containing *Pecten pseudo-Beudanti*, which is identical with the species of the Hornerschichten of Austria; at Wadi Gafra, where *Pecten pseudo-Beudanti*, *P. præscabriusculus*, Font., and *P. geneffensis*, Fuchs, are found; and these occur in all the district to the east of Cairo. These observers publish another section which they regard as the continuation of the Miocene series, and the representative of the Helvetian-Tortonian (second Mediterranean).

Blanckenhorn[2] says that he has not been able to find the above-named Pectens (except *P. geneffensis*) on the spot, or in Schweinfurth's collection or any other material at his disposal, and recognises them[3] as his new species *P. submalvinæ*, Blanck., and *P. Fraasi*, Fuchs, whilst *P. pseudo-Beudanti* he makes *P. Schweinfurthi*, Blanck., all of these being Helvetian fossils. He[4] also regards the two sections of Fourtau and Depéret as not superposable, but parallel to each other, and by their fossils belonging to the Middle Miocene.

In his discussion of all the previous work done on the Miocene

[1] "Sur les terrains néogènes de la Basse-Egypte et de l'isthme de Suez": Comptes Rendus des Séances de l'Acad. des Sciences, 1900, pp. 402–3.

[2] "Das Miocän": Zeitschr. d. Deutsch. geolog. Gesellschaft, 1901, pp. 52–59.

[3] Ibid., pp. 120–127.

[4] Ibid., p. 85.

rocks of Egypt, this author points out that, previous to his own examination of the area at Mogara in the Libyan Desert, no Lower Miocene beds were known in Egypt. Up to the present this is the only occurrence, but he points out that strong probability exists that these beds will be found in the district between Cairo and Suez, although none have been proved. After discussing and comparing the Petrified Forest near Cairo with that occurring at Mogara, which this author regards as Lower Miocene, he finally decides to put the gritty beds occurring above the basalt to the east of Cairo, together with the Petrified Forest in part, into the Lower Miocene. For this he has no fossil evidence whatever; and it is only from the resemblance between the lithological characters of the beds, and the fact that fossil wood occurs at the base of the Miocene in Mogara (a fact of little stratigraphical value since fossil trees are known from the Upper Eocene, and Oligocene on the other side of the Nile Valley), that he ventures to assign to these beds a Lower Miocene age.

In the course of this paper it will be shown that this decision is partly right, though in the main it is wrong, while in a later paper it is hoped that the much vexed question of the age of the Petrified Forest in this neighbourhood, with its associated lava-flows and thermal springs, will be definitely settled.

In order to better understand the occurrence of the beds in question, a brief sketch of the geological history of the period immediately preceding the Miocene is necessary. After the close of the Eocene period, the land on the east side of what is now the Nile Valley rose from under the sea and became dry land. This was the beginning of a continental period which persisted throughout Oligocene times. While in the district round the Fayum the sedimentation continued unbroken from the highest Eocene into the Lower Oligocene, on the east side of the present Nile Valley denudation was at work removing the Upper Eocene beds and producing the relief seen wherever the Gebel Ahmar Sands have been removed. Then these sands and gravels with drifted trees were deposited in a lagoon or estuary. These probably represent the upper part of the Lower Oligocene. After the sedimentation of these sands had continued for some time, a series of earth-movements were set up, by which these beds with the underlying rocks were thrown into ridges and troughs by two sets of folds more or less at right angles to each other, the axes of the one lying S.W.–N.E., and the other N.W.–S.E. These folds gave rise to shallow basins by their interference with each other, and it was in these that the Lower Miocene beds were deposited, after the outpouring of the basalt lavas, and the thermal springs which followed the dying out of the volcanoes had ceased. Between the deposition of the Gebel Ahmar Sands and the transgression of the first Mediterranean sea, there was another continental period during which these sands were denuded to a certain extent. After the Lower Miocene sea had invaded this area and was depositing its sediments, what more likely than that some of the silicified tree trunks were rolled in from the ridges surrounding these basins? Any silicified wood seen by the writer in Miocene beds has always been much broken up, and presented the appearance of having been moved after silicification rather than that of petrifaction *in sitû*. One has only to compare the trees in the Petrified Forest with these to see the difference.

According to Blanckenhorn[1] the Lower Miocene is a fluvio-marine formation characterized in Mogara by *Mytilus aquitanicus, Cytherea erycina*, and Anthracotherian bones. The Helvetian, on the other hand, has a numerous pecten and oyster fauna associated near its base with a more shallow-water assemblage of forms. In fact, the Lower Miocene is essentially a fluvio-marine formation, while the Helvetian is marine.

This author, in his Table of Miocene Strata in Egypt and Syria,[2] gives the following fossils as characteristic of the Lower Miocene of Mogara :—

Scutella Zitteli, Beyr.; *Mytilus aquitanicus*, M.E.; *Lucina ornata*, Ag.; *Lucina columbella*, Lam.; *Cardium* cf. *taurinum*, Micht.; *Venus ovata*, Penn.; *Cytherea erycina*, L.; *Corbula revoluta*, Brocc.; *Teredo Mediterranea*; *Turritella terebralis*, Lam.; *T. cathedralis*, Brongn.; *Crepidula cochlearis*, Bast.; *Galerus chinensis*, Lam.; together with fossil wood, *Podocnemis*, *Trionyx*, *Crocodilus*, *Brachyodus*, and *Rhinoceros*. In addition to these the following are given in the table of fossils for the Miocene[3] as occurring only in the Lower Miocene :—*Cupularia* cf. *urciolata*, Lam.; *Anomia ephippium*, var. *squamula*, L.; *Cardita rufescens*, Lam.; *Diplodonta rotundata*, Mont.; *Cardium paucicostatum*, Sow.; *Dosinia Adansoni*, Phil.; *Tapes Basteroti*, Desh.; *Tellina* cf. *exigua*, L.; *Ervilia pusilla*, Phil.; *Mactra burdigalensis*, May.; *Corbula Basteroti*, Hörn.; *Tugonia anatina*, Gmel.; *Oliva clavula*, Lam.

It is now possible to proceed to the description of the beds for which a Lower Miocene age is claimed.

Between 8 and 9 kilometres east of Abbassia there occurs a series of ridges of gritty limestone, calcareous grits, and ferruginous, calcareous, sandstones and grits, bounded on the south by a thin sheet of basalt, and faulted down on the north along the side of the Old Post Road to Suez. They persist to the north of this fracture, but are much masked by gravel and downwash. This series of beds lies in a shallow basin, and is unconformable to the basalt and overlaps on it. After examining these beds at different places and collecting the fossils, the following succession was made out, although the thicknesses cannot be taken as absolute, the beds never being found in an escarpment of any height to allow of a careful measurement being made :—

[1] Loc. cit., pp. 54–5.
[2] Loc. cit., p. 53.
[3] Loc. cit., pp. 106–112.

			metres.
	Top.	Purplish, hard, gritty limestone	5
	2.	Yellow gritty beds	5
	3.	Porous limestone with few grits containing pieces of *Echinolampas* sp., *Pecten* sp., casts of *Lucina ornata*, Ag., and *Cytherea pedemontana*, Brn.	10·4
Lower Miocene.	4.	Gritty limestone	13
	5.	Hard, dark, calcareous grit containing *Pecten Kochi*, Loc., *Lucina ornata*, Ag., *Cardium Michelottii*, Desh., *C. multicostatum*, Brocc., *Venus islandicoides*, Lam., *Venus* sp., *Tapes vetula*, Bast., *Tellina planata*, Lam., *Mactra corallina*, Lam., *Corbula revoluta*, Bast., *Turritella miotaurina*, Sacc., *Turritella* sp. ...	2
	6.	Yellow calcareous sand and grit containing *Ostrea* sp., *Pectunculus* sp., *Chama* sp., *Cardita* cf. *pinnula*, Bast., *Cardita* sp., *Lucina columbella*, Lam., *Lucina* (*Dentilucina*) sp., *Lucina* sp. (many), *Cardium paucicostatum*, Sow., *C.* cf. *paucicostatum*, Sow., *C. multicostatum*, Brocc., *Cardium*, sp. nov., *Cardium* sp., *Venus multilamellata*, Lam., *Cytherea pedemontana*, Brocc., *C. erycina*, Lam., *Tapes Basteroti*, May., *T. vetula*, Bast., *Tellina lacunosa*, Chemn., *Tellina planata*, Lam., *T. nitida*, Pol., *Tellina* sp., *Mactra corallina*, Lam. = (*M. stultorum*, Lam.), *Corbula revoluta*, Brocc., *Calyptræa chinensis*, Lam., *Turritella miotaurina*, Sacc., *T. terebralis*, Lam., *Ficula condita*, Brongn., *Oliva* sp., *Scaphander* sp.	11
	7.	Calcareous grits with limestone at the base containing *Cytherea* sp., *Tellina* sp.	7
	8.	Grits and siliceous limestone containing *Lucina* sp., *Cardium* sp., (?) *Tapes* sp.	6
	9.	Yellow siliceous grit containing small *Cardia*	5
	10.	Hard, black, calcareous sandstone	1·8
	11.	Yellow sandstones and grits	13

Basalt underlies this last bed.

The beds have a general dip of 3° to 5° N.E., but there is also a gentle inclination of about 2° to the north-west.

Further east the following fossils were obtained from the representative of Bed 7 of the above section :—*Ostrea* sp., *Cardita* sp., *Lucina columbella*, Lam., *Lucina* sp., *Cardium* sp., *Tapes vetula*, Bast., *Tapes* sp., *Mactra* sp., *Corbula Basteroti*, Hörn., *Corbula* sp., *Cancellaria* sp.

Round about Station 4 of the Old Post Road to Suez, a calcareous grit yielded the following fossils :—*Pinna* sp., *Ostrea* sp., *Modiola* sp., *Pectunculus* sp., *Cardita* sp., *Lucina columbella*, Lam., *L. ornata*, Ag., *L.* sp. nov., *Lucina* sp., *Cardium* sp., *Venus ovata*, Penn., *V.* cf. *islandicoides* L., *Cytherea erycina*, Lam., *Tapes* sp., *Tellina lacunosa*, Chemn., *T. nitida*, Pol., *T. planata*, L., *Calyptræa chinensis*, Lam., *Turritella terebralis*, Lam., *Strombus* sp., (?) *Panopæa* sp.

At the north foot of Gebel el Angobia in calcareous grits and marls, *Dosinia Adansoni*, Phil., is found associated with *Tapes vetula*, Bast., *Lucina ornata*, Ag., *Cardium multicostatum*, Brocc., *Turritella terebralis*, Lam., *T. cathedralis*, Brongn., *Conus* sp., and *Pleurotoma trochlearis*, Hörn.

At the base of Gebel Rieshi, 12 kilometres north-east of Bir Gendali, there is practically the same assemblage of fossils as in the previous case. Below these beds comes a series of conglomerates, gravels, sands, etc., lying between Gebel el Angobia and Amuna.

These overlie the basalt, and are seen to pass under the fossiliferous beds of the Miocene.

At the Middle Station, Old Railway to Suez, some gypseous marls and brown ferruginous limestones are brought up by a fault and exposed in a cutting. These contain the following fossils:—*Pecten* sp., *Cardita* sp., *Arca* cf. *Fichtelli*, Desh., *Cardium multicostatum*, Brocc., *Cardium* sp., *Dosinia Adansoni*, Phil., *Venus ovata*, Penn. (numerous), *V. multilamellata*, Lam., *V.* cf. *plicata*, Gmel., *Venus* sp., *Cytherea erycina*, Lam., *Trochus tauro-miocœnicus*, Sacc., *Turbo tauro-miocenicus*, Sacc., *Turritella terebralis*, Lam., *Ficula* sp., *Triton* sp., *Scaphander lignarius*, Lam., *Scaphander* sp.

At the foot of the Miocene escarpment to the south-west of Gebel Gafeisad or Agleiat Qamr, Lower Miocene fossils were also found in some sandy beds, while pieces of mammalian bones in a bad state of preservation were also seen.

From the base of the Miocene cliff 15 kilometres east of Dêr el Bêda the following fossils were obtained:—*Scutella Deflersi*, Gauth., *Scutella* sp., *Brissopsis*, sp. nov., *Pecten Kochi*, Loc., *P. Schweinfurthi*, Blanck., *P. Ziziniæ*, Blanck., *P. submalvinæ*, Blanck., *P. burdigalensis*, Lam., *Pecten* sp., *Pectunculus* sp., *Cardita* sp., *Cardium paucicostatum*, Sow., *C. multicostatum*, Brocc., *Cardium* sp., *Dosinia orbicularis*, Ag., (?) *Venus* sp., *Cytherea* sp., *Tapes vetula*, Bast., *Corbula revoluta*, Brocc., *Turritella* sp., *Ficula condita*, Brongn. Here there is undoubtedly a mingling of Helvetian and Lower Miocene fossils which marks what may be regarded as the passage-bed between these two stages of the Miocene.

At the foot of Gebel Genêffe a series of unfossiliferous beds (brown sandy limestones, gypseous clays, gypsumized limestone, and greenish marls) occur; they form a part of the Lower Miocene, as is shown by correlating the overlying fossiliferous beds with those in other sections in which these latter are found always to overlie the Lower Miocene beds.

In this district there is abundant proof to show that there was a great overlap of the Miocene beds from west to east. Near Cairo they lie on a thin layer of basalt which is a good distance from any of the known volcanic necks; further east in the immediate neighbourhood of the vents no basalt is found under the Miocene rocks except in very small patches, while the Oligocene sands and gravels are much thinner. This, to the writer's mind, is best explained by a gradual overlap from west to east. If it were otherwise, the basalt ought to be thickest in the neighbourhood of the volcanic vents, while west and east from them it would gradually thin out and disappear. The converse is the case, as the main basalt flow on the west side is remote from the volcano, while only on the flanks of the cone is it found close to the vent, and on the east it is entirely absent. The earlier submergence of the area near Cairo has protected the basalt from being totally swept away, as was the case with the longer exposed area to the east.

It would seem also as if deeper water existed to the east in Helvetian times, while the white limestone found there in such thickness was probably never deposited in the neighbourhood of Cairo. It is a fact that, as the Miocene is traced eastward, the beds thicken and become almost pure limestone, while others that were sandstone on the west have passed over into limestone further east.

REVIEWS.

I.—Photographs of Geological Interest in the United Kingdom.[1]

(PLATE XVIII.)

IT is again our pleasant task to call the attention of the readers of the Geological Magazine to the excellent work performed by Professor W. W. Watts, F.R.S., and his Committee for recording and preserving photographs of places and sections of geological interest in the United Kingdom. The report from which most of the following statements are taken shows that the past year has been exceptionally successful, the number of new photographs received having exceeded that of any previous year. The accessions number 543; the total number in the collection is 4,314, and the yearly average rises to 287. Since issuing the report 100 other photographs have been received.

The geographical scheme annexed shows that four counties are removed from last year's 'black list'—Cambridge, Kildare, Leitrim, and Wicklow having now made contributions to the collection. There are still 21 non-contributing counties—two in England, one in Wales, seven in Scotland, and eleven in Ireland.

To this year's list Yorkshire makes, as so often before, the largest contribution, 243; Norfolk follows with 43, Kent with 31, and Pembroke with 30. Considerable additions are made to the lists of Buckingham, Northampton, Suffolk, Fife, Linlithgow, Renfrew, Cork, and Sligo.

	Previous Collection.	Additions (1904).	Total.
England	2,308	415	2,723
Wales	250	41	291
Channel Islands	38	—	38
Isle of Man	60	1	61
Scotland	422	37	459
Ireland	597	49	646
Rock Structures, etc.	96	—	96
Total	3,771	543	4,314

[1] Fifteenth Report of the Committee, consisting of Professor James Geikie (Chairman), Professor W. W. Watts (Secretary), Professor T. G. Bonney, Professor E. J. Garwood, Professor S. H. Reynolds, Dr. Tempest Anderson, Dr. J. J. H. Teall, Mr. Godfrey Bingley, Mr. H. Coates, Mr. C. V. Crook, Mr. J. G. Goodchild, Mr. William Gray, Mr. W. Jerome Harrison, Mr. Robert Kidston, Mr. J. St. J. Phillips, Mr. A. S. Reid, Mr. R. Welch, Mr. W. Whitaker, and Mr. H. B. Woodward. (Drawn up by the Secretary, Professor W. W. Watts, M.A., F.R.S., Sec. Geol. Soc.) Read before the British Association, Cambridge, Section C (Geology), August, 1904.

"London Bridge," a natural arch in Middle Devonian Limestone, Torquay.

From a photograph by Professor S. H. Reynolds, M.A., F.G.S. (See p. 613.)

It is not easy to pick out any particular series of photographs for special mention, but a set of seventeen prints from Mr. Charles C. Buckingham and two from Mr. De Vere, all taken under the auspices of the East Kent Natural History Society, seem to be of exceptional interest. They illustrate the course and tributaries of the Kentish river Stour, and their association with the springs known as Bournes. Mr. Buckingham has also photographed Reculvers Church from the same points of view as Lyell's famous pictures, and the result brings home the potency of marine denudation and the need for coast defences.

Mr. R. Vowell Sherring, working in conjunction with the Bournemouth and District Society of Natural Science, sends some beautiful prints of the Bournemouth cliffs; Mr. Mellard Reade contributes some excellent photographs of the well-known gypsum boulder of Crosby; and Mr. Topham a series from the gravels of Eye in Northamptonshire. The rhythmical fretting of limestone by water in Hell Gill is illustrated by Mr. Rodwell under circumstances of considerable difficulty, and the marine destruction of the Scarborough landslips by Mr. Monckton. Mr. Leach sends photographs of a mass of Carboniferous Limestone at Tenby, supposed to show 10,000 specimens of *Productus*, and, curiously enough, almost the same post brought a notice that "the Corporation have for years been breaking up the stone for road repair, and are now in possession of a steam stone-breaker which will in the course of time cause this natural curiosity to disappear, unless some steps are taken to prevent it."

Messrs. Muff & Wright have taken an ideal set of photographs of the raised beaches and platforms of Cork, which are buried under boulder-clay, blown-sand, and 'head'; Mr. Pledge continues to illustrate Mr. Davies's work on the Purbeck and Portland of the Haddenham district; Mr. Robarts sends further contributions on the geology of Kent and Surrey from the Croydon Natural History and Scientific Society; and Mr. Plews gives the first photographs recorded from Cambridgeshire.

The importance of the contributions of members of the Committee will be realised from the fact that they are responsible for 426 photographs out of a total of 543. Mr. W. Jerome Harrison, one of the earliest and most earnest of geological photographers, and perhaps the pioneer of county photographic surveys, sends no less than 270 prints out of his large collection of a lifetime. These comprise a long series of the Yorkshire coast from Bridlington to Whitby; series from Cornwall, Norfolk, and Suffolk; and our first connected set from the Cambrian rocks of St. Davids. Mr. Bingley contributes 76 prints taken in Norfolk, Suffolk, Yorkshire, Anglesey, and Carnarvon. Professor Reynolds's work is well represented by illustrations from Hertfordshire, the Carboniferous area of Somerset, and volcanic areas in Fife, Haddington, and Linlithgow. Last, but not least, Mr. Welch makes a valuable gift of 35 prints taken in Lancashire and Ireland, in connexion with the work of the Belfast Naturalists' Field Club and of Mr. Praeger and Mr. Lamplugh.

They include examples from Antrim and Cork, the glacial and associated deposits of Down and Dublin, and phenomena connected with limestones and caves in Sligo. One of the photographs is both botanical and geological, for it shows the formation of tufa in a limestone district through the agency of colonies of various mosses.

To all the gentlemen named the Committee tender their best thanks, as well as to the following, who have contributed less in amount, it is true, but individual examples or series of high value: Mr. Epps, Mr. G. T. Atchison, Mr. Hopkinson, Messrs. Abley & Griffith, Mr. Hodson, Professor Armstrong, Mr. Cobbold, Dr. Matley, Dr. Flett, Dr. Abbott, and Mr. Smith.

Mr. Welch points out that one print registered last year (3,289), the cemented breccia of quartzite and slate at Howth, which contained bones of mammals and fishes with land and marine shells, is now the only record of an interesting geological fact, as the block has been washed away by the sea.

The third and last issue of the published series of "British Geological Photographs" was sent out to subscribers in May of this year. The completion and success of its first publication scheme marks an epoch in the history of the Committee and the fulfilment of a long-cherished desire of its founders.

Since the first meeting in 1890 the desirability of publishing a selected series of geological photographs has been kept before the Committee, but it was only in 1893 and 1894 that publishers were approached on the subject. With one consent they recommended application elsewhere, and so the matter was allowed to slumber till the Dover meeting in 1899. In this year a Sub-Committee of selection, consisting of Professor Bonney (Chairman), Professor Watts (Secretary and Editor), Professor Garwood, Dr. Mill, Dr. Teall, and Mr. H. B. Woodward, was appointed, a self-supporting subscription scheme drawn up, and a preliminary selection of typical photographs made. One hundred and ninety-three subscribers undertook to support a series which was to consist of issues of twenty photographs each year for three years. It was decided to issue the series in three forms—unmounted half-plate platinotypes, mounted platinotypes, and lantern-slides—and each issue was to be accompanied by descriptive letterpress.

Various unforeseen circumstances delayed the first issue, but it saw the light in September, 1902; issue ii followed in July, 1903; and the final issue in May, 1904. The actual series, as published, comprised seventy-two photographs, fifty-one being standard half-plates, ten quarter-plates, and eleven whole-plates, and an equal number of lantern-slides. The subjects ranged over most of the ordinary geological phenomena, the chief rock formations, and many of the more important British localities. The negatives were lent by thirty-four photographers, and a descriptive pamphlet of forty-two pages was written by thirty-four contributors, amongst whom are many of the most famous of contemporary British geologists. To both geologists and photographers the Committee express their warmest thanks.

The estimates on which the Sub-Committee worked proved to have been well founded, and the balance-sheet gives an account of all receipts and expenditure to date. It shows a balance in favour of the Committee of £95 13*s.* 2*d.*, and a prospective profit of over £130 when all outstanding accounts shall have been paid.

The balance-sheet, however, does not make one important point clear. Eight whole-plate platinotypes and twelve slides beyond the number agreed upon have been issued to subscribers. It is estimated that these additional photographs have cost £105. If this be added to the balance in hand the total profit has been £235, of which one-half has been returned to the subscribers and the other half retained by the Committee for the purpose of carrying on the work for which it was originally established by the Association.

It was pointed out in the Report for last year that in its fifteen years' work of collecting and storing photographs, the Committee had spent £101 10*s.* of the £130 granted to it by the Association. In making a clear profit of £130 the Committee may congratulate itself on having "earned its keep," and perhaps it is the only Committee of the Association which has ever succeeded in literally doing so. But, besides this, by scattering broadcast over the world typical photographs of geological features and phenomena it has rendered a service to geological, and perhaps to geographical, teaching which cannot be well over-estimated. The British Association photographs are forming the nucleus of dozens of teaching collections in the universities, schools, and museums of Britain; and numerous foreign subscribers write that they are only unable to subscribe to a second series because they now want the funds to accumulate other examples from their own countries. It is not so difficult to obtain geological photographs as it was fifteen years ago, for even the ubiquitous picture postcard is sometimes frankly geological.

About 100 intending subscribers to a new series have sent in their names, and the Committee recommend that such a new series be undertaken on the same terms as the last. With the smaller number of subscribers, however, the margin is narrow, and while profit to the Committee will be small, or absent, the subscribers will have to be content with the "contract number" of photographs. Possibly the number of subscribers will increase when it is known that the new series will be actually carried out.

Such a series will naturally be complete in itself, but it will also be supplementary to the first series, and in no way a repetition of it. The Committee would most warmly welcome any suggestions from subscribers and others as to the best points to be considered in the new series.

Examples of the published series of photographs were shown at the Exhibition arranged by the Geographical Association in London and the provinces this year. Another set was sent by request to the Exhibition at St. Louis, and it is proposed to present this collection to the Geographical and Geological Department at Harvard University when the Exhibition closes. To this set a gold medal in Group 16 has been awarded.

The duplicate collection of slides has been exhibited and explained within the year by Mr. Whitaker at the following local scientific societies:—The Christ's Hospital Natural History Society; the Greville Place Literary Society, Maida Vale; the Stratford Congregational Literary Society; and the Ashmolean Natural History Society, Oxford.

Applications by Local Societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

The Committee recommend that they be reappointed, without a grant.

Fifteenth List of Geological Photographs.

(*To August* 12, 1904.)

This list includes the geological photographs which have been received by the Secretary of the Committee since the publication of the last report. Photographers are asked to affix the registered numbers to their negatives for convenience of future reference. Their own numbers are added in order to enable them to do so.

Copies of photographs desired can, in most instances, be obtained from the photographer direct, or from the officers of the local society under whose auspices the views were taken.

The Committee *do not assume the copyright of any photographs* included in this list. Inquiries respecting photographs, and applications for permission to reproduce them should be addressed to the photographers direct.

It is recommended that, wherever the negative is suitable, the print be made by the cold-bath platinotype process.

The very best photographs lose half their utility, and all their value as documentary evidence, unless accurately described; and the Secretary would be grateful if, whenever possible, such explanatory details as can be given were written on the forms supplied by him for the purpose, and *not on the back of the photograph or elsewhere.* Much labour and error of transcription would thereby be saved. It is well, also, to use a permanent ink for this purpose. A local number, by which the print and negative can be recognised, should be written on the back of the photograph and on the top right-hand corner of the form.

Copies of photographs should be sent *unmounted* to Professor W. W. Watts, F.R.S., The University, Birmingham, and forms may be obtained from him.

Our Plate XVIII this month is taken from one of the series of Photographs of Geological Interest issued by the British Association Committee, and represents an excellent view of "London Bridge," a natural arch at Torquay, Devonshire (No. 2,938 of the series). Photographed and reproduced by permission of Professor S. H. Reynolds, M.A., F.G.S. The following description by Mr. W. A. E.

Ussher, F.G.S., and the block annexed, are taken by permission from the letterpress issued with the last set of the first published series of "British Geological Photographs":—"The natural arch depicted in the photograph forms a conspicuous object on the south coast of the Torquay Promontory between the Bath Saloons and Daddy Hole. It has been tunnelled by the sea through a small headland near the axis of an inverted synclinal curve in Middle Devonian Limestones. The prolongation of this axis eastward is well shown on the coast a quarter of a mile away. In the middle and lower part of the limestone masses of Torquay, a partial cleavage is often displayed by the beds, consequent on the pressure

Diagram figure of Natural Arch, Torquay; drawn to show inverted Syncline.

which has produced the folding in them; this structure, as shown in the photograph, becomes in certain cases most pronounced at and near the axis of the folds, causing a shattering of the rock at the point where the direction of strain cleavage approximates to, or coincides with, the inverted bedding planes. The dark marking extending horizontally on either side of the arch in the photograph denotes high-water mark. The railings give a scale. This locality, from a slightly different point of view, has been figured in the Memoir on the Geology of the Country around Torquay, p. 49 (Mem. Geol. Surv., 1903), in which the Middle Devonian Limestones of that district are also described."

II.—On some important occurrences of Granular Carbonate Rocks, with special reference to their Origin and Structure. By Bernhard Lindemann. Neues Jahrbuch f. Min. Geol. u. Palæont. XIX Beilage Band (1904), Heft 2.

THIS important paper on crystalline limestones and dolomites contains about 9 pages of bibliography, 5 or 6 pages of review of older theories of crystalline carbonate rocks, nearly 100 pages of descriptions of special occurrences, and 10 pages of discussion of the general character and origin of the rocks and of their accessory minerals. The second and last sections are briefly reviewed here.

Cotta held in 1827 that crystalline limestones might be either (1) original secretions of calcium carbonate from the fiery fluid planet mass, like the plutonic crystalline schists; (2) rocks independently erupted from the earth's interior; (3) altered compact (sedimentary) limestones.

The second or truly eruptive limestones were characterised by their numerous inclusions of fragments of baked schist (or gneiss) [such as are common in the crystalline limestones of Ceylon—however they got there]; and by their wonderful close and intimate relation to the schists or gneisses they are associated with. Later on, in 1853, he abandoned the eruptive view and thought that such limestones had been more softened by heat than the surrounding rocks, and had thus been able to *behave* as eruptive rocks, and force their way under the influence of pressure into the crevices of the surrounding rock and even to form dykes and bosses in them, and break across their foliation planes. Then followed a gradual consolidation to a granular crystalline rock, accompanied by the development of contact-metamorphic minerals. [This describes with wonderful exactness the sort of thing that seems to have happened in connection with the crystalline limestones of Ceylon, whatever their actual origin may have been.]

Naumann, too, believed that crystalline limestones might have consolidated from a state akin to fusion ("aus dem feurig erweichten Zustande"). The 'Neptunists,' on the other hand, thought that crystalline limestones resulted from the alteration of organic limestones by percolating waters which dissolved and redeposited the calcite, and introduced other carbonates and silicates as well; and they ignored the possibility of contact-metamorphism. These views seem to result from a confusion of the truly crystalline limestones of the schists with the ordinary crystallisation and obliteration of organic structure that has often taken place in sedimentary limestones.

At the present day a majority of geologists (Gümbel, Lepsius, Vogt, etc.) ascribe the characters of crystalline limestones to regional or dynamo-metamorphism; some others, to the contact-metamorphic effects of intrusive igneous rocks. In regional metamorphism four factors are involved, viz., (1) water as a solvent, (2) high temperature, (3) mechanical pressure, (4) long-extended time of action. [Certainly pressure alone appears to result in the degradation of already crystalline limestones, as in Iowa, and not in the *development* of a crystalline structure.]

Vogt has attempted to separate regional from contact-metamorphic crystalline limestones, on the ground of differences in mineral composition and of certain peculiarities of structure. He thinks that an interlocked or granulitic (*verzahnten*) structure is characteristic of regional metamorphic limestones, and that it is wanting in almost all that are of contact-metamorphic origin; and further, that, in consequence of this peculiarity, hardly any marbles save those of regional metamorphic character are valuable for ornamental purposes.

The observations of the author of the paper under review show, however, that these distinctions cannot be maintained. Nor does he agree with Vogt in regarding certain minerals (garnet, vesuvianite, scapolite, wollastonite, pyroxene, amphibole, epidote, chondrodite, felspar, tourmaline, spinel, etc.) as characteristic of contact-metamorphic limestones, and others (quartz, actinolite, mica, talc, chlorite, rutile, hematite) as occurring in limestone of regional metamorphic origin. According to our author, however, the accessory minerals *do* fall into two groups, the first, including garnet, wollastonite, vesuvianite, diopside, periclase, and spinel, being characteristic of limestones altered by *normal* contact-metamorphism, and the second, including quartz in rounded grains, and members of the mica, chlorite, amphibole, and epidote groups, and also corundum, occurring in limestones altered by *piezo*-contact-metamorphism (contact-metamorphism accompanied by pressure); here the carbon dioxide being unable to escape, the formation of wollastonite is impossible, and denser minerals are formed in place of lighter ones, corundum e.g. replacing spinel. On the other hand, phlogopite, forsterite, epidote, and pyrrhotite occur with either group of contact-metamorphosed limestones. [This classification does not *exactly* apply in Ceylon, where, in spite of the absence of wollastonite, spinel is not replaced by corundum.] All the minerals so far mentioned result from the alteration of matter present in the original limestone; magnetite and ilmenite are also primary minerals.

Other minerals—tourmaline, scapolite, apatite, fluor, topaz, and some mica—are probably of pneumatolytic origin, and derived from the intrusive magma; and so with pyrites, hematite, and sphene. Some lime-bearing silicates—particularly garnet, wollastonite, diopside, actinolite, etc., when they occur in concretionary nodules and layers near to the intrusive rock—may also be of external origin, and not merely developed from materials originally present in the limestone.

The author considers that the granular limestones and dolomites are without exception of organic origin, and that—at any rate in the vast majority of cases—their mineral composition and crystalline structure are the results of contact-metamorphism. The paper ends with a list of the accessory minerals that occur in crystalline limestones and dolomites. A. K. C.

III.—Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Nat. Hist.). The Jurassic Flora, II: Liassic and Oolitic Floras of England (excluding the Inferior Oolite Plants of the Yorkshire Coast). By A. C. Seward. pp. 192, pls. xiii, text-figs. 20. 1904.

THIS volume constitutes the Second Part of the Catalogue of Mesozoic Plants in the British Museum. The First Part, published in 1900 by the same author, dealt with the magnificent collection from the Inferior Oolite of Yorkshire. The present volume gives a full account of the other English plants from the Trias, Rhætic, and Jurassic. With the exception of those from the Stonesfield Slate of Oxfordshire and the Lias of Dorset, plant remains are not at all abundant in any of these formations, and such as occur are often fragmentary or ill-preserved. Thus, while a number of the specimens dealt with in this volume have proved unsatisfactory as records of the plant life of the period, their elucidation, as far as it has proved possible, has added considerably to what was previously known on this subject, and is therefore highly valuable.

After a brief discussion of the present state of our knowledge of the earliest Mesozoic floras in various parts of the world, the author passes on to describe in detail the few fragments of Triassic and Rhætic age in the collection. The former period is represented by only one plant remain, a seed known as *Carpolithes* sp. From the Rhætic, fragmentary specimens are referred to *Equisetites Muensteri* (a typical species of the period), *Lycopodites lanceolatus,* and a fern *Clathropteris platyphylla.*

The Lias plants are represented by several specimens of the following species among others :—*Thinnfeldia rhomboidalis, Cycadites rectangularis, Otozamites obtusus,* and *Pagiophyllum peregrinum.* Many of these are well-preserved and fairly perfect specimens. A new species of fossil wood is described as *Cupressinoxylon Barberi.*

A special section is devoted to a discussion on the nature and origin of Jet. It is shown that in all probability Whitby jet has been produced in large measure by the alteration of wood of the Araucarian type.

The collection from the Stonesfield Slate (Great Oolite) is the largest described in this volume. It includes examples of *Ginkgo digitata* and *Baierà Phillipsi* ; several Cycadean fronds such as *Williamsonia pecten, Zamites megaphyllus,* as well as two new species, *Sphenozamites Belli* and *Podozamites stonesfieldensis.* Coniferous remains, especially *Thuites expansus,* are also fairly abundant.

Perhaps the most interesting specimen botanically is a leaf, described as *Phyllites* sp., which in several respects closely resembles that of a recent Dicotyledon. The author remarks that "had the specimen been found in rocks known to contain the remains of Angiosperms, there would be no hesitation in identifying it as a leaf of a Dicotyledon ; but seeing that we know of no undoubted Angiospermous fossil in Jurassic strata, it is of the utmost importance to demand satisfactory evidence before identifying a plant, or fragment of a plant, as an Angiosperm."

The remains from the Oxfordian, Corallian, and Kimeridgian are few in number, and consist for the most part of Coniferous twigs or cones.

The memoir concludes with tables of the geographic distribution of the species described, and a short discussion on the botanical features of these floras. A full bibliography is appended.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The opening meeting of the session 1904–5 took place on November 9th.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Mr. E. T. Newton, in exhibiting, by permission of the Director of H.M. Geological Survey, a specimen of *Fayolia* near to *Fayolia grandis*, found by Dr. L. Moysey, of Nottingham, in the Coal-measures of Ilkeston (Derbyshire), pointed out that *Fayolia* was first described by Professors Renault & Zeiller in 1884, in their monograph on the "Houiller de Commentry." In 1894 Mr. Seward described the first British specimen, from Northumberland, in the Leeds *Naturalist*, but thought that it was not a plant. There was some resemblance to certain spiral egg-cases of Elasmobranchs; but Dr. Günther was unwilling to accept the Northumberland fossil as the egg-case of a fish. Mr. Kidston had not yet seen the specimen now exhibited; but, from a sketch, he recognised its relation to *Fayolia*. At present, there was still uncertainty as to the exact nature of this fossil.

The following communications were read:—

1. "Notes on Upper Jurassic Ammonites, with special reference to Specimens in the University Museum, Oxford: II.[1]" By Miss Maud Healey. (Communicated by Professor W. J. Sollas, Sc.D., LL.D., F.R.S.) This was the first occasion in the history of the Geological Society when a lady, the author of a paper, was not only present, but read her own paper and replied to the discussion thereon.

This paper gives a redescription of the types of *Cardioceras vertebrale*, Sow., *C. scarbrugense*, Y. & B., *C. cordatum*, Sow., and *C. excavatum*, Sow., and their varieties. Four varieties of the first, nine of the second, three of the third and fourth, are defined, and a description is given of a new species of *Cardioceras* belonging to the same group. Notes on species allied to the group and on others which have been wrongly confused with it are added. These species are so closely connected by innumerable transitional forms that their limits cannot be definitely fixed. The term 'species' is therefore used as equivalent to Professor J. W. Gregory's *circulus*: "It includes a number of 'forms,' which vary along lines radiating outward from a central type. Some of the members farthest removed from the centre may be within the range of another *circulus*, for the different *circuli* may overlap or be connected by an indefinite series of individuals." Each *circulus* is made up of *subcirculi* or varieties, and several *circuli* make up a group which need not necessarily correspond with a genus. *C. cordatum* is retained as the name of the whole group, although the type is a most unsatisfactory little specimen from the Corallian of Shotover.

[1] For Part I see Geol. Mag., 1904, p. 39.

2. "Sarsen-Stones in a Clay-Pit." By the Rev. E. C. Spicer, M.A., F.G.S.

Near to Bradenham, midway between High Wycombe and Prince's Risborough, certain clay-pits yield a clay for brick-making, in which are embedded large angular sarsen-stones, white saccharoidal sandstones with a siliceous cement. This clay is quite flintless: it rests upon, and is 'contained' by, Clay-with-Flints based upon Chalk, and is covered with roughly-mingled material containing horizontal bands with worn flint-pebbles and drifted sarsens of smaller size. Each patch of the clay fits roughly into a funnel-shaped depression lined with Clay-with-Flints. The depressions are probably swallow-holes, formed by underground solution of the Chalk, which was covered by wet clay and that by sands of the Bagshot Series. As the clay oozed out into the hollows the sarsens of these sands broke away, and became involved in the clay, much as blocks of the Malmstone at Atherfield become involved in the mud-glaciers which descend from the underlying Gault in the sea-cliffs. The overlying formation is due to much later, and probably Pleistocene, action after the flints of the Upper Chalk had been exposed by denudation.

3. "On the occurrence of *Elephas meridionalis* at Dewlish (Dorset). Second communication: Human agency suggested." By the Rev. Osmond Fisher, M.A., F.G.S.

This paper is in continuation of one published by the author in 1888. The site in which the elephant-remains were found is a narrow trench, examined to a depth of 12 feet in places, with nearly vertical sides, a smooth, chalk bottom, and an abrupt end. It was not a fault or a stream-course, and it was partly filled with fine dust-like sand which may have been wind-borne. The trench cuts diagonally across the scarp; and, even if it could be accounted for by natural agencies, it is difficult to explain how it happened that so many elephants fell into it. The author points out that in Africa elephants are caught by the natives in pitfalls of similar character constructed on the tracts leading to watercourses. This trench is in a corresponding position with regard to a stream, and it is suggested as possible that the trench may have been of human origin. There is, however, no conclusive evidence elsewhere that man was contemporary with *Elephas meridionalis*, which is characteristic of the Pliocene Age.

Manchester Literary and Philosophical Society.

Folds in Rock Strata.—Professor W. Boyd Dawkins, F.R.S., dealt with a subject of much interest to waterworks engineers in a paper entitled "Notes on the effect of Relaxation of Pressure in causing Folds at the Bottom of Valleys" read by him before the Manchester Literary and Philosophical Society, of which he is President. It directed attention to a new cause of folding of the rock other than that which has been long recognized by geologists as ultimately due to the folding of the outer layers of the earth as they follow the contracting nucleus. The deep cuts made through valleys to make watertight barriers in the construction of reservoirs revealed the fact that the bottom of the valleys, wherever it was formed of shales and thin sandstones, was more or less folded and contorted. These folds and contortions caused the shales to let the water through with more or less freedom, and he had been called in repeatedly to advise as to how far it was necessary to carry the puddle trenches down below the valley bottom. He found, as a matter of experience, that these folds were superficial, and if the sinking was made to a sufficient depth below the bottom of the valley they disappeared altogether. It was therefore obvious that they were not due to deep-seated movements of compression resulting from the contraction of the earth. They are due to the relaxation of pressure caused by the removal of the rock by denudation from the area of the valley, and are analogous in every particular to the 'creep' in coal workings, caused by the excavation of coal, by which the surrounding strata crush down into the area of relaxed pressure and ultimately fill it up. This may be studied in any coal-pit where there is a superincumbent pressure, say, of more than 1,000 feet.

Two illustrations of folding and faulting by relaxation of pressure are presented by the puddle trench of the Langsett reservoir belonging to the Sheffield Corporation, and by the two reservoirs now under construction on the head waters of the Derwent by the Derwent Water Board. In the first of these the foldings in question at the bottom of the valley in the shale under the first grit are strongly marked at the surface. These folds gradually disappear, and are based upon a hard black unmoved shale offering a good foundation about 60 feet below the bottom of the valley. This is in the valley of the Little Don. The thickness of rock removed from the bottom of the valley amounted to no less than something like 8,000 feet of Coal-measures and Millstone Grit. In the case of the Derwent, in which the folding is much more marked and is accompanied by faulting, the thickness of rock removed amounted to at least 9,700 feet (7,200 feet of Coal-measures, 2,000 feet of Millstone Grit, and at least 500 feet of Yoredale). In this the movement had not extended beyond a depth of 90 feet. In the case of the Derwent reservoir lower down the river there are two systems of folding and faulting which do not penetrate beyond 60 feet from the surface. At that point a good foundation is found for the puddle trench of the embankment. These points are of considerable importance in considering the sites for reservoirs.—From *Water*, November 15th, 1904, No. 71, p. 491.

CORRESPONDENCE.

THE NEW QUESTION OF RIPPLE-MARK.

SIR,—In the August number of the GEOLOGICAL MAGAZINE I proposed to offer at some future time an explanatory paper on the formation of ripple-mark; writing then under the impression that experts were quite agreed upon a subject not generally known.

After my August paper was in type, Mrs. S. Ayrton expounded the subject of ripple-mark at the soirée of the Royal Society, and subsequently delivered a lecture at Cambridge under the auspices and special sanction of Section G.

In the course of the latter lecture Mrs. Ayrton ignored all previous enquirers, except Professor Darwin, whom she considered not to have fully appreciated the significance of his own experiments. This places me in a difficulty, as I am in doubt whether Mrs. Ayrton has considered the work of modern writers, or only the views expressed in the older text-books. Then there is another difficulty, and that is, that the subject was considered by Professor Osborne-Reynolds' Committee on Tides and Waves, which was a Section G committee; while the subject comes within the purview of the reappointed Committee on Terrestrial Waves, etc. As a matter of fact, Mrs. Ayrton's views, as endorsed by the Royal Society and Section G, are in conflict with the views accepted by two committees of the British Association and of all modern workers. Indeed, Mrs. Ayrton uses the words "Contrary to accepted opinion."

I am aware that Bacon declares that unanimity is a very dangerous thing, and that, theoretically, it might be safer for me to differ from Professors Darwin and Osborne-Reynolds, and Dr. Vaughan Cornish, who are the modern authorities who have dealt more particularly with the sand-ripples of tidal and other continuous currents; but, except in some microscopic points of details, there seems to me to be no room for doubt.

During the past months of September and October I had the little Moorland stream, the river Bovey, under close observation, and for eight weeks one particular sand-flat was more or less rippled.

Mrs. Ayrton maintains that a steady current cannot produce sand-ripples, and suggests that certain sand-waves on the Goodwin Sands are caused by stationary sea-waves. So far as my observation goes, there are no stationary waves in the open sea; and it is an uncontrovertible fact that a steady current, as understood by geologists, viz., a current flowing to all outward appearances continuously in the same direction, can, under certain conditions of speed, depth, and composition of bottom, form sand-ripples, as pointed out by Dr. Sorby, F.R.S., in 1859.

The point that geologists want decided is whether the sand-ripples proved by Monsier Siau in the Indian Ocean, in a depth of over 100 fathoms, were produced by continuous currents or by wave-action. A good deal turns upon the answer. To me the balance of evidence seems to be in favour of wave-action, because, as a rule, deep currents do not disturb the bottom, but slide over the strata of water which are in contact with the bottom; but I come to that conclusion in face of the fact that under certain circumstances continuous currents have been proved to ripple a sandy bottom.

I should like to see a committee appointed, to consist of all the leading workers who have written upon the subject of current ripple-mark, and especially of those who have delivered popular lectures. I think, for instance, that if Professors Darwin, Osborne-Reynolds, and Fleming, with Dr. Vaughan Cornish and Mrs. S. Ayrton, were to confer and compare experiences a unanimous report might easily be arrived at. Until something of the sort is done the exposition of the subject, as endorsed and supported by the Royal Society and the British Association in their corporate capacities, will either be accepted by the public or cause a great deal of perplexity. The question does not touch my own special work, as all seem agreed as to the ripple-making powers of reciprocal wave-currents. A. R. Hunt.

November 7th, 1904.

ELEPHAS MERIDIONALIS AT DEWLISH.

Sir,—I regret that I was unable to be present at the meeting of the Geological Society on the 9th inst., when my paper on the Dewlish elephant trench was read, suggesting human agency. I crave your permission to reply to one or two criticisms as reported in the Abstracts of the Proceedings. It is there said that some 'eoliths' found there were exhibited by me. If what I *did* exhibit is referred to, they were merely shown as geological specimens from the drift of the gravel with which the trench had eventually become filled—not as 'eoliths.' I have seen some 'eoliths' which were collected at Dewlish, but in my opinion (whatever that may be worth) they do not strengthen my hypothesis that the trench is artificial.

Mr. Hudleston remarked that he understood that the remains of only one elephant had been found. There are in existence *nine* well-preserved molars in museums, four at Dorchester, two at Salisbury, two at Cambridge, and one at Manchester. I exhibited at Cambridge all these except the Salisbury specimens. Mr. Pleydell in his paper in the "Dorset Field Club," 1889, mentions seven molars, so that two of the above enumerated must have been omitted in his list. In this paper he gives a list of remains. He says that isolated plates of other molars were scattered in various parts of the deposit, and that in some places fragments of ivory were so numerous as to predominate over other materials. This I think disposes of Mr. Hudleston's objection that the remains of only one elephant had been found.

It is obvious that the trench was not wide enough to contain the carcase of an elephant. But if such a beast once got his fore legs into a narrow trench twelve feet deep, he must have been in the "helpless condition" that Sir Samuel Baker refers to, in which he might have been dispatched at leisure. It is not likely that primitive men would have expended more labour upon their pitfall than was absolutely necessary. O. Fisher.

Harlton, Cambridge,
November 18th, 1904.

THE DISCOVERY OF *MARSUPITES* IN THE CHALK OF THE CROYDON AREA.

SIR,—With reference to Dr. Hinde's paper on "The Zone of *Marsupites* in the Chalk near Croydon," we should like to point out that though in general his observations corroborate ours, we found at least four specimens of *Marsupites* with nearly complete tests, one with brachial joints in position, and a block containing most of the test plates and associated brachial plates, which is now in the possession of Dr. Bather. We also found several specimens of *Echinoconus conicus* near the Pank's Hill Road end, and in another part *Janira quinquecostata.* We agree with him that "the dip of the Chalk from the summit towards the north is probably about the same as that of the general slope of the surface," and see no occasion for Mr. Dibley's theory of a fold in the chalk. He says that the upper part of the *Cor-anguinum* beds are exposed at Beddington. We have questioned him as to this, and he admits he should have written Carshalton, and says he meant the section we showed him a few months ago which we then thought was no higher than the *Cor-anguinum* zone. Recently we have found there, among other fossils, tests and brachial plates of *Uintacrinus.*

With all due respect to Dr. Hinde, we cannot help expressing our surprise that he did not consider it necessary to refer to us as the original discoverers of the *Marsupites* zone in Surrey. Mr. Dibley certainly mentions us in a somewhat casual way, but as Dr. Hinde's paper is page-headed "Discovery of *Marsupites*, etc.," few readers will be aware that we made the discovery, spent days and hours among the thrown out blocks, inspected the trenches and *tunnels*, and had prepared a paper for the Proceedings of the Geologists' Association. It was unfortunate that our paper was not first in the field, as we were, but as we are mentioned in the number of your journal which contains Dr. Hinde's article, we have the satisfaction of knowing that the credit, if any, will be equally divided between the discoverers and the eminent geologist who has given his valuable time to the production of such an interesting and scientific paper.

W. WRIGHT.
B. C. POLKINGHORNE.

13, DEVEREUX ROAD,
WANDSWORTH COMMON, S.W.
November 16th, 1904.

MISCELLANEOUS.

THE Palæontology of the Lower Coal-measures of Lancashire is very fully dealt with by Mr. H. Bolton in the Transactions of the Manchester Geological and Mining Society (vol. xxviii, part 14).

ERRATUM.—In Mr. Coomáraswámy's paper on the Balangoda Group, in the August number, p. 422, the figure was one-half natural size, and not $5\frac{1}{2}$ times as there stated.

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